NASA Technical Memorandum 104740

Medical Evaluations on the KC-135 1990 Flight Report Summary

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This document represents the medical investigations completed on the KC-135 during Fiscal Year 1990 in support of the development of the Health Maintenance Facility and Medical Operations. The experiments are comprised of engineering evaluations of medical hardware and medical procedures. The investigating teams are made up of both medical and engineering personnel responsible for the development of medical hardware and medical operations. The hardware evaluated during this time includes dental equipment, a coagulation analyzer, selected pharmaceutical aerosol devices, a prototype air/fluid separator, a prototype packaging and stowage system for medical supplies, a microliter metering system, and a workstation for minor surgical procedures. The results of these engineering evaluations will be used in the design of flight hardware as well as to identify hardware specific training requirements. Also during this fiscal year, the following medical procedures were evaluated using prototype hardware: dental procedures, spinal immobilization, medical transport, and fluid management during minor surgical procedures.

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PREFACE

This document is a product of the efforts extended by the Medical Operations Branch at the Johnson Space Center to support medical evaluations in a microgravity environment. It is a collection of 18 flight reports from work performed on the KC-135. The reports, appearing in chronological order, investigate various areas of medical science.

The intention of this document is to serve as a record of the continued development, planning, and evolution of the Health Maintenance Facility and Medical Operations for Space Station Freedom.

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HEALTH MAINTENANCE FACILITY — DENTAL EQUIPMENT REQUIREMENTS

PRINCIPAL INVESTIGATORS:	John Young, D.D.S. John Gosbee, M.D.
CO-INVESTIGATOR:	Roger Billica, M.D.
GROUP/ORGANIZATION:	UTHSC-San Antonio KRUG International/NASA SD2
FLIGHT DATE:	January 23, 1990

TEST OBJECTIVES:

1. Test the effectiveness of the HMF dental suction/particle containment system, which controls fluids and debris generated during simulated dental treatment, in microgravity.

2. Test the effectiveness of fiber-optic intraoral lighting systems in microgravity, while simulating dental treatment.

3. Evaluate the operation and function of off-the-shelf dental handheld instruments, a portable dental hand drill, and temporary filling material during microgravity.

TEST DESCRIPTION:

A mannequin head with teeth will be restrained at the head of the table of the HMF patient restraint device. A prototype laminar flow/suction and particle containment device and an instrument tray with restraint devices, dental instruments and dental hand drill, will be mounted and deployed "above" the mannequin head. Portions of minor dental procedures will be simulated during microgravity parabolas. Particles normally generated during dental procedures will be simulated with small amounts of a fine mist, and the drilling of small areas of the mannequin's teeth. Various portions of the laminar flow/suction device will be sequentially turned on, while particles are being generated.

TEST SET-UP AND FLIGHT EQUIPMENT:

Space required: *Full width of KC-135, and 10 feet of length*

1. HMF prototype Patient Restraint Device
2. Fiber-optic light source (a model currently used in dental practice)
3. 2 HP Vacumm cleaner and small (3/4 HP) compressor for the suction containment device
4. A cardboard fold-out suction/containment chamber attached to a vacuum hose
5. A 1/4" plastic tube with holes drilled in attached to the air compressor to create a laminar air flow
6. Mannequin head and torso
7. Instrument tray with small elastic restraint strings at right angles to restrain various hand held instruments and dental supplies
8. Dental instruments restrained with bungees to a plastic tray
9. A NiCad battery-powered drill restrained onto the tray

DATA ACQUISITION SYSTEM:

1. In-flight paper recording
2. Postflight debriefings of experimenters
3. Video and still photography (video by J. Young, stills by NASA)

IN-FLIGHT TEST PROCEDURES WITH PERSONAL OBSERVATIONS:

Video and still photography pending. Most of the procedures were viewed through the video camera lens.

1. A mannequin head with teeth will be restrained at the head of the table of

the HMF patient restraint device.

- Approx. 20 inches apart
- Adequate room for both JY and RB to get both forearms and hands on and into the mouth.

2. A prototype laminar flow/suction and particle containment device and an instrument tray will be mounted and deployed "above" the mannequin head.

   - Both could easily be adapted to deploy above any well defined area (20 inch by 20 inch) on the patient, for other medical/surgical procedures

3. Small amounts of water mist (< 2cc) will be sprayed "through" the mouth of the mannequin, with no suction devices used. (control)

   - Spray extrudes in a geyser-like fashion and "hangs" in a volume around the mannequin head)approx 30"x30"x30")

4. A small battery-powered dental drill will be used to drill on the plastic teeth, with no suction devices used. (control)

   - Plastic particles extrude rapidly in several directions (<2mm size), and a dust "hangs" in a volume around the patient (as above)

5. Both of the above actions will be repeated with the suction/laminar flow device in use to entrain the mist or particles.

   - 90-95% of water and plastic tooth particles are entrained into the suction collector.

6. The suction collector will be reconfigured with a absorbant cloth over it (called a "camel cloth" chamois), and water sprayed into the laminar air flow.

   - The initial water spray/particles "bounce" off the dry camel cloth, with only some of them being soaked into the cloth.

   - As the camel cloth gets wet, most of the water spray/particles are soaked in, with few "bouncing away".

7. A handheld fiber optic light will be used to visualize areas of the teeth that are drilled.

   - This light source is easy to handle, and adequately illuminates the areas of the teeth and mouth.

8. The operator will utilize the dental hand drill to prepare the drilled plastic teeth for a temporary filling, using the light source and mirror.

   - No inherent problems encountered
   - Two sets of hands are required to hold the drill, mirror, light probe, and local "tip" suction.
   - Some unsteadiness of the operator's hands may be caused by inadequate or poorly positioned foot and waist restraints.

9. Zinc-Oxide Eugenol and Composite temporary filling materials will be placed upon the holes in the plastic teeth. Blue light and water are used, respectively, to "set" the material.

10. Both of these fillings were trimmed and "polished" with the dental drill.

    - No problems noted here

NASA PHOTO REFERENCE

S90-28208
Demonstration of suction tip

S90-28220
Dental tray and assembly with laminar flow/particle containment system

S90-28223
Dental technique in zero-gravity

S90-28211
Demonstrating dental technique in zero-gravity

DENTAL EQUIPMENT TEST DURING ZERO-GRAVITY FLIGHT

PRINCIPAL INVESTIGATOR:	John Young, D.D.S. (UTHSC San Antonio)
CO-INVESTIGATORS:	John Gosbee, M.D. (KRUG) Roger Billica, M.D. (KRUG)
FLIGHT DATE:	January 23, 1990

EXECUTIVE SUMMARY:

The overall objectives of this program are to establish performance criteria and develop prototype equipment for use in the HMF in meeting the needs of dental emergencies during space missions. The primary efforts during this flight were to test patient-operator relationships, patient (manikin) restraint and positioning, task lighting systems, use and operation of dental rotary instruments, suction and particle containment system, dental hand instrument delivery and control procedures, and use of dental treatment materials. The initial efforts during the flight focused on verification of the efficacy of the particle containment system. An absorptive barrier was also tested in lieu of the suction collector. To test the instrument delivery system, teeth in the manikin were prepared with the dental drill to receive restorations; some with temporary filling material and another with definitive filling material (composite resin).

The tests of the laminar-air particle containment system confirmed earlier results which showed that directing particles with laminar air into a suction receiver provided excellent control of particulates. Suction without the laminar flow was not effective, and neither was directing particles against an absorptive barrier. The best particle containment came from the combination use of the laminar-air/suction collector in concert with immediate area suction from a surgical high-volume suction tip. Lighting in the treatment area was provided by a flexible fiberoptic probe. This system is quite effective for small areas, but generalized task/ambient illumination is required. The instrument containment system (elastic cord network) was extremely effective and easy to use. The most serious problem with instrument delivery and actual treatment was the lack of time during the microgravity sequences. The restorative materials handled and finished well, considering the time available. Flexible operator foot-loop

restraints placed on the floor provided good stability while still allowing a fair amount of mobility. A "tether" system was tested which bound the operator to the side of the table. This system works well for keeping the operator in the general area, but was too flexible for definitive stability necessary for delicate procedures. "Locking" of the operators leg under the table seemed to provide the best stability.

OBJECTIVES

The major objectives of this flight were to: (see attached test protocol, Attachment 1)

- Test the effectiveness of the laminar-air/particle containment system with and without suction applied and with an absorptive barrier in lieu of the suction collector.
- Test an elastic cord network of instrument/material restraint on the delivery system tray.
- Use the instrument delivery system to prepare teeth in the manikin to receive dental restorations of the type we project may be required during space flights.
- Dispense, place, cure and finish dental restorative materials in the microgravity atmosphere to determine their suitability for use in the HMF.

The following ongoing objectives were also evaluated:

- Test overall compatibility of prototype dental treatment assembly with HMF treatment/restraint table.
- Explore behavior of particles as they might exit the oral cavity during dental treatment.
- Test the performance of a dental fiberoptic illumination system in the null gravity environment.
- Test performance of dental hand motor with various burs used in tooth preparation.

MATERIALS

The HMF restraint table and dental power pack were installed in NASA aircraft #930 on Monday, January 22, 1990 in preparation for the Tuesday flight.

On Tuesday morning, once airborne, the dental instrument tray, mannequin and particle collectors were fixed to the restraint table and connected to the power pack. The equipment consisted of:

1. Dental instrument tray assembly
   - instrument tray with elastic cord restraints
   - straight tube, laminar air curtain under tray (21 ea, 1 mm air holes @ 20 psi)
   - dental treatment instruments
   - pressure canisters (2) for vapor particle generation and syringe
   - dental motor power pack
   - "micro" fiberoptic light source
2. Anatomic mannequin with full dentition and particle spray nozzle
3. Prototype particle collector cone with tubing, 3-way dental syringe (water, air, or combination spray), surgical HVE aspirator, and small cone mounted on a "chase" tubing for collection of debris which might escape the treatment area
4. Power pack - (mounted to floor under table)
   - 3/4 HP diaphragm air compressor
   - 2 HP vacuum source
   - rheostat (vacuum control)
   - fiberoptic light source (primary)

- power source for tray mounted micro light source
- power strip for central connection

5. All equipment mounted with no difficulty and with the exception of a clogged spray nozzle in the mannequin, performed as projected from prior testing.

6. Current Problems:

   A spray nozzle failure hindered our particle generation during the latter part of the first set of parabolas. The nozzle was cleared by "back flushing" through the nozzle using the air portion of the 3-way syringe which was added to the equipment for this flight.

   Once again our position in the aircraft was essentially midship, which posed a couple of problems not experienced in the flights when we were directly behind the cockpit. First there were windows directly opposite the mannequin head and the resultant light helped to obscure vision of the aerosol particles in the videotape. Second, there was an air conditioning vent directly in front of the table and the air flow down and backward perhaps interfered somewhat with our measurements. This may, however, simulate conditions which we might find in the space station cabin itself?

METHOD **(Test Protocol, all in 0-gravity)**

1. Evaluate patient-operator relationships, patient (mannequin) restraint and positioning.

2. Determine the direction and dispersion of aerosol particles generated from the oral cavity, *without* air curtain or collectors activated. (videotape)

3. Evaluate air curtain and determine ability of laminar air stream to divert and direct particles as generated from the oral cavity. (video/ team)

4. Evaluate suction/collection system and determine the ability of the system to collect and contain the particles.

5. Evaluate the efficiency of an absorbent barrier to trap and contain particulates directed against it.

6. Test ability of instrument tray elastic cord restraint system to hold instruments and materials in position and determine ease of accessing instruments as needed.

7. Illuminate the treatment areas with the fiberoptic probe and subjectively determine necessary intensity and overall effectiveness.

8. Use the dental engine to prepare teeth in the mannequin for restoration, in a manner consistent with normal dental treatment. Determine subjective cutting efficiency and ability of collection system to control effluent particulates.

9. Dispense, place, cure and finish dental restorative materials in the teeth prepared in 3.8 above.

RESULTS

1. Evaluate patient-operator relationships, patient (mannequin) restraint and positioning, plus compatibility of equipment with HMF treatment/restraint table.

   As previously reported, the instrument tray assembly with laminar air curtain appears to fit well within the concept of the table. The tray is fastened to the head end of the table with the universal rail clamps and is positioned directly over the patients' upper forehead. This position appears to allow reasonable access to the face and oral/maxillofacial regions. The laminar air generation tube is mounted under the leading edge of the tray and it allows the laminar air flow to be directed across the face from the forehead towards the chin and chest area and hence into the chest mounted collector. The tray position also allows equal access to the patient, instruments and materials from either side of the table.

   The particle collector was supported by the chest of the mannequin and held in position with elastic straps. The connecting suction tubing was directed over the edge of the table to the power pack below. The high volume evacuator (HVE) was fastened to the table edge rail through a circular holder which kept the hose under control, yet allowed use as

necessary during the test.

The overall configuration works very well in the microgravity environment. Our tests with the absorbent barrier pointed up the necessity for a suction type of collector.

Operator restraints consisting of flexible foot loops and a mountaineering type of tether system was evaluated for operator positioning. The foot loops worked very well, once the foot was inside the loop. The tether system also worked well for general restraint, allowed a nice range of motion, but was not rigid enough for definitive positioning. Perhaps it is all we need for safety and confidence and in conjunction with the foot loops may indeed be a simple answer to operator restraint.

Need:

- A series of tests with a full-sized human will be necessary to determine an optimum patient restraint system. A conscious patient should pose no problem as far as keeping the head and oral cavity in the working area of the operator. An unconscious patient, however, may pose a different problem and a head positioner and restraint may be necessary. I would propose to test a "catcher's mitt" type of positioner with restraint straps.

- More experience with the foot loops and tether.

2. Determine the direction and dispersion of aerosol particles generated from the oral cavity, *without* air curtain or collectors activated (videotape). The particulates created by both the pressure cannister and drilling on the mannequin teeth appeared to behave as in past flights. The stream of aerosol particles proceeded from the orifice in a rather well directed stream until they struck the deflector shield of the collector. From that point they appeared to disperse widely, depending on stream velocity. The tooth debris appeared to disperse laterally as it came off of the bur and then diffused in the general area in a manner consistent with the air flow in the aircraft. In previous flights, dispersion throughout the aircraft was verified by personnel in the tail section who told us they smelled "dental clinic" almost immediately when we started into the parabolic flight. The aerosol had been scented with a small amount of dental mouthwash!

3. Evaluate air curtain and determine ability of laminar air stream to divert and direct particles as generated from the oral cavity.

As detailed in 2.2.1.2 above, the straight tube air curtain (20 PSI) diverted the emerging particles very well. The particles responded well to limited changes in direction of the curtain from horizontal downward. Much more than about 15' downward movement was beyond the range of reality considering the physical structure of a human and the fact that it would be counter productive to direct the particles down and away from the collector on the chest area.

The 1 mm holes in the tubing @ 18 psi, 30 L/min flow, gives approximately 400 FPM velocity at the entrance to the collector and offers a more direct flow of the curtain without as much dispersion as the larger holes in previous tubing. There is no question that the particulates are captured by the air curtain, incorporated into the flow, and directed towards the collector.

4. Evaluate suction/collection system and determine the ability of the system to collect and contain the particles.

   The system was set up as indicated in 4.1; "The laminar air generation tube is mounted under the leading edge of the tray and it allows the laminar air flow to be directed across the face from the forehead towards the chin and chest area and hence into the chest mounted collector."

   The "A" collector from previous tests was used due to its proven performance.

   Collector "A" - Basically a triangular collector with a front rectangular opening of approximately 3"(H) X 12"(W), and 7" deep with a 1 1/4" ID connecting tube at the rear. There is a "flap", approximately 12" wide X 6" deep, attached to the top section. The flap is deployed at approximately 45` and gives a deflection shield which tends to direct the particles downward into the collector.

   The high volume evacuator (HVE) hose which had a suction tip flow rate of approximately 35 L/min was routed as per 4.1 and used as close to the point of particle generation as possible. This method provided the best particle control, as expected. The original premise was that we would try to control as much of the particle dispersion as possible at the source with the HVE. The laminar air curtain would then capture and direct stray particles into a collection system.

The possibility of a third longer hose and round funnel cone for "free hand" particle chase and capture still holds promise and bears investigation as mentioned in the first report. This "chase hose" was installed on the equipment for this flight, and tested out at volume flow rates of approximately 35 L/min with the chest collector suction on and 360 L/min with it off. However, during the flight we lost some suction power which made testing doubtful and we found a longer hose was needed for effective testing. We experienced a partial loss of suction power towards the end of the flight; no reason has been found for this loss as of this date. (works fine at 1 G in lab)

We had originally thought an "umbrella" type of collector might be a third line of defense, but I seriously doubt that the air flow volume will be available to make this concept viable. The "chase cone", however, may take relatively little air volume to be effective.

5. Evaluate the efficiency of an absorbent barrier to trap and contain particulates directed against it.

   Questions arose as to the possible effectiveness of a "fly paper" type of barrier that might capture particulates without the use of a suction cone system. A highly absorbent rayon "synthetic" chamois material was used as a barrier against which the particulates were directed. This material (when damp) has an extremely high rate of moisture retention. The barrier was tested dry in the beginning and was dampened during use. There was no question that the dampness increased the effectiveness of the barrier. However, significant amounts of the aerosol and particulates were seen escaping from the area when only the barrier was used. It appeared that the particulates were effectively directed against the barrier, but they appeared to rebound and disperse. When the suction cone was turned back on this phenomena ceased. The possibility exists that lining the suction cone with the absorbent material may further enhance particle retention. A new suction cone will be constructed and tested in the laboratory and possibly in microgravity flight.

6. Test ability of instrument tray elastic cord restraint system to hold instruments and materials in position and determine ease of accessing instruments as needed.

   In our previous tests we used magnetic tape to restrain ferrous instruments and overall it worked well. However, there are a great

many treatment items which are not ferrous and do not lend themselves well to adding ferrous or magnetic surfaces. (ie: gauze, medicaments, etc.) A series of elastic cords were incorporated "net-like" on the tray surface and the treatment items were secured under the cords. This functioned extremely well for the most part. The only potential problem arose with the hand instruments when a larger instrument raised the cords so that smaller instruments could escape. Additional cords could easily be incorporated into the tray and lining the instrument area with magnetic material as well is certainly reasonable.

7. Illuminate the treatment areas with the fiberoptic probe and subjectively determine necessary intensity and overall effectiveness.

   Again as in earlier tests, "The fiberoptic illumination probe worked extremely well. With the ambient illumination levels projected for the HMF area, the probe should provide ample light for direct and trans-illumination for a number of conditions and treatments."

   Adjustment of beam intensity from the operating tray area is still desirable and should be explored on later tests.

   During these tests the probe was held by the assistant and provided excellent illumination of the operative sites. It further was used as a "curing light" for the light-cured restorative resin we used on the mannequin. This was accomplished by fitting a removable blue filter to the end of the probe which gave us the necessary 550 nanometer wave length necessary for curing. A decision has yet to be made as to the definitive type of restorative materials to be recommended, however, this test does point out the viability of the resin system.

8. Use the dental engine to prepare teeth in the mannequin for restoration, in a manner consistent with normal dental treatment. Determine subjective cutting efficiency and ability of collection system to control effluent particulates (video/team).

   Three teeth were prepared in the mannequin for dental restorations which were deemed probable during space flights. A front tooth was prepared to repair a simulated fracture such as might be experienced with hitting ones self in the face with a slipping wrench or tool. Two posterior teeth were prepared to treat problems which might arise from broken, or defective fillings or decayed teeth.

The previously tested Aseptico Portapac, model ADU-03, electric/battery dental drill was used to prepare the teeth. The drill worked very well, providing the necessary torque and control to cut tooth structure. Different burs were selected and changed during microgravity conditions. Little difficulty was encountered and in a stable microgravity state there should be no problem with a system of this type.

The particle containment/suction system worked extremely well for these procedures. When the suction tip is placed in close proximity to the tooth during preparation, the particulates are cleanly sucked into the system.

9. Dispense, place, cure and finish dental restorative materials in the teeth prepared above.

Two restorative materials were tested during this flight. They are both pre-mixed in syringe form and require no other materials for activation.

The first "Tempit" by Centrix Inc. is a temporary white colored filling material which consists mainly of calcium sulfate and zinc oxide and sulfate. It is a sealing material which is used as temporary sealing of tooth cavities between appointments. It is not intended for long term use and has little strength under chewing conditions. It was selected due to its handling ease and that fact that it would provide relief for certain dental problems in mainly posterior teeth. (other types of materials will be investigated for this use).

The second material is a light cured tooth-colored resin "Silux Plus" by 3M. These are light activated bis-GMA resins which have proved to be extremely durable and esthetic restorative materials. This material was selected for use in repair of fractured or chipped teeth which cannot be effectively smoothed down until definitive treatment is available. The use of the resins is a little more complex than the use of the zinc oxide materials, but they are significantly stronger. Once again, the 3M material was used because it was convenient and a good representative of the type of material I wanted to test. We may have better materials coming.

An additional material which I want to test in the microgravity environment is the "glass-ionomer" class of materials. They have unique properties which may lend themselves to our needs.

DISCUSSION

I am very pleased with the results to this point. With the exception of the few problems indicated above, our tests ran close to the protocol. The following observations and conclusions were made:

1. Collector "A" with the flap extended, and situated on the mannequin chest provided excellent particle control in these tests.

2. Absorbent barrier material alone does not appear to provide adequate aerosol/particulate capture.

3. The single tube laminar air curtain generator with 1 mm air holes, 20 psi, and 400 FPM air flow provides excellent particle control and direction.

4. The high volume evacuator (HVE) provides excellent particle control at the source of generation, but should not be the ONLY source of particle control. This test showed we need phase 2 (laminar air curtain and collector), and possibly phase 3 (chase cone).

5. The dental engine performed well. The final brand, configuration, power source, etc. is not as important as the function.

6. The elastic cord restraint system used on the delivery tray for retention of instruments and materials performed very well. I believe this concept should be given every consideration in the final design.

7. The tooth restorative materials handled well considering the short working time we had in the parabolas. Other materials need to be tested to determine the type of material to be recommended.

Further development and testing is necessary as outlined above. For future tests we need to consider at least the following:

1. Use a human subject to simulate actual patient restraint and positioning. (work on head positioning).

2. Provide a more rigid or "shaped" series of foot loops which may be more easily accessed from the standing position.

3. Work on the table "tethering" as was explored during this flight. The tether needs to be flexible, yet with some firmness.

4. Fabricate particle collector with absorbent lining. The collector will be patterned after collector "A" of this test, probably with the flap assembly.

5. Validate the use of higher air velocity in the curtain along with smaller collector ports. Since we know the system can work, we need to try and reduce the bulk.

6. Make more flexible and maneuverable HVE assembly, to include tips for one-person operation.

7. Investigate "chase hose". Make shut off valve for main collector to give full power to hose when needed.

8. Reconfigure fiberoptic light assembly.

9. Construct a new delivery tray with enhanced elastic cord hold downs and magnetic insterts.

10. Try to provide a more effective dark background for video recording of test procedures.

11. Mount both dental engines and devise quantitative tests for efficiency.

We still need to look into task lighting. As per previous reports; "The table mounted quartz light is probably OK for now, but Dr. Houchens and I need to have further time with this. We will need to mount the quartz light for a subsequent test flight, however, at this point it would most likely interfere with our particle containment tests."

Future needs, after determining the basic requirements:

1. Matching dental system to HMF utility (electrical and suction) systems.

2. Downsizing to fit storage and weight requirements.

3. Continue working out treatment sequences, materials and instruments.

SUMMARY:

This January 1990 flight went very well in most respects. We were very ambitious in our protocol due to our lack of flying time, but most all tests

went according to protocol. The basic findings from these tests were:

1. Operator/patient relationships seem to be working out OK. Foot loop restraints and table "tethers" were used during this test. The loops worked very well, once the feet were in them. The tether was a little too loose for definitive positioning, but certainly provided a stable reference point from which to work as well as providing an excellent margin of safety.

2. The basic test equipment configuration and mounting continues to work very well, was stable, and suffered only minor mechanical problems which were basically due to lack of time to fully assemble the unit after takeoff and some blockage in our aerosol lines.

3. Aerosol particles generated for the test were well contained with The suction collector and surgical suction tip.

4. The absorbent barrier, in lieu of the suction collector, did not provide adequate capture and retention of aerosols and particulates.

5. The single tube laminar air curtain, with 1 mm air holes and 20 psi air pressure, captured and directed the particles in an acceptable manner.

6. The high volume aspirator (HVE) was very efficient in capturing debris at the source of generation; again as expected.

7. The fiberoptic light probe worked extremely well.

8. The dental engine worked well, had adequate power, and appeared to have sufficient battery life to sustain working power for most any dental treatment anticipated.

9. The preparation of mannequin teeth to accept dental restorations worked very well, considering the parabola time available.

10. The dental zinc oxide and composite resin restorative materials used to repair the teeth functioned quite well. Other types of materials will be tested.

These tests were essential in that it allowed verification of the conditions observed in earlier flights and allowed visualization of the particle control system in operation with a different laminar air generator and

collector configuration in the 0-G environment. As we gain experience with the dental handpiece and instruments we are gaining an understanding of the problems to be overcome in providing treatment in the space craft environment. Further testing and refinement are necessary as indicated above, but valuable experience with the prototype system was gained.

RECOMMENDATION:

Continue development flights to address the subjects as outlined above. The protocols should be limited to exploration in some depth of individual systems/problems. Up to this time, we have been trying to "broad brush" the entire system, but due to the short parabola microgravity times the time is rapidly approaching that repetitive studies of individual entities is essential.

ATTACHMENT:

1. January 23, 1990, Dental Flight Test Protocol

NEEDS:

- Back up aerosol units
- Test aerosol in lab prior to flight
- Noncorrosive aerosol cannisters. (use new cannisters each time)
- Differing air curtains, smaller holes, higher velocity
- Mount FO generator on HVE clamp, with rheostat
- Handpiece "parking ports", or some such. (perhaps slits in a membrane and just poke items into it?)
- Stronger foot loops with more "shape" for easier foot placement.

TRY:

- Chase hose
- HVE holder for one person use
- Different suction tips
- Smaller tubing = greater velocity? (measure velocities in 1 G)
- Different collector shapes.
- Absorbent lining

- Continue on with 3-way syringe.

FUTURE:

- We need to consider how the water/air separation will occur in the particle containment system.

NASA PHOTO REFERENCE

S90-28208
Demonstration of suction tip

S90-28220
Dental tray and assembly with laminar flow/particle containment system

S90-28223
Dental technique in zero-gravity

S90-28211
Demonstrating dental technique in zero-gravity

MINI-RACK TESTBED EVALUATION

PRINCIPAL INVESTIGATOR:	John Gosbee, M.D.
CO-INVESTIGATORS:	John Gosbee, M.D. Barbara Stegmann, M.D. Terry Guess
FLIGHT DATE:	January 26, 1990

NOTE: *The names John Gosbee, Barbara Stegmann, and Terry Guess will be abbreviated as JG, BG, and TG, respectively, when referenced throughout this report.*

GOAL:

Characterize the features of the HMF-like (mini) racks and drawers onboard the KC-135 as a test bed for the Space Station Freedom HMF racks.

EXECUTIVE SUMMARY:

The specific objectives of this experiment are: 1) to test and evaluate the mini-rack structures and drawers for use as a test bed on the KC-135; and 2) to evaluate the attachments, mounting points, and inner drawer assemblies of the mini-racks for various medical equipment and supplies.

To accomplish these objectives, the mini-racks will have medical equipment mounted in some portions of the racks; and self-contained drawers full of medical supplies mounted in other portions of the racks. The wires and attachment lines will be deployed upon the equipment and a patient mannequin, detached, and restowed. The medical supplies will be unstowed from the drawers, and then restowed.

Observations and subjective ratings for each task, stowage, restraint, and deployment mechanism are included in this report. Description of inflight photography is included. Diagrams that illustrate layout of racks, restraint systems, and potential deployment mechanisms are included.

Major conclusions and issues include: **1)** the mini-racks and drawer assemblies are satisfactory for use as a HMF test bed onboard the KC-135 test aircraft; **2)** there are significant problems with the handling and restowage of coiled tubing, leads, and catheters; **3)** optimal inner drawer restraint mechanism should have the following characteristics: allow stowage and destowage with one hand; remove one item without dislodging others; CMO can visualize the contents of the drawer while restrained; containment of items even when the drawer is forcibly opened or closed; and friction should be minimized for both the foam and item stored; **4)** contents cannot be visualized, or easily destowed, from drawers above chest height of the CMO; **5)** hard-sided central supply items are more easily stowed and destowed into a foam or plastic enclosure for restraint.

It is recommended that several items and mechanisms evaluated in this experiment should be redesigned and retested aboard the KC-135. These include: **1)** a proper deployment device for the IV pump; **2)** devices for controlled deployment of medical supplies proximal to the MRS; **3)** hard side containers to stow and restrain central supply items within foam-lined drawers; and **4)** a vest and apron for storage and deployment of diagnostic instruments and other items that has smooth lined pockets and identification mechanisms.

TEST EQUIPMENT AND CONFIGURATION (see diagram 1):

Two test racks, with dimensions 19"x30"x48", secured adjacent to each other, facing the prototype Medical Restraint System (MRS).

HMF prototype MRS secured and centered 32" away from the test racks. A rope was tied around the perimeter of the MRS surface as a waist restraint attachment point for the experimenters. Duct tape foot loops were placed along the floor below the edge of the MRS surface; and at 90 deg. to the rack face, between the MRS and the racks.

Full-size Patient Henri Mannequin (30 pounds); restrained to the MRS surface.

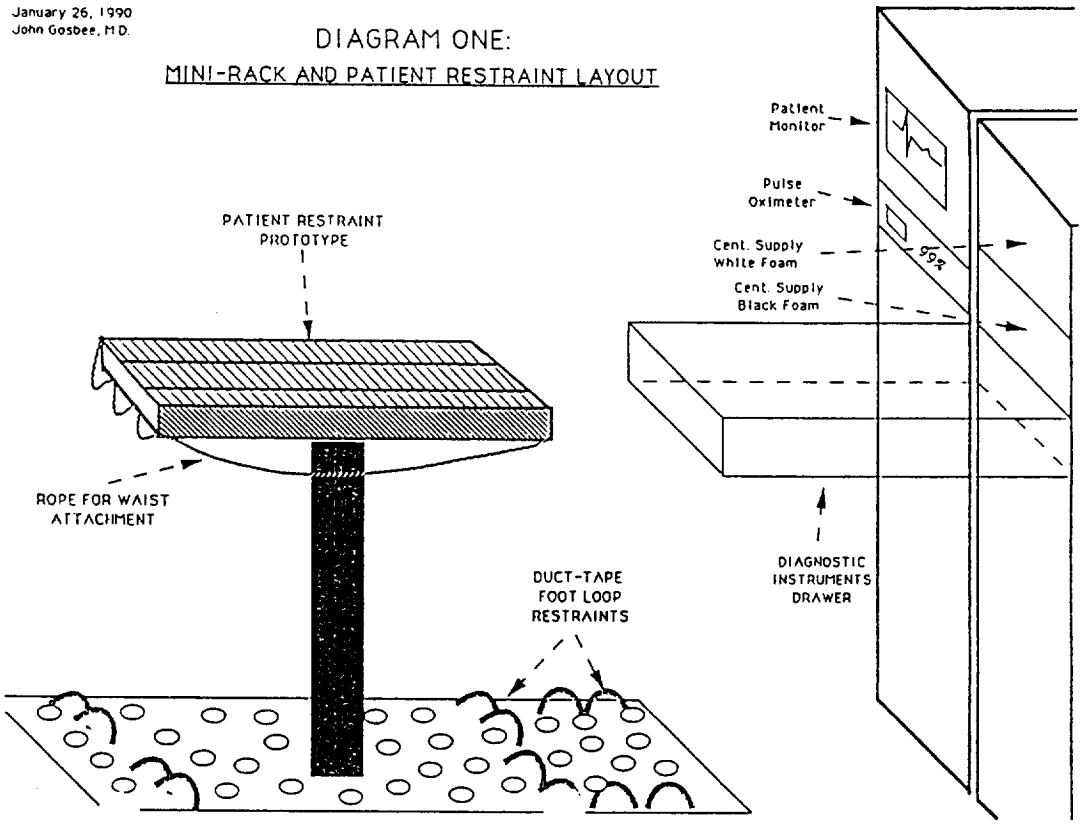
Marquette 7000 Patient Multivariable Monitor (EKG, body temp, arterial and venous pressure); rack mounted 38-48 inches above floor.

Nelchor Pulse Oximeter (% oxygen saturation and pulse rate); rack mounted 33-37 inches above floor.

January 26, 1990
John Gosbee, M.D.

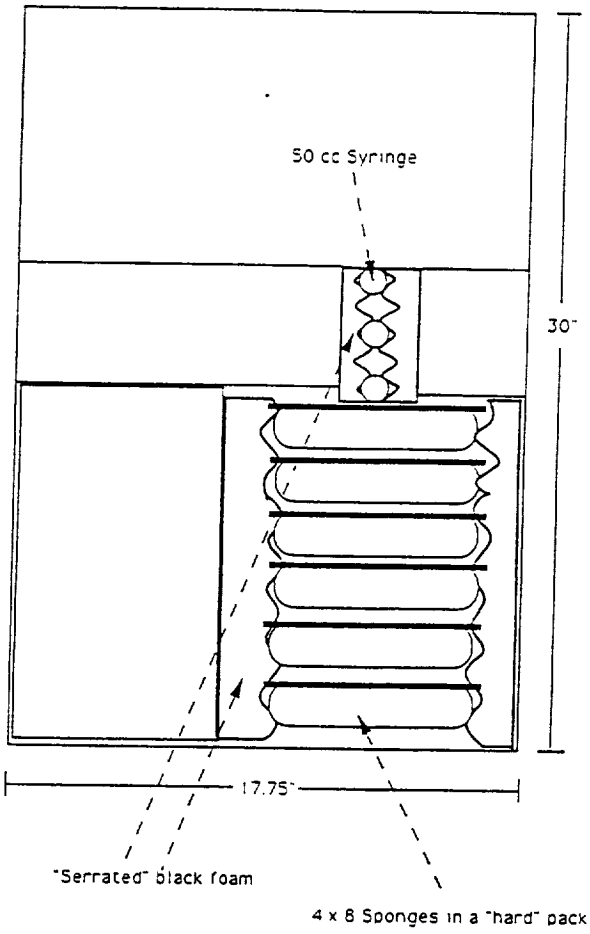
DIAGRAM ONE:

MINI-RACK AND PATIENT RESTRAINT LAYOUT



Jan 25, 1990
John Gossee, MD

DIAGRAM TWO:
Black Foam Drawer Layout



I-Med IV pump; restrained with velcro straps in the drawer "behind" the monitor.

Medical supplies; restrained with various techniques/devices in 2 drawers. These supplies and restraint devices are listed below in the "Results" section. White foam drawer was located 42-47 inches above floor, and Black foam drawer 36-41 inches above floor (both are 5 inch drawers). Diagram two depicts the Black foam drawer.

Medical diagnostic instruments; contained within a vest garment, which was held in a drawer with one velcro strap (stethoscope, blood pressure cuff, oto/ophthalmoscope, tuning fork, and penlight).

EXPERIMENTER DATA:

JG is 73" tall, with 34" sleeve length

BS is 67" tall, with 32" sleeve length

DATA ACQUISITION SYSTEMS:

In-flight written questionnaires

In-flight Still and video photography

Post-flight debriefing and questionnaire

PROCEDURES AND RESULTS:

The format for below is the following:

1. Name of the drawer/equipment
2. Description of how the experimenters were restrained
3. A numbered list of the procedures accomplished

4. Following each procedure is:
   - Numerical rank of difficulty from 1-10, with the initials of the experimenter who ranked it.
   - Comments from the experimenters.

General guidelines for the ranking are:

1. Experimenter can't do the procedure at all

2. Experimenter can do the procedure with modifications to the "usual" 1-G methods/procedures

3. Experimenter can accomplish the procedure equivalent to 1-G

At the end of each report, there is a description of how the experimenters were restrained

I-MED IV PUMP

1. Tubing and IV bags for the IV pump will be deployed out of drawer.

   Tubing: 3, TG; 2, JG; 3, BS. Tubing coils up, hard to find and hold ends

   IV bags: 7 all. No good place to put them once deployed (velcro??)

   IV Pump: 7, TG; 8 JG. Drawer opens easily, need 2 sets of hands to remove pump, and then close the drawer fast before the end of 0-G

2. IV pump, tubing and IV bags will be attached/mounted on MRS

   JG 5; BS 5
   IV bags "bungeed" on near side of head, IV pump on far side on MRS
   Took two parabolas, with JG and BS working

3. The pump will be turned on, and proper operation noted.

   JG 6; BS 7 (crowded area around head on the MRS)
   BS must bend over pt. head to push buttons and see displays
   BS notes that preflight training was essential, given the poor position of the displays and controls

   JG could not see from far side of MRS, nor could he really help

4. Flow rate and volume infused will be entered, and the pump started.

   BS 9; JG 6. No problem entering commands, once CMO in position

5. Operation in general of the system will be noted

   Air-in-line error was rapidly detected and fixed with a quick flush
   Once cleared pump ran through 4-5 parabolas, until an "occluded" error stopped the pump. It may have been secondary to the use of bungees to restrain the IV bags, but no more time was allotted.

6. The leads and tubing will be removed from the mannequin and stowed back in the "briefcase": NOT done, ran out of parabolas for this part.

   Assistant CMO: one point tether and 1-foot loop for steps 1 and 2, near side, MRS at waist 3-6, far side

   CMO: one point tether for steps 1 and 2, MRS at waist for 3-6, no loops, all near

MARQUETTE PATIENT MONITOR:

1. Attachments for the patient monitor will be deployed out of a soft briefcase-like enclosure, which is removed from the white foam CS drawer.

   JG 8; BS 7; TG 8. Bag out of rear end of a CS drawer no problem
   JG 8. Removing only the EKG umbilical from the multi-folder bag was easy. To assist the CMO with the loose ends, a place near the patient to hold the bag for a short while was needed.

2. The EKG lead will be attached to the front of the monitor.

   BS 9; JG 8; TG 9
   BS was given only one end at a time, while JG held the slack
   Easy to see and line up this end of the umbilical, but need to be close, and adequate light levels to "match" colored dots.

3. The five patient leads will be affixed to the mannequin.

   JG 4; BS 4. Even with assistance, BS found it harder than one-G to grab

just one of five lines, and other lines tangled easily.
JG provided one EKG pad at a time, so as not to fill the BS hands.
Worked best if BS attached the pads to the leads prior to placing on mannequin.

4. The equipment will be turned on, and proper operation noted (as best possible).

   Easy to view patient monitor, a bit harder for the CMO to twist around while being restrained at the waist on the MRS.

   EKG lead line slack (5 feet) was coiled and bungeed near the waist of the mannequin so it wouldn't tangle or float up in the way

5. Temperature monitor lead is attached to the patient and monitor.

   Monitor attachment: JG 3. Hard to see how the male and female ends "line up" to plug it in.

   "Real" attachment to patient not done, but all slack taken up

6. The leads will be removed from the mannequin and restowed.

   JG 2; BS 2. Almost impossible to recoil the lead lines to properly restow the lines in the "briefcase".
   Ended up stuffing them in so that the soft side "briefcase" bulged fat

   Both CMO's near side. JG with waist on MRS. BS one pt tether and waist on MRS.

PULSE OXIMETER

1. Attachments for the pulse oximeter will be deployed out of a soft briefcase-like enclosure.

   The folder-like arrangement of the briefcase allowed easy selected access to each of the four coiled leads, including the two for the pulse oximeter.

2. These attachments will be attached to the front of the pulse oximeter

BS, 10; JG, 10; TG, 10. Needed both CMOs to hold either end from floating or tangling, before attaching to pulse oximeter outlet.

3. The pulse oximeter will be turned on, and proper operation noted.

   All 10. No problem noted

4. The leads from the pulse oximeter will be attached to the mannequin

   BS, 8; JG, 7; TG, 7. Needed both CMOs to hold either end from floating or tangling, before attaching to mannequin.

5. The leads will be removed from the mannequin and stowed back in the "briefcase".

   See patient monitor comments above. All gave this a 3.

   Both JG and BS used waist on edge of MRS, BS "twisted" over to attach line to rack. Also, BS notes that her make-shift swiss seat slides down so as not to give her a firm, stable attachment to MRS edge. In addition, BS could not easily reposition the swiss seat without removing. It was difficult to use the carabiner because the seat straps were pulled tight in an attempt to keep from slipping.

DRAWER WITH WHITE FOAM:

White foam is low density, easily compressible, and tacky.

1. 2 inch cling in "cylinder"

   JG 9; BS 7; TG 8 to remove. A bit hard to grasp and pull out through the individual small holes
   JG 5; BS 5; TG 5 to replace. The plastic cylinder loses some of its form, and you almost have to rip the holes to stuff them back in.

2. 4x4 gauze in "kleenex box"

   JG 8, to remove the first few. JG 5, to remove the last few, because the plastic container loses its shape, and is not firmly held in place.
   JG 6, to replace, when few are removed. JG 4, to replace, if most are removed, due to the characteristics of the plastic "box" cited above.

3. Wet gauze in "kleenex box"

   JG 10. to remove a few. JG 8 to remove the last few (see 4x4 gauze)
   JG 8 to replace a few. JG 4 to replace, if most are removed.

4. Iodine scrub brush in shallow depression. Complete failure. This item floated loose when the drawer was opened, and no amount of "cramming" it back into place helped.

5. Bulb syringe in cut-out depression

   This item partially shook lose upon forcible drawer opening, and it was not obvious how to restow it so that it fit.
   JG 10 to remove; JG 6 to replace

6. Ace wrap in cylindrical hole

   JG 10, BS 10 to both remove and replace. One of the better designs, since the item fit snugly into place.

7. SAM splint in circular hole, with velcro strap over top

   BS 10 to remove and replace. One of the better designs, but the velcro strap may or may not be required?

8 Foam and plaster (OCL) splint in fitted slot

   JG 10 to remove, 9 to replace. Good design, but foam was sticky so that replacing was somewhat hampered.

   JG and BS at opposite sides of the drawer, using one point tether at 30 deg. JG also used foot loop distal from the racks at 90 deg. BS braced feet on rack edges and MRS holes, and did not use the foot loops.

DRAWER WITH BLACK FOAM:

1. 4 x 8 sponges pack:

   JG 10; BS 10; TG 10. All agreed that this was an excellent storage, deployment and restowage device. Tension and friction of the foam was optimal to easily remove, and then to restow. Even after the pack

was opened, and some 4x8's removed, the pack could be restowed. Removal and replacement was a one-handed operation.

2. Syringes:

   JG 10; BS 10. Tension and friction of the foam was optimal to easily remove, and then to restow. The syringe was packed in a plastic over cover, so the sides were smooth, with low friction. Removal and replacement was a one-handed operation.

3. Ace wraps:

   BS 9 in and out. JG 8 out, and 6 in. The wraps without a plastic cover had such high friction that they "grabbed" at the foam while being removed or replaced. This grabbing pulled the foam edges up, and required the CMO to push the edges of the foam away to replace the ace wraps. Removal was one-handed, replacement was two-handed.

4. 2 inch cling wrap:

   JG 10 out, 8 in. Removal was easy, and each item could be visualized. Replacing the soft-sided cling was a bit difficult since it squished a bit, and had to be replaced with two hands.

5. Needles

   BS 10 in and out; JG 10 in and out. Tension and friction of the foam was optimal to easily remove, and then to restow. The needles were packed in a plastic over covers, so the sides were smooth, with low friction. Removal and replacement was a one-handed operation.

   JG was restrained at the waist on the near side of the MRS, and twisted around to reach the CS drawer. BS was restrained at the waist on the far side of the MRS, and was handed the CS items out of the drawer by JG.

PHYSICIANS INSTRUMENT VEST

1. Handheld diagnostic instruments will be stored in a fishing vest, which will be removed from a rack-mounted drawer.

   JG 9; TG 8. Two-handed: one to pull the velcro, one to pull out the vest from the drawer.

2. Handheld diagnostic instruments will be removed, and then restowed, from each pocket. (only enough time to test these three items)

Stethoscope	BS 5, tightt fit and the tubing was sticking to the fabric of the pocket
Tuning Fork	BS 10 removal and replacement in the pocket without difficulty.
Nasal speculum	BS 10. removal and replacement in the pocket without difficulty.

3. Vest with instruments will be stowed back into drawer.

   JG 2; TG 3. With only one velcro strap across the vest in the drawer, the edges of the vest "float free" above the confines of the drawer. This gets caught on the drawer above the vest drawer, when the drawer is closed. Recommend adding at least one more lateral and one longitudinal strap to hold the vest within the confines of the drawer; OR make a hard or soft cover over the whole drawer.

   BS restrained at waist on far side of MRS, JG restrained at waist on near side of MRS.

GENERAL HUMAN FACTORS ISSUES

1. Evaluation of the drawer "height" off the floor:

Patient monitor	BS 10, JG 10
Pulse oximeter	BS 10, JG 10
Top CS drawer	BS 4, JG 7, too high to visualize and get both arms over the top of, while being restrained at the feet and waist.
Middle CS drawer	BS 9, JG 10, very close to optimal height to visualize items, manipulate items, and utilize open drawer as a work area.
PI vest drawer	JG 10, basily within JG's reach while restrained to the MRS at the waist. Since this item is fully removed for deployment on someone's torso,

the height of the drawer to use as a work area is not a crucial factor.

2. Rack drawers to restraint to CMO configuration (set-up)

Patient monitor	JG 9; BS 9, location of the displays and controls near where the CMO stands is optimal, so that the CMO doesn't have relocate their waist restraint.
Pulse oximeter	JG 8; BS 9, location of the displays and controls near where the CMO stands is optimal, so that the CMO doesn't have relocate their waist restraint.
Top CS drawer	JG 5, a bit high for JG to reach all items, and to adequately visualize all the items, while restrained at waist to the MRS. In addition, some items required both hands to replace, which was difficult since the waist restraint required most of the twisting at the mid and upper torso.
Middle CS drawer items adequately	JG 8, all items within easy reach for JG, and all visualized.
PI vest drawer	JG 7, vest was within easy reach, but required both hands: one to undo the velcro, while the other hand grasped the now unrestrained vest.

3. Ease of opening drawers

Solid CMO restraint was not required to release drawer latches. All CS drawers opened and closed smoothly during 0-G. To unlatch the drawer, one must be in front of it. To extend the drawer to its full length, the CMO must:

- "stand" to the side of the drawer;
- use one hand to stabilize their body on the edge of the rack, or the edge of the MRS, while using the other to pull the drawer open;

- or be firmly restrained with a "three-point" stance - one point tether at an angle in front, one foot in a foot loop, and one foot positioned to make the tripod complete.

CMO RESTRAINT DEVICES

1. One point tether to the ground, at an angle (approximately 60 degrees to the floor) and foot loops made of tape (at 90 deg to face of racks)

   BS used frequently for both deployment of CS drawers and equipment. Overall they supplied a mobile, flexible restraint, but BS occasionally used the open drawers as supplementary restraints. BS did not use foot loops.

   JG used when assisting in some of the equipment deployment, and the white foam drawer. Most of the time the tether was supplemented with a foot loop over the distal foot. Overall this was an unwieldily and marginally satisfactory restraint

2. Waist restraint to the edge of the MRS surface

   BS used during EKG lead, IV set-up, and black foam drawer supply deployment. Overall, the waist restraint slipped down on the legs, and offered marginal restraint. It did allow freedom for both hands to manipulate items over the top of the MRS.

   JG used during EKG lead, pulse oximeter lead, and black foam drawer deployment activities. Given a tight fit around the waist and proper height adjustment of the MRS surface, this was an optimal restraint technique. While restrained on the near side of the MRS, JG could twist around and reach back to all five drawers, in both mini-racks, to open, turn on, and/or unstow items.

3. Ad hoc (wrapping legs around items, or between items)

   Not really utilized or evaluated as a sole technique for restraint. In order to form the above mentioned three point stance, JG used the bottom edges of the racks to brace his inside foot.

ADDITIONAL PROCEDURES AND OBSERVATIONS:

1. Both CS drawers were forcibly opened and closed to dislodge loose items:

   - Items in the white foam drawer shifted upwards slightly, and the flaps and strings were partially catching on the surfaces above the drawer.

   - Items in the black foam drawer did not shift noticeably.

2. Both a needle and syringe were removed from the black foam drawer by JG, who handed them across the MRS surface to BS. BS then assembled and disassembled them. JG then restowed them.

   - The CMO near the racks could use the open drawer somewhat as a work surface. However, the exposed area of the black foam drawer was not suitable to restrain items once removed from there foam restraints. Perhaps the open drawer could be used as a hard work surface with miniature bungees and velcro.

   - There is a real need for a work surface next to or even over the top of the patient, and/or next to the CMO on the far side of the MRS (out of reach of the open drawers).

PHOTOGRAPHY:

Stills:

S90-28168
The MRS prototype has the patient mannequin on it in the middle of the photograph, and the two HMF prototype racks with equipment and supply drawers are located on the left side. In the background, JG is destowing IV bags in orange containers from a "central supply" drawer, located in one of the HMF "mini" racks. In the foreground, BS is restrained at the waist to the edge of the MRS.

S90-28169
JG assists BS in restraining the IV bags and tubing under a bungee on the MRS surface, near the head of the mannequin.

S90-28171
While restrained at the waist on the MRS, BS is moving the IV pump across the MRS. Rope that is strung around the perimeter of the MRS is visible on the left hand side. Also visible in the wide velcro strap and bungee that are used to restrain the mannequin to the MRS.

S90-28172
Since JG in unrestrained, he has limited success in helping BS deploy the IV pump onto a "pole" mounted on the MRS. Blue and black webbing is visible around JG and BS waist, which is used for waist restraint attachment.

S90-28173
Since JG is unrestrained, he uses one hand to steady himself on the rack, and the other hand to pull open the top central supply drawer (white foam). Rope that is strung around the perimeter of the MRS is visible.

S90-28179
IV pump, bags, and tubing is deployed and restrained in the foreground. BS is attaching EKG pads onto the mannequin's chest. JG is holding and deploying leads and tubing from the soft-sided "briefcase" in the background. T. Guess is video taping the events on the right in the back.

S90-28180
While restrained to the MRS at the waist, JG is attaching the pulse oximeter lead to the pulse oximeter by twisting and stretching (in the background). BS is experiencing an occupational hazard in the foreground (as most of has or will).

S90-28181
While restrained to the MRS at the waist, JG is completing the attachment of the pulse oximeter lead to the pulse oximeter (in the background).

S90-28183
BS controls the loose pulse oximeter lead, while JG attachs the end of the lead to the mannikin's finger tip.

S90-28184
JG unsuccessfully attempts to restow the leads and catheters back into the "briefcase", while BS looks on.

S90-28195
JG stands beside an opened central supply drawer (black foam). He is

restrained at the waist with a one-point tether (black strap) at a diagonal to the ground.

S90-28196
JG stands beside an opened central supply drawer (white foam) and is destowing a large syringe from a "holster"-like cut out in the foam. He is restrained at the waist with a one-point tether (black strap) at a diagonal to the ground.

S90-28197
JG stands beside an opened central supply drawer (white foam) and holding a large syringe. He is restrained at the waist with a one-point tether (black strap) at a diagonal to the ground. Note that he can use both hands to manipulate this object, since the one point tether is sufficiently restraining him.

Video:

NASA master reference #115460. Video was reviewed by the experimenters. Overall quality was marginal due to light levels. Observations derived from the video are included in the above sections.

CONCLUSIONS:

1. The mini-racks and drawer assemblies are satisfactory for use as a HMF test bed onboard the KC-135 test aircraft.

2. The following are brief summaries of the above empiric observations:

   a. There are significant problems with the handling and restowage of coiled tubing, leads, and catheters.

   b. The mechanism that leads attach to the front panel of rack-mounted instruments should be simple, fast, and easy to visualize.

   c. The deployment mechanism used for the IV pump was unsatisfactory.

d. Any inner drawer restraint mechanism should have the following characteristics:

- Allow stowage and destowage with one hand.
- Remove one item without dislodging others
- Visualize the contents of the drawer
- Contain items even when the drawer is forcibly opened or closed (as it may be during an emergency)
- Regardless of the shape of the foam that is used for restraint, friction ahould be minimized for both the foam and item stored

e. Contents cannot be visualized, or easily destowed, from drawers above chest height of the CMO.

f. Soft-wrapped (soft-sided) central supply items are difficult to restow if they are wedged into a foam or plastic enclosure for restraint.

g. Hard-sided central supply items are more easily stowed and destowed into a foam or plastic enclosure for restraint.

h. The most optimal inner drawer restraint types were (see above for details):

- 4x4 dry and wet gauze in the "kleenex" box plastic enclosure
- SAM splint and Ace wrap in the cylindrical cut outs of the white foam
- OCL splint in the fitted slot
- 4x8 sponge hard-side packs, hard-side syringe containers, 2 inch cling wrap, and needles in the "serrated" black foam.

i. Positive and negative attributes of the physicians instrument vest were identified (see above).

RECOMMENDATIONS:

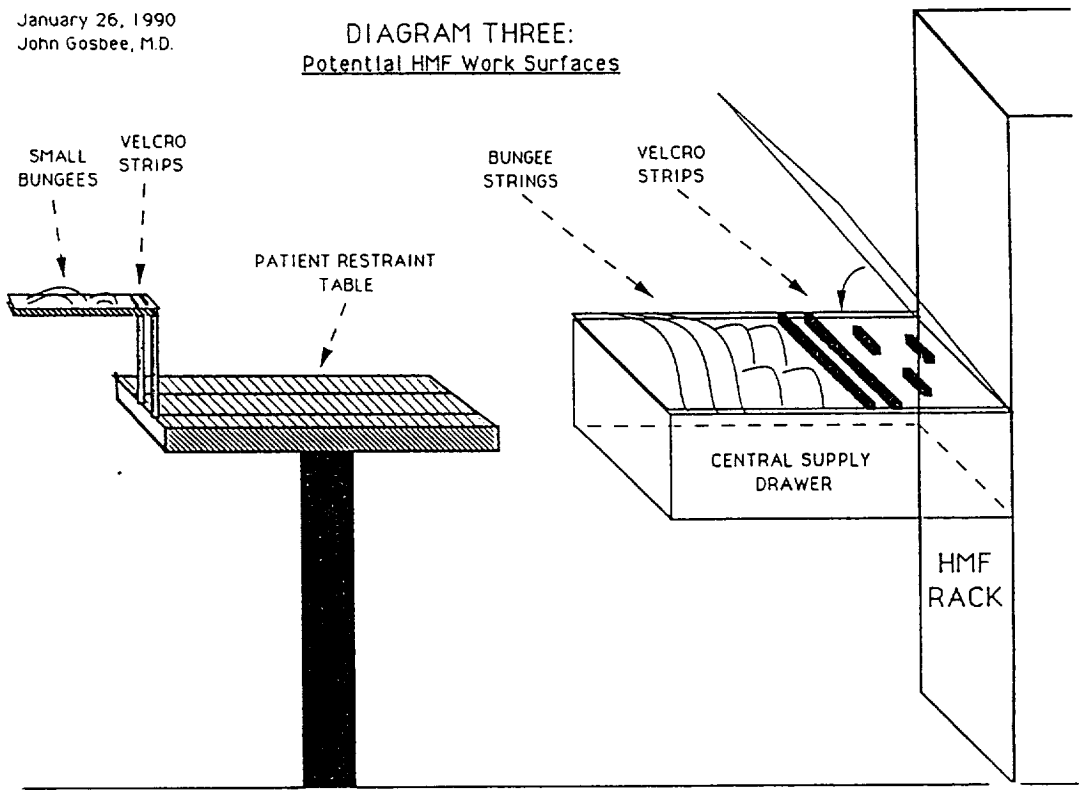
1. A proper deployment device for the IV pump is required. A prototype for testing on the KC-135 should be developed.

2. Diagram 3 *(next page)* depicts potential solutions for controlled deployment of medical supplies proximal to the MRS that should be tested on the KC-135.

3. Evaluate the use of the hard side containers to stow and restrain central supply items other than 4x8 sponges.

4. Have KRUG soft goods review this report and fabricate another inner drawer restraint prototype(s) for follow-on KC-135 testing.

5. Fabricate a vest and apron for storage and deployment of diagnostic instruments and other items that has smooth lined pockets and good identification mechanisms for pocket contents for KC-135 testing.


January 26, 1990
John Gosbee, M.D.
DIAGRAM THREE:
Potential HMF Work Surfaces
SMALL BUNGEES
VELCRO STRIPS
PATIENT RESTRAINT TABLE
BUNGEE STRINGS
VELCRO STRIPS
CENTRAL SUPPLY DRAWER
HMF RACK

OPERATION AND PERFORMANCE OF THE CIBA-CORNING 512 COAGULATION MONITOR DURING PARABOLIC FLIGHT

PRINCIPAL INVESTIGATOR:	Robyn Gocke
CO-INVESTIGATORS:	Charles W. Lloyd, Nancy K. Greenthaner
FLIGHT DATE:	February 26, 1990

INTRODUCTION:

The Ciba-Corning 512 Coagulation Monitor determines the clotting characteristics of the blood. The analyzer operates by laser detection of the cessation of blood flow in a capillary channel within a test cartridge. Proper function of the analyzer must be tested in a zero-g environment. Prothrombin time (PT) will be determined and a comparison between PT times, pre-flight, in-flight, and post-flight, will be conducted. In conjunction with this study, another will be performed on Prothrombin time and Partial Thromboplastin Time cartridges which are not inserted into the analyzer. Capillary action as a function of time will be evaluated at room temperature on these cartridges.

GOAL:

To assess the functionality and evaluate procedures and operations required to operate the Ciba-Corning 512 Coagulation Monitor during parabolic flight.

OBJECTIVES:

- Confirm proper capillary action within the prothrombin time (PT) test cartridge in zero-g (inside and outside of the analyzer).
- Confirm proper capillary action within the partial thromboplastin time (PTT) test cartridge in zero-g (outside of the analyzer).
- Evaluate speed, timing, and accuracy in performing PT's.

- Compare prothrombin times, pre-flight, in-flight, and post-flight, on test subjects.

- To determine the most effective positioning of the monitor in order to accurately place a drop of blood on the test cartridge.

MATERIALS:

- Ciba-Corning 512 Coagulation Monitor
- 2 Autolancets (including replacement lancets)
- Nonsterile 2x2 gauze pads
- Alcohol wipes
- PT cartridges (foil wrapped)
- PTT cartridges (foil wrapped)
- Tape
- Permanent markers
- Towels
- Lap board with biohazard box and supply box (velcroed to board)
- Extra battery pack
- Test simulator
- Latex gloves
- Bandaids
- Kimwipes

- 50 microliter capillary tubes with plungers
- Report sheets and clipboard
- Writing pen
- Stopwatch

FLIGHT PERSONNEL:

1.	Robyn Gocke	MDSSC
2.	Chuck Lloyd	NASA
3.	Nancy Greenthaner	KRUG

GROUND SUPPORT:

1. Terry Guess
2. Art Freeman

VIDEO SUPPORT:

Video support and still photos are requested if available on the flight.

PRE-FLIGHT PROCEDURES

1-G Testing of the Ciba-Corning 512 Coagulation Monitor:

Study #1

1. Place the Test Simulator cartridge into the monitor. The "PLEASE WAIT" message will appear. When answer appears, read and record result (appr. 32 sec). This ensures that the monitor is operating properly.

2. Remove a PT test cartridge from its foil wrapper, place the foil wrapper in the waste container, place the PT test cartridge in the monitor, and allow it to warm (45 sec).

3. Place a fresh lancet on the autolancet. Remove the lancet cover. Swab the fingertip with an alcohol wipe, dry with a piece of gauze, and

perform fingerstick. Recap the lancet, place alcohol wipe and used lancet in the biohazard container. Collect a drop of blood with a 50 microliter capillary tube.

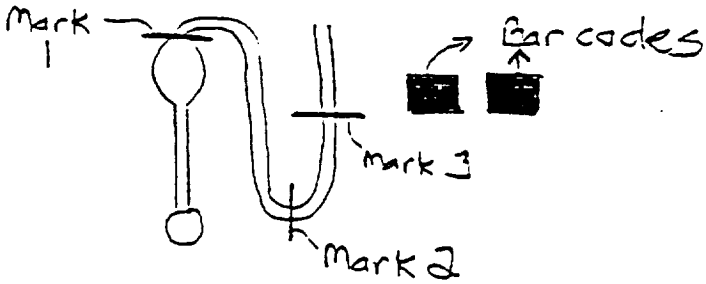
4. When the analyzer states "APPLY DROP OF BLOOD", apply a drop of blood from the capillary tube onto the sample well (the "APPLY DROP OF BLOOD" message stays lit for 90 seconds, then the message disappears and the test cartridge must be reinserted if the drop of blood has not been applied). Apply pressure to the finger with the piece of gauze. Discard gauze in the biohazard container when finished.

5. The test result will be displayed in approximately 30 seconds. Read and record result.

6. Remove cartridge from monitor, mark a line with a permanent marker where the cessation of blood flow occurred, the name of the subject, and date, and place in a container for biohazardous materials. These cartridges will be kept for future analysis (visual observation of capillary channels).

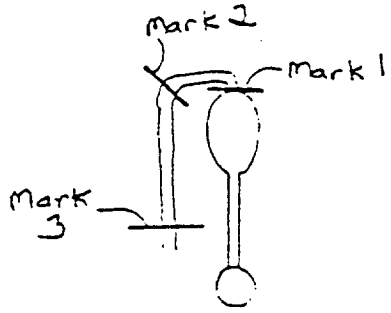
Study 2: Flow vs. Time

PT Cartridge capillary channel marks:



Mark 3 is placed adjacent to the bottom of the bar codes on the cartridge

PTT Cartridge capillary channel marks:



Mark 3 is placed at the bottom of the inside of the black fluid barrier on the cartridge

1. Remove a PT or PTT cartridge from its foil wrapper. Label the appropriate places with a permanent marker.

2. Perform fingerstick as described above and apply blood to cartridge. Simultaneously start the stopwatch and record the times at which the blood crosses the marks on the cartridge.

3. Place the cartridge into its foil wrapper and discard into a biohazardous container.

4. Repeat steps 1-3 until a minimum of 10 results are obtained on each cartridge.

IN-FLIGHT PROCEDURES

0-G Testing of the Ciba-Corning 512 Coagulation Monitor:

A lap board that can be securely fastened to the arm rests of two chairs will be used. The board has strips of velcro that can be placed around the bottom of the arm rests and be brought around to the top of the board, securely fastening it to the chairs. Supplies will be contained in a box which is velcroed to the lap board. The monitor will be velcroed to the lap board as well as a biohazard container. The board will necessitate the placement of the subjects in three seats because the board straps onto two seats and half of another seat. It will be necessary to be seated in the front row.

Study 1

1. The first 2 parabolas are on a contingency basis.

2. During 0-g of the 3th parabola, place the Test Simulator cartridge into the monitor. The "PLEASE WAIT" message will appear. When the answer appears, read and record result (appr. 32 sec). This ensures that the monitor is operating properly.

3. During 0-g of the 4th parabola remove a PT test cartridge from its foil wrapper (store the foil wrapper to place used cartridge into), place the PT test cartridge in the monitor, and allow it to warm (45 sec).

4. Place a fresh lancet on the autolancet. Uncap the lancet. Swab the finger with an alcohol wipe, dry with a piece of gauze, and perform fingerstick. Recap the lancet, place alcohol wipe and used lancet in the biohazard container. Collect a drop of blood in a 50 microliter capillary tube.

5. During 0-g of the 5th parabola, when the analyzer states "APPLY DROP OF BLOOD", apply a drop of blood from the capillary tube onto the sample well (the "APPLY DROP OF BLOOD" message stays lit for 90 seconds, then the message disappears and the test cartridge must be reinserted if the drop of blood has not been applied). Apply pressure to the finger with the piece of gauze. Place the gauze in the biohazard container when finished.

6. The test result will be displayed in approximately 30 seconds. Read and record result.

7. Remove cartridge from monitor, mark a line with a permanent marker where the cessation of blood flow occurred, name of subject, and date. Place into its foil wrapper and discard into a container for biohazardous materials. These cartridges will be kept for future analysis (visual observation of capillary channels).

8. The PT test will only be able to be performed every other parabola due to the warm-up time of the cartridge (45 sec). Study #1 will be performed during the odd numbered parabolas beginning with parabola 5 and Study #2 will be performed during the even numbered parabolas beginning with parabola 4.

STUDY #2 (Flow vs time):

First set of 10 parabolas:

1. During the time it takes for the KC-135 to reach the point where it begins parabolas, remove 5 PT cartridges from their respective foil wrappers. Place velcro strips on the bottom of each cartridge and mark the appropriate places for timed studies with a permanent marker. Place cartridges under the velcro straps on the lap board.

2. The first 2 parabolas are on a contingency basis.

3. Perform a fingerstick as described above (in the 2-g portion of the latter part of the 3rd parabola). In 0-g of the 4th parabola, place a drop of blood from the capillary tube onto the sample well of the cartridge. Simultaneously start the stopwatch.

4. Record the time that it takes for the blood to reach each point marked on the cartridge.

5. Perform this study in the 0-g portions of the even numbered parabolas.

Second set of 10 parabolas:

6. When the first set of 10 parabolas is completed and the KC-135 is in a go-around, unwrap 5 more PT cartridges, place velcro strips on back of them, and mark the appropriate places for timed studies. Place cartridges under the velcro straps on the lap board.

7. Perform steps 3 and 4 above beginning with 0-g of the 12th parabola.

Third set of 10 parabolas:

8. When the second set of 10 parabolas is completed and the KC-135 is in a go-around, unwrap 5 more PT cartridges, place velcro strips on back of them, and mark the appropriate places for timed studies. Place cartridges under the velcro straps on the lap board.

9. Perform steps 3 and 4 above beginning with 0-g of the 22nd parabola.

10. When the third set of 10 parabolas is completed and the KC-135 is in a go-around, unwrap 5 PTT cartridges, place velcro strips on back of

them, and mark the appropriate places for timed studies. Place cartridges under the velcro straps on the lap board.

11. Perform steps 3 and 4 above beginning with 0-g of the 32nd parabola.

POST-FLIGHT PROCEDURES

1-G Testing of the Ciba-Corning 512 Coagulation Monitor:

Study #1:

1. Place the Test Simulator cartridge into the monitor. The "PLEASE WAIT" message will appear. When answer appears, read and record result (appr. 32 sec). This ensures that the monitor is operating properly (this procedure should be performed daily).

2. Remove a PT test cartridge from its foil wrapper (save the foil wrapper to place used cartridge into), place the PT test cartridge in the monitor, and allow it to warm (45 sec).

3. Place a fresh lancet on the autolancet. Uncap the lancet. Swab the finger with an alcohol wipe, dry with a piece of gauze, and perform fingerstick. Collect a drop of blood in a 50 microliter capillary tube. Recap the lancet, place alcohol wipe and used lancet in the biohazard container.

4. When the analyzer states "APPLY DROP OF BLOOD", apply a drop of blood from the capillary tube onto the sample well (the "APPLY DROP OF BLOOD" message stays lit for 90 seconds, then the message disappears and the test cartridge must be reinserted if the drop of blood has not been applied). Apply pressure to the finger with the piece of gauze. Discard the gauze in the biohazard container when finished.

5. The test result will be displayed in approximately 30 seconds. Read and record result.

6. Remove cartridge from monitor, mark a line with a permanent marker where the cessation of blood flow occurred, name of subject, and date, and place into its foil wrapper, and place in a container for biohazardous materials. These cartridges will be kept for future analysis (visual observation of capillary channels).

STUDY #2 (Flow vs time):

1. Remove a PT or PTT cartridge from its foil wrapper. Label the appropriate places with a permanent marker.

2. Perform fingerstick as described above and apply blood to cartridge. Simultaneously start the stopwatch and record the times at which the blood crosses the marks on the cartridge.

3. Place the cartridge into its foil wrapper and discard into a biohazardous container.

4. Repeat steps 1-3 until a minimum of 10 results are obtained on each cartridge.

DISCUSSION:

Observations and comments from Flight Investigators:

All blood during the KC-135 flight was introduced to the sample well with a glass capillary tube by means of a plunger within the capillary tube. Glass is known to adhere platelets which interferes with PT and PTT readings, although the time that the blood was in the capillary tube did not seem to affect the results of the PT tests performed.

The fingerstick was performed in the 2-g portion of the parabola, therefore the blood crept down the finger causing the collection of the sample to be difficult. Tissue fluids, epithelial cells and other contaminants may have been introduced into the sample by scraping the skin when collecting the sample. The results seem very reasonable considering these problems.

All flight subjects were medicated with Scopalamine during the flight. It is unknown whether or not this affected the PT results. It would be helpful to obtain results with the subjects medicated in one-g.

Results:

The results for the study are arranged in a matrix (see Appendix A) with appropriate comments after each entry. Close attention should be paid to these comments due to errors that may have occurred in sampling, pipetting, etc. PT Level I control was consistently out of range due to problems with

the control itself. When a new lot was purchased, no problems evolved.

Test simulator results were excellent pre- and post-flight (32 sec consistently); in-flight results were not obtained due to the warm-up time required for the simulator. Since this is an electronic function only, the expected results on the simulator would be the same in zero-g.

The following table contains each subject number, number of samples obtained, mean, one standard deviation, and accuracy (5% is the accepted accuracy in ground-based clinical laboratories). Position 3 of the flow vs time study was not studied in-flight due to amount of time that it took for the blood to reach the position (~23-27 sec). No results were obtained post-flight in any position for the flow vs time study.

TABLE 1

SUBJECT	#SAMPLES	MEAN (sec)	ONE STD DEV	ACCURACY (%)
Pre-flight:				
#1	12	11.1	0.49	~4.5
#2	1	10.7		
#3	1	10.5		
#4	3	11.0	0.44	4.0
In-flight:				
#1	1	10.7		
#2	8	11.2	0.67	6.0
#3	0			
#4	0			
Post-flight:				
#1	0			
#2	4	11.0	0.68	~6.0
#3	0			
#4	0			
Flow vs Time				
Pre-flight:				
Position 1	4	9.5	1.9	20
2	7	15.6	1.6	10
3	7	24.7	1.8	7
In-flight:				
Position 1	13	11.6	1.6	14
2	5	21.2	1.5	7
3		0		

SUMMARY:

The accuracy readings for the test results obtained (see Table 1 above) were satisfactory with the exception of the flow vs time study (Study #2). This study need further investigation to determine if flow is consistent in a zero-gravity environment.

The Ciba-Corning 512 Coagulation Monitor is best suited for the Space Station due to the use of whole blood, dry reagents, and capillary action (closed system). Minimal modifications would be needed for zero-g adaptibility. The monitor produced acceptable accuracy (flow vs time study needs further investigation) and a complete evaluation should be performed in a one-g environment.

At the present time, Biotrack, Inc. (manufacturer of the 512) is not interested in participating in the conversion into flight hardware.

HAZARD ANALYSIS COVER SHEET

DATE:	February 26, 1990
HAZARD ANALYSIS OF:	Ciba-Corning 512 Coagulation Monitor
SYSTEM/BUILDING NUMBER:	Parsec II (KRUG - HMF)
SYSTEM/BUILDING NAME:	Parsec II (KRUG - HMF)
PREPARED BY:	Robyn Gocke
ORGANIZATION (MAIL CODE):	MDSSC - CHeCS
TELEPHONE EXTENSION:	283-4832

HAZARD ANALYSIS REPORT

SYSTEM PURPOSE:

The Ciba-Corning 512 Coagulation Monitor represents an analyzer for the Medical Analytical Laboratory subsystem of the Health Maintenance Facility.

Its size, weight, volume, and whole blood capability allow for a more effective method of performing blood coagulation analyses.

SYSTEM FUNCTIONAL DESCRIPTION:

The Ciba-Corning 512 Coagulation Monitor is a hand-held laser photometer weighing 1.2 lb. The blood sample travels through the cartridge capillary channel and the built-in laser detects the cessation of blood flow (clotting) by sensing variation in the movement of red blood cells. The time elapsed between sample application and clotting is automatically measured. The PT result is displayed in seconds as a ratio to normal.

HAZARD ANALYSIS SUMMARY:

1. **Blood loss from the PT test cartridge**

   If a small amount of blood leaks or floats out of the test cartridge, the other investigators will be prepared to clean it up with towels. Large fluid loss is not anticipated since the system will be checked out in the laboratory prior to the flight.

2. **Waste containment**

   All waste will be placed in a container for biohazardous material. The container will be velcroed to the lap board which will be strapped to two flight seats.

3. **Fingersticks**

   All fingersticks will be self-sticks. A secondary person will supervise the stick in case problems arise such as prolonged bleeding or loss of lancet to environment. Extra gauze pads and alcohol swabs will be available. The secondary person will be prepared to perform the fingerstick if necessary.

4. **Gloves**

   Latex gloves will be available in the event that the subject cannot perform a satisfactory fingerstick on him/herself. The person performing the fingerstick will put on gloves before performing the stick.

NASA PHOTO REFERENCE

S90-31852 - 54
Sample preparation

S90-31859 - 60
Sample acquisition (thumb stick)

S90-31865
Sample testing

	A	B	C	D	E	F	G	H	I	J	K
1		DATE	TEST SIMULATOR	PT	APTT	R VALUE	INR VALUE	SUBJECT	FLOW VS TIME STUDY POSITION 1	POSITION 2	POSITION 3
2			sec	sec	sec				sec	sec	sec
3			(Range: 31-33 sec)								
4											
5	Lot numbers of cartridges										
6	and controls used (see remarks)										
7											
8	PRE-FLIGHT RESULTS										
9		11/8/89	32			1.03					
10		11/9/89	32			0.99	0.98	Subject #1			
11		11/9/89		11.9		1.03					
12		11/13/89	32					Subject #1			
13	*Data not used in evaluation	11/13/89		11		0.92	0.84	Subject #1			
14		11/13/89				1.03					
15		11/15/89	32			0.94	0.88	Subject #1			
16		11/15/89		11.3		0.85	0.71	Level 1			
17		11/15/89		10.2		1.84	3.46	Level 2			
18		11/15/89	32			1.03					
19		11/17/89		10.2		0.85	0.71	Level 1			
20		11/17/89		23.7		1.98	4.02	Level 2			
21		11/17/89		10.9		0.91	0.83	Subject #1			
22		11/17/89		11.3		0.94	0.88	Subject #1			
23		2/1/90	32			1.03					
24		2/1/90		11.4		0.95	0.9	Subject #1			
25		2/1/90		9.3		0.77	0.59	Level 1			
26		2/1/90		21.3		1.77	3.21	Level 2			
27		2/1/90				1.03					
28		2/8/90	32			0.92	0.85	Subject #1			
29		2/8/90		11.1		0.89	0.79	Subject #2			
30		2/8/90		10.7		0.87	0.75	Subject #3			
31		2/8/90		10.5							
32		2/12/90	32			1.03					
33		2/12/90		9.4		0.78	0.61	Level 1			
34		2/12/90		24.7		2.08	4.35	Level 2			
35		2/12/90		10.4				Subject #1			
36	*Data not used in evaluation	2/12/90		10.2		0.85	0.71	Subject #1			
37		2/12/90									
38		2/12/90								17	29
39		2/12/90								21	32
40		2/12/90								17	25
41		2/13/90	32			1.03					
42		2/13/90		11.6		0.97	0.93	Subject #1			
43		2/13/90		10.1		0.84	0.71	Subject #1			
44		2/13/90								18	29
45		2/13/90								18	29
46	*Data not used in evaluation	2/13/90		9.8				Subject #1			
47	*Data not used in evaluation	2/13/90		9.9				Subject #1			
48		2/15/90	32			1.03					
49		2/15/90		11.2		0.94	0.86	Subject #1			
50		2/15/90		11.2		0.93	0.89	Subject #1			
51		2/15/90		10.8		0.9	0.8	Subject #4			
52		2/15/90		10.7		0.89	0.79	Subject #4			
53		2/15/90		11.5		0.96	0.91	Subject #4		15	23
54		2/16/90								17	27
55		2/15/90								17	27
56		2/15/90								17	25
57		2/15/90							8	17	25
58		2/15/90							8	16	23
59		2/20/90							10	13	23
60		2/20/90							12	14	25

	A	B	C	D	E	F	G	H	I	J	K
1										J	
2		DATE	TEST SIMULATOR sec	PT sec	APTT sec	R VALUE	INR VALUE	SUBJECT	FLOW VS TIME STUDY POSITION 1 sec	POSITION 2 sec	POSITION 3 sec
3			(Range: 31-33 sec)								
61	PRE-FLIGHT (CONT'D)	2/20/90	32			1.00					
62		2/20/90		9.5		0.79	0.62	Level 1			
63		2/20/90		22.3		1.06	3.55	Level 2			
64		2/20/90		12.1		1.01	1.01	Level 1			
65		2/20/90		33.9		2.83	8.32	Level 2			
66		2/20/90			58.9	1.9		Level 1			
67		2/20/90			105.5	3.4		Level 2			
68											
69	IN-FLIGHT RESULTS	2/26/90									
70	PARABOLA 1										
71	2										
72	3										
73	4										
74	5			10.7		0.09	0.79	Subject #1			
75	6										
76	7										
77	8								13		
78	9										
79	10			10.2		0.85	0.71	Subject #2			
80	11								10	22	
81	12			11.2		0.95	0.91	Subject #2			
82	13								11		
83	14										
84	15			11.3		0.94	0.89	Subject #2			
85	16								12		
86	17										
87	18										
88	19			11.3		0.94	0.88	Subject #2			
89	20								12		
90	21										
91	22			10.1		0.84	0.7	Subject #2			
92	23								10	21	
93	24			11.9		0.99	0.98	Subject #2			
94	25								13		
95	26			11.5		0.96	0.92	Subject #2			
96	27								10	21	
97	28			11.8		0.98	0.96	Subject #2			
98	29								14		
99	*30 - Data not used in evaluation			12.2		1.01	1.03	Subject #2			
100	31								14		
101	32										
102	33								11	23	
103	34								12		
104	35								9	19	
105											
106	POST-FLIGHT RESULTS										
107		3/20/90	32			1.00					
108		3/20/90		10.3		0.85	0.73	Subject #2			
109		3/20/90		10.6		0.88	0.77	Subject #2			
110	Data not used in evaluation	3/26/90		12		1	1	Subject #2			
111		3/26/90		11.3		0.94	0.89	Subject #2			
112		3/26/90		11.8		0.98	0.96	Subject #2			
113		3/26/90	32			1.00					
114											

	L
1	REMARKS
2	
3	
4	
5	Cartridges: PT=P802H36, P80218; PTT= CA9J12 Controls: PT=CP9E05,CP9K15; PTT=CA9J12
6	
7	
8	
9	
10	
11	
12	
13	Insufficient drop of blood
14	
15	
16	
17	Lot CP9E05 (range: 10.3-12.7), exp. 6/91. Level 1 out of range. Improper dilution is possible due to pipet.
18	Lot CP9E05 (range: 21.1-27.1), exp 6/91.
19	
20	Lot CP9E05 (range: 10.3-12.7), exp. 6/91. Level 1 out of range. Improper dilution is possible due to pipet.
21	Lot CP9E05 (range: 21.1-27.1), exp 6/91.
22	Drawn in AM
23	Drawn in PM
24	
25	
26	Lot CP9E05 (range: 10.3-12.7), exp. 6/91. Level 1 out of range. Improper dilution is possible due to pipet.
27	Lot CP9E05 (range: 21.1-27.1), exp 6/91.
28	
29	
30	
31	
32	
33	Lot CP9E05 (range: 10.3-12.7), exp. 6/91. Level 1 out of range. Improper dilution is possible due to pipet.
34	Lot CP9E05 (range: 21.1-27.1), exp 6/91.
35	
36	Repeat on same stick
37	Heparinized blood-didn't clot, interupted test
38	Test to time flow in cartridge (unheated flow study), injected in center of sample well, heparinized blood.
39	EDTA blood, injected in back of sample well
40	Sodium citrated blood, injected in center of sample well
41	
42	Blood introduced with finger
43	Blood introduced with capillary tube
44	
45	
46	After using same fingerstick 3 times
47	After using same fingerstick, squirted due to clot
48	
49	Blood introduced with finger, total time from sample introduction to result-31 sec
50	Blood introduced with capillary tube, total time from sample introduction to result-31 sec
51	Blood introduced with finger, total time from sample introduction to result-31 sec
52	Blood introduced with capillary tube, total time from sample introduction to result-31 sec
53	Blood introduced with capillary tube, total time from sample introduction to result-31 sec
54	EDTA blood
55	EDTA blood
56	EDTA blood
57	EDTA blood
58	EDTA blood
59	EDTA blood
60	EDTA blood

	L
1	REMARKS
2	
3	
61	
62	Lot CP9E05 (range: 10.3-12.7), exp. 8/91. Level 1 out of range.
63	Lot CP9E05 (range: 21.1-27.1), exp 8/91.
64	Lot CP9K15 (range: 10.7-13.1), exp. 8/91
65	Lot CP9K15 (range: 18.1-23.3), exp. 8/91
66	Lot CA9J12 (range: 44.2-71.8), exp. 7/90
67	Lot CA9J12 (range: 84.7-117.1), exp. 7/90
68	
69	Everyone was medicated with Scopalamine, all blood was applied with a glass capillary tube
70	
71	Evaluation of set-up and orientation of flyers
72	Evaluation of set-up and orientation of flyers
73	Loss of parabola due to lack of time to warm test simulator
74	Pressure difference in pipette tip caused loss of blood for unheated flow study
75	
76	?clot in capillary tube, slow fill
77	Subject #1 became ill
78	
79	Missed sequence on meter - had to reinsert cartridge
80	
81	
82	
83	
84	Bad stick
85	
86	
87	Miss
88	Miss
89	
90	Miss
91	
92	
93	Very good flow study
94	
95	Started early
96	
97	Good
98	
99	Good
100	Surface tension made it hard to get blood
101	
102	Subject #3 became ill
103	Negative-g attend. Right on edge of 0-g and 2-g.
104	Late start, uneven fill
105	
106	
107	Noone was medicated
108	
109	Glass capillary tube was used for collection
110	Glass capillary tube was used for collection
111	Glass capillary tube was used for collection, blood was very slow coming out of finger (not used)
112	Glass capillary tube was used for collection
113	Blood was applied with finger (hanging drop of blood)
114	

APPLICATION AND USE OF SPINAL IMMOBILIZATION DEVICES IN ZERO- GRAVITY FLIGHT

PRINCIPAL INVESTIGATOR:	Debra T. Krupa, R.N.
CO-INVESTIGATORS:	John Gosbee, M.D. Roger Billica, M.D. Joey Boyce, M.D.
FLIGHT DATE:	February 27, 1990

GOAL:

To assess the adaptability of off-the-shelf spinal immobilization equipment for use during microgravity and the evaluation of the application procedures of the equipment.

OVERVIEW:

A KC-135 parabolic flight was performed on Tuesday, February 27, 1990 for the purpose of evaluation of spinal immobilization techniques in microgravity. The flight followed the standard 40 parabola profile with four NASA/KRUG experimenters involved in the effort. One performed as coordinator/recorder, one as test subject, and two as the Crew Medical Officers (CMO). The flight was to evaluate the application of spinal immobilization devices and techniques in microgravity as are performed during initial stabilization or patient transport scenarios. The sequence of detail for examination of the following listed objectives included: attempted cervical spine immobilization with all free-floating, the patient restrained to the floor, various hand positioning techniques; c-collar placement; Kendrick Extrication Device (KED) application with various restraints for patient and CMO; patient immobilization and transport using the KED; patient transported on KED and spine board. Observations for each task are included with this report. Description of inflight photography is included. Major conclusions and issues include: 1) CMO restraint must precede patient restraint in order to properly stabilize the cervical spine; 2) terrestrial protocols for application of cervical spine immobilization must be adapted for use in microgravity; 3) current equipment used for spinal immobilization appears to be easily used as "off the shelf" or with minor modifications; 4)

movement of the patient for transport after immobilization was accomplished easily.

OBJECTIVES:

1. Determination of the proper technique required to apply cervical spine immobilization in microgravity by hand placement.

2. Evaluation of off-the-shelf equipment for spinal immobilization: hard cervical collar, and the kendrick extrication device.

3. To determine the proper technique for application of the equipment in microgravity while maintaining cervical spine precautions.

4. To assess the proper position of the Crew Medical Officers and assistants for application and stabilization procedures.

5. To subjectively assess the ease with which the apparatus may be applied in comparison with the 1-G environment.

6. To evaluate the time required to apply stabilization and equipment in microgravity.

7. To evaluate the comfort of the equipment for the patient.

8. To evaluate the ability to transport the patient in a microgravity environment while immobilized with the equipment.

BACKGROUND:

Cervical spine immobilization and stabilization is one of the basic principles behind the application of basic trauma life support and a basis for the continued application of advanced measures. It is required that to provide these essential services to the trauma patient, appropriate measures are followed from the first moment care is begun. On the space station, the Health Maintenance Facility (HMF) is designed to accommodate the care of one critically ill or injured crewmember from injury through stabilization and transport to the ground. The possibility for cervical spine injury exists at any place where humans are performing work and utilizing machinery or equipment. In planning for the provision of trauma life support, it is

necessary that the specific steps in the provision of the care be accurately evaluated for any required adaptations to the unique environment of space. This includes the equipment and the procedures for utilization.

REQUIREMENTS:

Materials:

1. Hard collar for cervical spine stabilization
2. KED
3. Long spinal board
4. Restraints for caregivers and recorder
5. Photography
6. Clipboard and writing materials
7. Tape

PERSONNEL AND SUPPORT:

- Two operators, one subject, and director/recorder
- Video recording by director and non-dedicated still photography by NASA.

PRE-FLIGHT PROCEDURES:

1-G Testing of ATLS Protocols

1. Ground based training in the Parsec II lab to identify the procedure required for application of spinal immobilization equipment.
2. Identify victim as having the potential for a spinal cord injury.
3. Move patient to work area while protecting the spine.
4. Stabilize the cervical spine and apply collar.
5. Identify appropriate spinal immobilization device to be used (i.e. K.E.D. vs long board).

6. Prepare the board for use.

7. Restrain the patient while the device is being applied.

8. Place patient on the board while protecting the spine.

9. Restrain patient on the board.

10. Move patient while on restraint to the work area.

11. Document good technique was used during the procedure.

INFLIGHT PROCEDURES

Parabolas 1 - 10

These parabolas will be used to evaluate the safest method of moving an injured crewmember to the work area while maintaining cervical spine precautions. After the patient has been moved, a hard neck immobilization collar will be applied.

Cervical Spine Stabilization With Collar

1. The patient is found floating and has suspected cervical spine injury. The 2 CMO's will approach the patient and will assume assigned roles as leader and team member. The leader (CMO 1) will take position at the patient's head and places their hand on the patient's head and neck to stabilize it. He will explain to the patient what to expect, and not to move his head or neck. The CMO 2 will position himself over the patients upper torso to facilitate stabilization of the body.

2. The CMOs will attempt to move the patient to the work area while maintaining cervical spine stabilization while only utilizing their hands.

3. This will be first attempted with the CMOs and the patient unrestrained.

4. This will be repeated with the CMOs utilizing cords over their feet for stabilization.

5. The scenario will then be repeated with the CMO 1 stabilizing the patient's cervical spine with his hands and CMO 2 will attempt proper placement of a hard cervical collar.

6. The CMOs will then attempt to move the patient while maintaining stabilization with the cervical collar in place.

Parabolas 11 - 20

These parabolas will be used to evaluate the appropriate method of applying a short spinal immobilization device known as the KED board. This device wraps around the torso and head to prevent movement of the upper spine.

KED Application

1. CMOs float to patient who is free floating and has the cervical collar in place. CMO 1 places the KED around the patients torso and holds onto the patients head portion of the device.

2. CMO 2 then floats to the front of the patient and applies the chest pieces around the patient. He then fastens the chest straps firmly in place.

3. CMO 2 then pulls the leg straps through the patient's legs and crosses them to fasten left to right, and right to left. These are then tightened firmly.

4. CMO 2 then wraps the head portion of the device around the patient's head and affixes this portion using the head strap over the forehead.

5. The patient should then be securely immobilized from the hips to the head.

6. The CMO's will then attempt to move the patient while in zero gravity to the work area, guiding movement with the device.

7. This will be reattempted with the CMO's utilizing foot restraints for CMO 1 as he holds the patient.

8. If there are any parabolas left, the CMO's will alternate roles, and reattempt the application.

Parabolas 21 - 30

These parabolas will be used to evaluate the appropriate application of a long spinal immobilization board in a patient with a suspected spinal cord injury. This board is a full length wooden board placed against the patient's back and held in place with straps. It prevents movement of the entire spine.

Long Board Application

1. The patient is floating freely. The CMOs approach the patient with the long board and supplies.

2. CMO 1 takes position as leader at the patient's head, places his hands on the patient's head to stabilize it. CMO 1 places hands on each side of head with thumbs along the mandible and fingers behind the head on the occipital ridge. He maintains gentle and firm in-line stabilization until the devices are applied. The leader then briefly explains to the patient what to expect, why it is being done and not to move his head or neck.

3. CMO 1 assigns assistants to areas of the patient's body that they will be responsible for. CMO 2 is to be at the front of the patient over mid torso, and CMO 3 is to manage the long board from the opposite side.

4. CMO 1 directs that CMO 2 is to position extremities so as not to injure them with turning the patient.

5. CMO 1 then announces that as a group they will roll the patient over to the right side and CMO 3 will move the long board into position.

6. They roll the patient as a group to his side, CMO 3 places the board and they roll the patient back onto the board. CMO 1 is to keep the patient's nose in alignment with the umbilicus at all times during the move.

Cervical Collar, Bags, and Tape

1. CMO 1 continues to hold inline stabilization of the head, as CMO 2 applies the cervical collar.

2. CMO 1 releases in line stabilization and continues to place hands on patient's head to hold in alignment. CMO 3 places bags at patient's head

on both sides, and CMO 2 then tapes the patient across his forehead to the board, over the bags to prevent rotation and lateral head movements.

3. CMO 2 and 3 apply straps to patient to encircle, at shoulders, hips and knees.

4. If there are any parabolas left the CMOs 1 and 2 will alternate roles.

Parabolas 31 - 40

These parabolas will be used to reevaluate any procedures that had difficulties during the previous parabolas. If no repeat procedures are required, these parabolas will be used for evaluation of a sort spinal board. These will follow the application procedures for the KED with the addition of the section of application of the cervical collar, bags, and tape.

KC 135 INFLIGHT WORKSHEET

APPLICATION AND USE OF SPINAL IMMOBILIZATION DEVICES

MANIFEST: Debra Krupa - DK (KRUG)
John Gosbee - JG (KRUG)
Roger Billica - RB (KRUG)
Joey Boyce - JB (NASA)

PARABOLAS 1 - 10

1. Cervical spine stabilization manually and patient movement

   Unrestrained
   Restrained

2. Application of hard cervical collar and patient movement

PARABOLAS 11 - 20

1. KED application without restraints

2. KED application with foot restraints

PARABOLAS 21 - 30

1. Movement of patient on KED
2. Application of long board

PARABOLAS 31 - 40

1. Movement of patient on long board

Repeat previous scenarios with alternate CMO's and refine as required.

RESULTS AND DISCUSSION:

Manual Cervical Spine Stabilization:

It was very difficult to adequately stabilize or immobilize the patient with the CMOs and patient free floating. The CMO's each tended to use the patient as leverage in this situation, which then created a medically contraindicated situation. It appeared to be most successful to restrain one CMO prior to restraint or attempt to stabilize the patient. This allowed the restrained CMO(1) to establish control over the patient movements. CMO2 was then easily able to move the patient to the proper position for CMO1 to stabilize. As CMO1 held the patient stable, CMO2 was able to restrain himself and then work in coordination with CMO1 to attain spinal immobilization.

Attempts to manually immobilize the patient's head/neck with the patient in the standard one gravity (G) position (at the top of the patient's head) was not easily performed, nor did it prove to adequately immobilize the head/neck.

The preferred method identified for manual stabilization of the head/neck was for the CMO to confront the anterior aspect of the patient (face-to-face), place his forearms against the patient's chest and place his hands around the patient's jaw (as in the chin lift jaw thrust maneuver). This provided the strongest sense of stabilization to both the CMO and to the patient, and was the easiest to perform.

The maneuvering of the patient was performed with the patient in the neutral position of microgravity. This appeared to be the method appropriate

for provision of minimal risk of further spinal injury. It was identified by the experimenters that this preferred sequence of events might imply an adjustment to standard terrestrial basic life support protocols.

Application of Hard Cervical Collar:

After acquisition of appropriate stabilization and restraint, it was a fairly simple task to apply a C-collar. One CMO was used to stabilize the head/neck as described above, and one CMO applied the collar. The patient reported that the collar stabilized his head/neck to a much larger degree than manual stabilization.

Application of KED

Again it was discovered that once the patient and CMO were adequately restrained, it was fairly simple to apply the KED. The CMOs and the patient each reported the that the KED provided adequate stabilization. It was noted that the easiest method for placement of the patient on the KED was to lift him and slide the KED beneath him.

Patient Movement with KED:

With the patient restrained within the KED it was very easy to transport and maneuver the patient while maintaining spinal immobilization. The first attempts at transport appeared somewhat awkward, and this was attributed to the CMO's inexperience in microgravity. The location of the hand holds on the KED made it quite easy to maneuver the patient through 360 degrees of movement directions and maintain control as well as stabilization. The patient reported that he felt very secure, and restrained within the KED through all movements.

Application of long board

The combination of the KED and a full-length back board provided very effective stabilization and additional control for transport. However, the additional length of the long board and its rigidity made it more difficult to maneuver. The buckle type straps were easier to apply and adjust than the velcro straps. The velcro straps were difficult to locate and release.

PHOTOGRAPHY

Stills:

S90-31808
The patient (JB) is free floating. JG and RB are attempting to control his movements and move him into position for stabilization.

S90-31809
JB has been moved to the floor of the aircraft for restraint. JG is attempting to stabilize his head/neck from the anterior while RB places the cervical collar on. RB and JG are restrained by bungee cords over their legs and JB has bungee cords over his chest.

S90-31810
After placing the cervical collar on JB, JG is lifting JB for RB to slide the KED into position. Note the placement of the various bungee cords for restraint. DK is filming in the background

S90-31811
RB is holding JB head stable as JG secures the chest straps of the KED.

S90-31812
Same as 318811

S90-31813
Same as 31811. RB is repositioning his restraint cords. (The floor is uncomfortable on knees after a while.)

S90-31814
Same as 31811

S90-31819
RB and DK are attempting to transport JB in the KED. Note that RB is able to brace himself between the floor and ceiling of the aircraft. It is very easy to move JB around in the KED.

S90-31820
RB and DK are turning JB to transport him down the length of the aircraft.

S90-31821
RB and DK are moving JB through the aircraft with the KED. They use the hand ropes to translate through the aircraft.

S90-31822
RB and DK are returning JB to the long spine board. He is not falling. He is floating.

S90-31823
RB and DK are preparing to secure JB to the spine board.

S90-31824
To secure JB to the spine board, RB is secured to the grid, and DK has placed her heels beneath bungee cords. RB is securing the chest strap. DK is reaching across to find the thigh strap.

S90-31825
RB and DK are lifting JB on the spine board for transport.

S90-31826
RB and DK are lowering JB back to the floor.

Video:

NASA reference - customer supplied VHS - work order # 04051.

Video was reviewed by the experimenters. Overall quality was good, with occasional sections of the film out of proper line of sight related to the inexperience of the director to filming in microgravity. Observations from the video are included within the above discussions.

CONCLUSIONS:

This flight experiment was extremely worthwhile in assisting to clarify and define the issues related to medical immobilization, stabilization, and transport. It was clear to the experimenters that terrestrial protocols may not apply universally for microgravity and that CMO restraint must precede patient restraint. The terrestrial mechanisms for spinal immobilization performed equally effective in microgravity.

It was decided that the order of events for this procedure should be:

- one attendant is well stabilized
- second attendant moves patient to first attendant
- the patient is stabilized
- the patient is then placed within the immobilization devices
- the patient is ready for transport

Face to face/neck stabilization provided optimal positioning for stabilization in microgravity. The hard collar was more effective than manual stabilization.

It was impossible to place the patient in the KED without restraints on the attendants. The attendants frequently used the patients clothing for lifting/movement of the patient. The ease of placement of immobilization devices will depend upon what type of restraint devices are available throughout the station for the attendants.

The placement of the long board was easily completed.

Lifting patient to place on various immobilization devices is preferred to rolling.

RECOMMENDATIONS:

1. The procedure identified during this flight for proper microgravity immobilization/stabilization of the cervical spine should be recorded and maintained for inclusion in further evaluations to enable proper inclusion in the operational data file.

2. Continued flights for performance of trauma life support procedures and equipment are recommended to identify any further adjustments to standard terrestrial protocols.

3. Evaluation of restraint mechanism for the CMO should continue, as this appeared to be the rate limiting step in many procedures.

4. The principles of design of the KED should be incorporated within the design of the transport portion of the patient restraint. This device provided appropriate stabilization as well as ease in transport.

5. Further flights for the evaluation of transport principles and procedures should occur to build upon this flight.

ATLS: CATHETER AND TUBE PLACEMENT

PRINCIPLE INVESTIGATORS:	John Gosbee, M.D. (KRUG) Debra Krupa (KRUG)
CO-INVESTIGATORS:	L. Pepper, D.O. (NASA SD2) D. Orsak (MDSSC)
FLIGHT DATE:	February 28, 1990

TEST OBJECTIVE:

Evaluate the equipment and procedures for performing medical procedures during microgravity.

TEST DESCRIPTION:

The specific objectives of this experiment are: 1) to evaluate the rack-mounted equipment and medical supplies necessary for medical procedures; and 2) to evaluate the attachments, mounting points, and inner drawer assemblies for the medical supplies; and 3) evaluate the procedures for performing medical scenarios. The resources available in the HMF mini-racks include to accomplish medical scenarios/procedures include: 1) medical equipment mounted in the racks; 2) a patch panel with places to attach tubing and catheters; 3) self-contained drawers full of critical care medical supplies; and 4) an ALS "backpack" for deploying supplies. The attachment lines, tubing and associated medical supplies, will be deployed and utilized with the equipment and a patient mannequin. Data collection is provided by direct observations by the inflight experimenters, and analysis of still and video photography.

EQUIPMENT AND CONFIGURATION:

Two mini-racks (19"x30"x48")

- Central supply drawer located near the top of the rack
- Drawer with the ALS pack and tubing located at the bottom of the rack

- Patch panel with connections for suction and oxygen tubing located near the bottom of the rack

HMF prototype Medical Restraint System

Patient Mannequin with capability to simulate insertion of:

- Foley catheter
- Naso-gastric tube
- Endotracheal tube

(See **Figure 1** for a graphical depiction of the configuration)

DATA ACQUISITION:

- In-flight written questionnaires
- Self report post-test
- Still and video photography

EXPERIMENTER INFORMATION:

John Gosbee (JG)	Male	6'1"	165#
Debra Krupa (DK)	Female	5'5"	115#
Larry Pepper (LP)	Male	5'11"	155#

IN-FLIGHT TEST PROCEDURES AND ASSSOCIATED RESULTS:

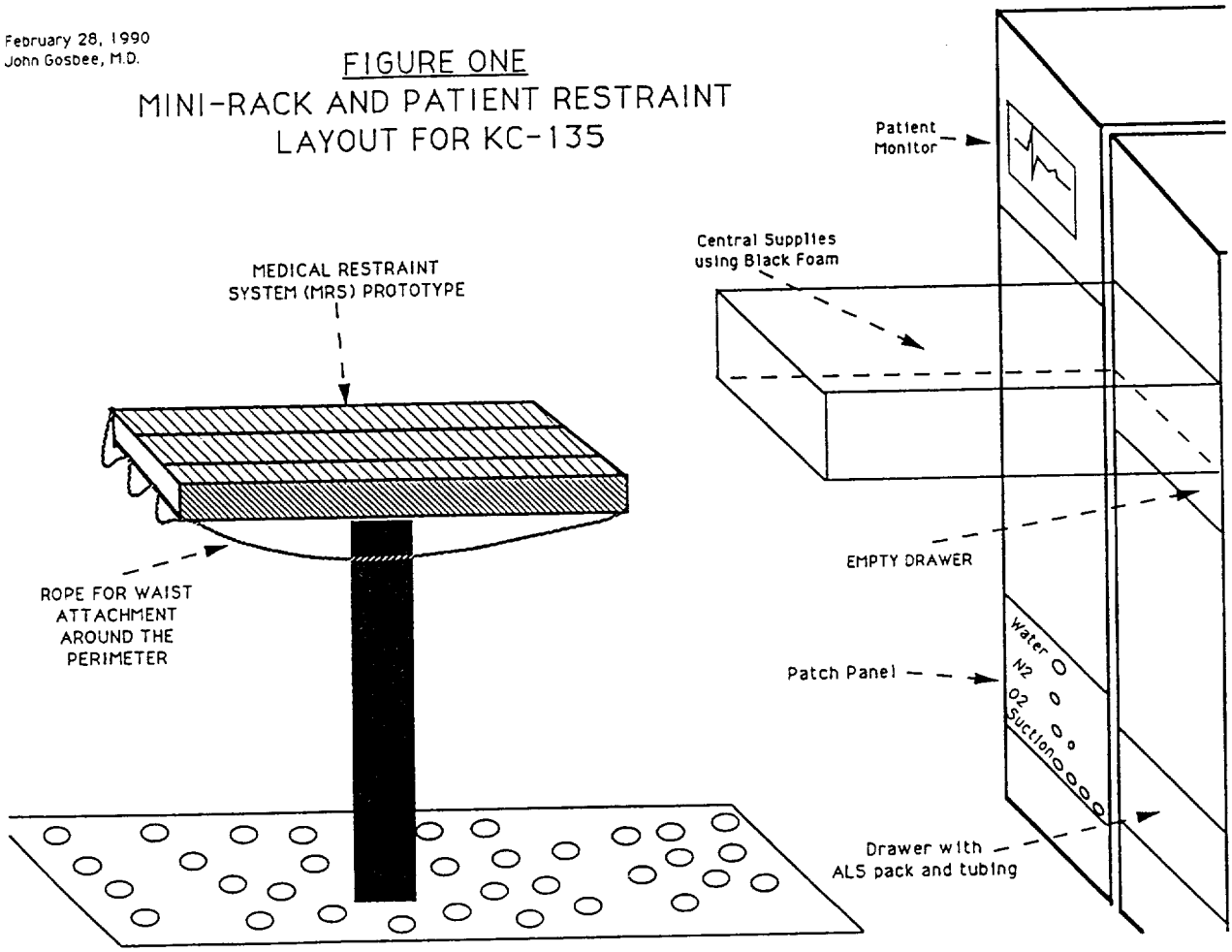
Names and locations of CMO's for first 1 3/4 procedures:

DK is Chief CMO, on near side of MRS with Swiss seat waist restraint or using ad hoc restraints in front of the racks (e.g. using one hand, or a short tether)

February 28, 1990
John Gosbee, M.D.

FIGURE ONE

MINI-RACK AND PATIENT RESTRAINT LAYOUT FOR KC-135



JG is Asst. CMO, on far side of MRS with Swiss seat waist restraint

1. DK destows a sharp trash container, hands it to JG to deploy on far side of MRS

   DK "cheated" in deploying this from behind the Patient Monitor. Otherwise it was easy to handle, and for JG to fix between the rope and the edge of the MRS.
   JG 9

2. DK destows the soft trash container and deploys on near side of MRS with JG's assistance. Since DK's restraint at low altitudes was poor, and she only could use one hand, JG had to assist from underneath.
   JG 5

FOLEY CATHETER

1. Both CMO's put on sterile gloves, DK first since she won't stay sterile. DK had to use one hand to restrain herself in front of the racks to disengage and open the drawer.

   Having one CMO hold the opened packet of gloves was necessary for the other to aseptically put them on. The CMO has to place one hand on the finger tip end and one hand holding the folded paper open.

   JG 7 (if there is enough time, and both CMO's know the proper technique)

2. DK destows, opens and presents a FREPP to JG, who uses it to prep the area, and then hands the FREPP to DK for disposal

   DK had to twist and stretch to her limit to disengage the drawer, and open it. Once open, one FREPP could be fairly easily removed, opened, and presented to JG in an aseptic fashion.

   JG 8

3. DK destows, opens, and presents the Foley catheter to JG; DK disposes the overwrap.

   DK had to twist and stretch to her limit to open the drawer; but stretched

less once the drawer is opened up and closer to the MRS. No problem destowing or presenting the Foley. However, DK had to be real careful to not let any unsterile part of the overwrap, or her arms touch the sterile Foley that JG was extracting.

JG 6

4. DK destows Foley tube and bag, and attachs tube to Foley catheter, and bag to edge of MRS

   DK could easily reach these items in the now extended drawer, but decided to extract several items at once (like a squirrel), and place them under bungees near the mannequin legs for easy access. JG had to give the Foley catheter end to DK, who then attached it the tube and bag, which was accomplished easily, since both DK and JG were well restrained and could use both hands. The overwrap for the Foley bag did not fit into the soft trash container, and was difficult to bend or crush in an attempt to do so.

   JG 8

5. DK destows the water-filled Foley syringe, and checks the Foley balloon on the catheter.

   Upon removal of the syringe from its overwrap, water was sprayed out. DK had to grab the Foley catheter end, because JG and DK couldn't line them up.

   JG 8, if DK grabs both the syringe and the catheter end.

6. DK destows the KY jelly, JG covers the end of the Foley catheter with jelly, inserts into urethra of mannequin, and DK blows up balloon.

   It was almost impossible for JG to manuver the sterile tip of the Foley into the small opening of the KY jelly packet, which DK was holding. In fact, the tip touched the outer edge of the packet and became "unsterile". This was due to fine tremors in both hands, and some unsteadiness in the CMO restraint mechanisms. (Another method for doing this procedure is required!)

   JG 2

7. DK destows generic plastic tubing and attachs one end to low intermmittent suction on the patch panel, and the other end of Foley bag.

   The tubing was located in a drawer near the floor, as was the patch panel. Since DK had to release from the MRS to access these two areas, she had to restrain herself with only one hand. This method was unsteady and uncoordinated, so extraction of the tubing was slow, and dislodged other items in the drawer; and attaching the tubing to the patch panel was slow and the tubing wasn't attached very well. In addition, the velcro strips that held down the cover used to hold items in the lower drawer was almost impossible to put back into place properly.

   JG 3 destowing tubing
   JG 8 attaching tubing to Foley
   JG 4 attaching tubing to patch panel

OVERALL COMMENTS:

More intensive one-g practice, and/or more parabolas to accomplish certain tasks, may have made the above tasks easier to accomplish in microgravity.

Some tasks above were abbreviated, or accomplished in the 2-g portion of flight in the interest of time (e.g., putting on gloves, repositioning some loose items).

Since adequate restraint mechanisms for a CMO in front of the racks have not been identified or evaluted, ad hoc methods were attempted by DK with very limited success.

NASO-GASTRIC (NG) TUBE

1. ALS pack is destowed, opened, and bungeed to the end of the MRS

   Since the ALS pack was in the back of the low drawer, DK again had difficulty opening the drawer, opening the velcroed cover, and extracting the pack. In fact, DK opened the entire cover, but the other items in the drawer were wedged into place and did not float out.

Placing and restraining the ALS pack over the legs of the mannequin required both DK and JG. Several items that were loosely held down inside the pack floated loose during the deployment. Since there was no labels or color code cues, it was difficult to replace loose items, and good restraint areas of the pack got "filled" up quickly with several disparate items. Bob Williams made a very astute comment: "its too busy, you can't find things, or remember where to restow them".

JG 5

2. DK destows tape from drawer, hands to JG, who tears long piece of tape

   Similar problems to those above. This cloth tape tended to "stick" to the black foam, and was hard to remove from the drawer.

   JG 6

3. DK destows a generic piece of tubing, attachs one end to the suction port on the patch panel, and holds the other end near the patient head.

   Again, the access to the lower drawer and patch panel was difficult, but there was some decrease in those difficulties with practice.

   JG 4

4. DK destows the NG tube, unwraps it, and hands it to JG. DK disposes overwrap material.

   No real problem with the upper central supply drawer extended. Again, DK removed several items, including some listed below, and placed them under bungees located over the mannequin's legs.

   JG 8

5. DK destows the 60cc syringe, and hands to JG, who attachs it to the NG tube

   No problems noted. JG 8

6. DK destows KY jelly, JG covers end of NG tube with jelly

Since the NG tube does not have to be sterile, DK could hold both the KY packet and the NG tube tip at the same time. Thus, there was no difficulty accomplishing this procedure.

JG 9

7. JG inserts tube into nares of mannequin

   Since JG had solid waist restraint, this two-handed procedure was no more difficult than in one-G. JG 10

8. DK tapes NG into place.
   LP takes DK place on the near side of the MRS from the racks.
   DK takes JG place on the far side of the MRS from the racks.

9. LP destows a stethoscope from the ALS pack. Difficulty finding this, since it was in an opaque zippered pocket

   JG 7

10. LP attachs NG tube to generic suction tubing, and then to the patch panel. Suction turned on and set at low intermittent on patch panel.

    Since LP is taller, and has longer arms, he is able to reach the patch panel while still attached to the MRS (i.e. restrained at the waist). Thus, this task was easier than DK was doing it.

OVERALL COMMENTS:

Since this is a clean procedure, not an sterile one, both CMO's could manipulate all items utilized, and work together. During Foley catheter insertion, JG could only touch sterile items, but not non-sterile items; and DK could not touch sterile items, but could handle non-sterile items. Therefore, this procedure was accomplished easier and faster than Foley catheter insertion.

Both LP and DK had abit of difficulty in finding items in the upper drawer and the various areas of the ALS pack. Both had to be careful not to dislodge items loosely held underneath elastic when vigorously extracting another item.

NASAL CANNULA

1. DK destows nasal cannula oxygen tube from ALS pack

2. DK gives cannula end to LP to place on mannequin nose and head

   With proper waist restraint, LP sould use both hands and easily place the nasal cannula, with DK's help. JG 8

3. LP attachs other end of nasal cannula tube to oxygen outlet on patch panel, and sets the flow rate to 4 liters per minute

   No problems noted in attaching the cannula. JG 7. However, there were so many tubes going from the patch panel to the mannequin that LP was getting his feet tangled when he moved from place to place around the MRS (recall that the feet pressing against the floor provides the main stabilization forces, when using the waist restraint on the MRS).

INTUBATION

1. LP destows tip suction and catheter from lower drawer. and attachs one end to the patch panel suction port.

   LP has some difficulty destowing and manipulating this tubing. Once attached to the panel, LP stuck the tip suction under the mannikin's left arm/shoulder, since no site for restraining this end of the suction near the patient's head had been planned or designed for.

   JG 7

2. LP moves to head of table

   Quite abit of difficulty releasing the carabiner, and then reattaching it to the rope that is strung around the perimeter of the MRS.

   JG 4

3. DK destows two pieces of laryngyscope from ALS pack, assembles them and hands it to LP. DK destows ET tube, 10 cc syringe, and AMBU bag from the ALS pack, and gives them to LP.

SaLP first tried to hold the laryngoscope, AMBU bag, and ET tube in his hands, but found that he needed to locally restrain some of them. In fact, with LP's first attempt to intubate he forgot that he needed the AMBU bag and the suction tip ready to use.

For the second trial, LP gathered all the items under a bungee near the head of the mannequin prior to attempting the intubation.

4. LP intubates mannequin

   The posture necessary for LP to visualize the pharynx of the mannequin for intubation was difficult to attain and keep. LP needed to bend down, move his lower torso away from the MRS, and then extend his neck backwards. However, his waist restraint impeded this manuver. There is a need to rapidly access the ET tube and laryngoscope right after removing the face mask and suctioning the patient's oro-pharynx.

   JG 6

5. DK attachs AMBU bag and ventilates mannequin, while LP checks for breath sounds with a stethoscope.

   No real problems noted

   JG 9

6. LP destows ventilator tubing and attachs one end to the "ventilator" and the other end to the ET tube.

   Again, there was some problem accessing the tube and attaching it, since both the drawer and patch panel were close to the floor. There did appear to be a training effect regarding restraint during access to the lower drawers, which LP also mentioned.

   JG 6

   JG replaces LP near the racks
   LP replaces DK on the other of the MRS

7. JG destows tape and rips off pieces. JG tapes ET tube into place, while LP holds it up.

No problem with destowing, but this cloth tape is hard to rip. Since it takes two hands to manuver the tape, another set of hands has to hold the ET tube out of the way

JG 8

OVERALL COMMENTS:

JG was able to adequately restrain his body near the bottom of the racks. To do this he "wedged" his body the MRS and racks, by placing his upper back against the edge of the MRS surface, and feet pushing up against the racks. This manuver required a certain amount of flexibility, and height.

CENTRAL VENOUS CATHETER PLACEMENT

1. JG destows gloves and assists LP in putting them on aseptically

   Specific technique required (see above)

2. JG destows FREPPs, presnts to LP, who preps left shoulder

   No problems noted. JG 9

3. JG removes tape and rips six pieces (4 for drapes and 2 for IV bags)

   No problems noted. JG 9

4. JG hands two one tape-edged drapes to LP one at a time. JG assists LP with laying it down on the side near LP, while DO tapes the two edges

   Very hard to control all four loose edges of the drape without contamination, since LP is "sterile" and JG "dirty". It appears that packaging the drapes appropriately, and defining proper 0-G procedures could overcome these difficulties.

   JG 4

5. DO removes a syringe and CV catheter , and presents them to LP aseptically.

The catheter and syringe were easy to shake out of there hard plastic containers so that LP could grab them in a sterile fashion.

JG 9

6. LP mock inserts the CV catheter

   The low fidelity of simulation for this particular task makes evaluation difficult. A mannequin that allows better simulation is required.

   JG no comment

7. JG removes an IV bag with tubing already attached from the ALS pack, and gives it to LP.

   With all the other lines and tubes next to the mannikin's head, it is difficult to find an open spot to restrain the IV bag and catheter.

NASA PHOTO REFERENCE

S90-31759 - 60
Peparation of catheter for insertion

S90-31762 - 63
Deployment of package material

S90-31766 - 67
Peparation of catheter for insertion

S90-31776 - 78
Deployment of package material

S90-31782 - 87
Deployment and usage of various tubing

S90-31792 - 93
Deployment and usage of various tubing

EVALUATION OF AEROSOLIZED MEDICATIONS DURING PARABOLIC FLIGHT MANEUVERS

PRINCIPAL INVESTIGATORS:	Charles W. Lloyd, Pharm.D.
CO-INVESTIGATORS:	William J. Martin, Pharm.D. John Gosbee, M.D.
FLIGHT DATES:	March 27, 1990

EXECUTIVE SUMMARY

The goal of this experiment was to visually evaluate the effect gravity has on delivery of medications by the use of various aerosol devices. To assist the visual inspection of the devices, high speed video or film was to be considered. During the preliminary ground testing in the studio it was concluded that high speed video would not be capable to provide sufficient resolution of the aerosolized mist. After evaluation of the high speed film ground test data it was determined that the ideal film speed would be 250 FPS using a 50 mm lense.

During parabolic flight the same four aerosols were retested as performed in the studio. It appears that the Cetacaine spray and the Ventolin inhaler function without failure during all test. The pump spray (Nostril) appeared to function normally when the container was full however it appeared to began to fail to deliver a full mist with larger droplet size when the container was nearly empty. The simple hand spray bottle appeared to work when the container was full and performed progressively worse as the container was emptied.

During the Apollo flights they reported that "standard" spray bottles proved to be unsatisfactory, however they did not indicate why. It appears that we would also conclude that "standard" spray bottles do not function as well in zero-g by failing to produce a normal mist spray. The standard spray bottle allowed the fluid to come out in a narrow fluid stream when held with the *nozzle either level or slightly titled upward.

INTRODUCTION (Justification):

This proposal outlines a procedure designed to evaluate the utility of selected aerosolized medication devices under zero gravity conditions during KC-135 parabolic flight. Results obtained from this experiment would be extrapolated to the situation of a continuous micro-g environment, such as aboard Space Station Freedom. There is concern that such devices may be inconsistent in their delivery of the manufacturer's preset quantity of drug per unit of use (i.e., inhalation, puff, nozzle depression) under zero-g conditions. The current draft of the HMF pharmaceutical formulary contains three aerosol preparations:

1. Benzocaine 20% (topical anesthetic)
2. Albuterol (bronchodilator)
3. Nitroglycerin (vasodilator)

GOAL:

To determine if delivery of medications through use of an aerosolizing device is an acceptable method of drug
delivery in a zero-g environment.

OBJECTIVES:

1. Compare patterns of spray dispersion under control (1-G) and zero-G conditions).

2. Determine total available quantities of drug for each delivery system under control (1-G) and zero-G conditions.

MATERIALS AND METHODS (Approach):

MATERIALS

Flight Crew

Three people shall be required. One investigator will work inside the glove box while the other person shall manage exchange of materials from the

storage bags to the glove box.

- C. Lloyd (CL)
- J. Gosbee (JG)
- High Speed Film support

Drugs

1. Benzocaine 14%, Butyl Aminobenzoate 2%, Tetracaine Hydrochloride 2% topical Anesthetic Spray (Cetacaine), manufactured by Cetylite Industries. Average expulsion rate is 200 mg per second, (Quantity = 2 bottles). 56 gm net weight. Also contains Benzalkonium chloride 0.5% and Cetyl dimethyl ethylammonium bromide 0.005%. Lot #299-4, Exp Date 6/91.

2. Microcrystalline suspension of albuterol Inhaler (Ventolin) 17 gm, Allen & Hanburys, Division of Glaxo Pharmaceuticals, 200 metered inhalations, 90 mcg/actuation, (Quantity = 2). Also contains Trichloromonofluoromethane and dichlorodifluoro-methane. Lot #Z13679HA, Exp Date FEB 92. (Quantity = 2)

3. Phenylephrine HCl 0.25% (NOSTRIL) Nasal Decongestant, Metered one-way pump spray, 15 mL, Boehringer Ingelheim. Also contains Benzalkonium chloride 0.004%, Boric acid, Sodium borate, and water. Lot #839001A, Exp Date JUL 92. (Quantity = 2)

4. Oxymetazoline HCl 0.05% (GENASAL), AFRIN generic, nasal decongestant spray, 30 mL, Goldine Laboratories. Also contains Phenylmeric acetate 0.02 mg/mL.Exp Date APR 92. (Quantity = 2)

KC-135 Working Space Requirements

1. Forward in the aircraft.

2. Full width of the plane

3. At least 12 feet in length.

NOTE:

Justification for this set up is to allow for the camera(s) to be fixed mounted and blackout curtains placed around the lense(s) to avoid any secondary lighting to effect the filming. There will be no real-time adjustments for the

lenses positioning in-flight. To perform this type of filming the set-up also requires additional lighting to be in key positions around the glovebox.

Supplies

1. Glove box and supporting stand
2. Velcro material to secure drug products
3. Flat black absorbant cloth to line inside of glove box
4. Bungy cord to secure investigator in-flight
5. Duct Tape
6. Cleaning solution and towels

PROCEDURES (TO BE PERFORMED PRE- AND IN-FLIGHT)

Spray Dispersion

1. Shake pressurized container well
2. Hold the device in the appropriate orientation for administration of the drug product and depress the plunger (command given by photographer) to provide one to two actuations.
3. Positioning of the device by the investigator working in the glovebox will be determined pre-flight and marked inside the box. The high-speed photographer shall determine the
4. Repeat above procedure x 5 for each drug
5. Camera specs for PRE-FLIGHT testing performed in the building #8, JSC, Photography studio:

SHUTTER	*FPS*	*SIZE (mm)*	*#RUNS*
36	100	10	2 of #1
36	250	10	2 of #1
36	250	25	2 of #2
36	100	25	2 of #2
72	100	25	#1-4a
72	250	25	#1-4a
72	250	10	#1-4
72	100	10	#1-4
72	100	25	#1-4
72	250	25	#1-4

DRUG CODE:

#1 - Cetacaine
#2 - Ventolin
#3 - Nostril
#4 - Afrin (generic)

Not all lighting was turned on during the first filming therefore these two set-ups were repeated at the end.

6. Perform still photography if possible during the filming. If this is not possible then complete after all high-speeding filming hasbeen completed.

GROUND SUPPORT REQUIRED

Flight (CL and JG) and Ground (Dr. Martin, T Guess and A. Freemen) crews will need to obtain necessary supplies, prepare the test items, and perform 1 to 2 ground test pre-flight.

FLIGHT SUPPORT REQUIRED

The Ground crew will need to assist the flight crew with the set up of the glovebox on the plane pre-flight.

NUMBER OF FLIGHTS AND DATES DESIRED:

Number of flights: 2

Requested Dates:

- First quarter of 1990

Actual Flight Dates:

- March 27, 1990 (1 day)

PROJECTED RESULTS:

It is believed that the aerosols will perform properly until the pick-up stem of the canister begins to contain air/fluid mixture secondary to the micro-g environment. Afterwards the output should become erratic and not deliver a full dose of the medication.

Pre-flight (1-g testing) Results

1. Glovebox and supporting materials were taken to the photography studio in building #8 on February 20, 1990 for the pre-flight testing.

2. The objective of the pre-flight testing was to determine the appropriate film to be used, camera set-up requirements, lighting requirements and camera settings for the in-flight filming.

3. The pre-flight testing would also modify testing procedures and identify any additional material needs.

4. Both in-flight investigators had an opportunity to perform all in-flight procedures while test filming was being evaluated.

5. All test articles (drug products) were filmed.

6. Additional materials needed included:

   - Flat black cloth material to line the inside of the glovebox.

7. KC-135 positioning and space requirements identified:
   - Forward in the aircraft.
   - Full width of the plane
   - At least 12 feet in length.

8. When the Cetacaine spray bottle was turned upside done and actuated it failed tofunction properly as soon as the pick up straw emptied. The Ventolin Inhaler fails tospray properly within 2 puffs when operated upside down. The pump spray and standard spray bottles are also positional dependent and fail quickly when operated in the improper position.

9. Post shoot viewing of the film has been scheduled for Monday March 5, 1990, 8 am, building #8 to determine if further ground testing shall be required, finalize cameraset-up and specs, and in-flight procedures.

In-flight Results (March 27th)

Immediately prior to the flight velcro was placed inside the glove box directly behind the gloves. All aerosol containers and the containers were inspected and the fluid level was marked on each container. Also **bungy cords were set up to restrain the investigator's ankles while performing the testing in the box. White tape was used to mark hand positioning to assure proper focusing of the camera. The following revisions were made to the in-flight procedures:

1. The order containers tested would also be Cetacaine, Ventolin, Pump container, and then Standard spray bottle.

2. During the first set of parabolas each 1/2 empty aerosol container would be tested during to consecutive parabolas. during the first parabola the aerosol device could be filmed immediately after entering in to the zero-g portion of the parabola. During the second parabola the same device would be actuated multiple times during the zero-g portion of the parabola and filming would start in the last 10 seconds.

3. In all cases at least 3 actuations of the device would be attempted to be filmed.

4. Starting with the second set of parabolas a set of full aerosol devices

would be used and sprayed until empty.

Parabola Set #1:

During the first set of parabolas a large bottle of Windex window cleaner was filmed. Since the bottle is clear plastic with a green colored fluid it was felt it may assist us to understand what may be happening inside some of the other containers. The Windex bottle was approximately 75% empty at the time of testing which allowed for the fluid to move away from the pick up straw during the parabola. During the first of 2 parabolas the solution appeared to begin to entrain air and slowly began to migrate up the walls of the container away from the opening in the pick up straw. This movement and entrainment of air is believed to be secondary to the operator pumping the spray and occasional zero-g forces. By the end of the first parabola the majority of the fluid had moved up into the neck of the bottle and the device began to dysfunction. During the second parabola the investigator was instructed to swirl the fluid around prior to the filming. This resulted in excessive foaming and entrainment of air into the fluid. The device failed to function.

During the next three parabolas Cetacaine spray was tested. During all tests the device appeared to function as normal. The spray stream to remain continuous throughout each actuation. During parabolas 6 and 7 the ventolin inhaler was filmed with no notable failures.

The pump spray container was evaluated early and late during parabolas 8 and 9. The operator stated that the device appeared to fail as the Windex bottle did when the fluid had shifted up into the neck of the bottle. The failure was characterized as occurring sporadically and late in the parabola.

During parabola 10 the early phase of the parabola filming was completed using the standard spray bottle. The device appeared to function normally.

Parabola Set #2:

During the first 2 parabolas of the second set the standard spray bottle. It is believed that the camera lense was partially blocked by the blackout curtain. Starting with parabola 3 the full containers were used in the order outlined above. Filming was performed early the first parabola and late during the second parabola for each device. It appeared that all devices functioned without out failure except the standard spray bottle. When the standard spray bottle was used it was actuated either with the nozzle tip pointing slightly upward or outward with the tip level to the base of the

glove box. This device appeared to function properly in a intermittent fashion. One of three types of spray patterned was noted:

1. Normal mist spray which forms a v-pattern was the spray leaves the nozzle. This usually occurred when the device was predominantly full and the nozzle tip was pointed slightly upwards.

2. A simple narrow stream of liquid. This occurred if the nozzle tip was pointed out level with the base of the glove box. It appeared to occur when the fluid moved up into the neck of the bottle.

3. Slight bubbling and little or no fluid. This occurred more and more as the bottle was used and the residual fluid volume was furthest from the nozzle tip.

Parabola Set #3:

During the third set of parabolas no high speed filming was performed to allow for still photography to be completed. During the first parabola of the third set the Windex bottle was retested. During the remainder of the parabolas the containers were all retested. It appears that in all cases other then the standard spray bottle the devices function normally.

Parabola Set #4

Testing and filming only occurred during the first 5 parabolas. At this point all containers were believed to be nearly empty. The Cetacaine and Ventolin Inhaler continued to function without a failure. The pump and standard spray bottles failed to function properly. In both cases the device would fail and then after several actuations the device would function properly.

Post-flight (1-g) Results

No further testing was required. Each container was emptied and the approximate volume recorded:

Partial Filled Containers

#1	Cetacaine	8 seconds continuous
#2	Ventolin	97 puffs
#3	Nostril	8/15 mL remained
#4	Afrin (generic)	1/30 mL remained

Full Containers

#1	Cetacaine	42 seconds continuous
#2	Ventolin	192 puffs
#3	Nasalcrom	6/13 mL remained
#4	Neo-Synephrine	2/15 mL remained

It was noted during the process of determining the remaining volume in these containers that the Ventolin bottles formed a white powder around the nozzle opening. It has been suggested that this accumulation of powder may result inless volume being delivered per actuation. It is suggested during further testing that this type of product only be actuated 2 to 10 times, then the container nozzle opening be wiped off and the bottle shaken.

DISCUSSION AND CONCLUSIONS:

After reviewing the film and photographs it was determined that pressurized aerosol containers appeared to function better than either the standard squeeze type or pump type bottles. Other than the filming of the Windex bottle we were unable to suggest a reason for this behavior.It was reported in the Biomedical findings of the ApolloProgram that the standard squeeze type dropper bottle did not function well, however there was no comments regarding the other type of aerosol bottles evaluated in this experiment.

It is suggested that during the second flight of this experiment the investigators should repeat using clear bottles. To fulfill this objective the Cetylite company has provided with Cetacaine bottles which are clear. Other types of spray bottles will be obtained from Calmar Dispensing Systems, makers of various sizes, shapes, and types of spray containers. This second flight will be projected for the FY 91 HMF KC-135 fight year.

During the post-flight evaluation it was discovered that we had not

evaluated these 1-g positional sensitive containers in different positions during Zero-G. This testing will be answered during the second flight as a specific objective.

The function of flying containers which were either "partial filled" or "full" was to allow for efficient us of our flight time. However, this process has some problems. First it was not known what the actual volume of the containers were pre-flight nor what volume was used during flight. therefore it was not possible to address the impact of partially filled containers on overall usefulness as compared to use in a 1-G environment. It did become clear during the flight that pressurized containers functioned at various fills and to a lesser extent this was also true for the pump and standard spray bottles. During future flights it is recommended that comparisons be performed to the effects zero-g has on fluid sprayed in zero-g versus 1-g testing. These volumes then may suggest potential reduction in container usefulness in a micro-g environment. It would also be extremely helpful to perform 1-g versus zero-g actuations of a product like Ventolin which is report to deliver 90 mcg per actuation. This type of test would require the cooperation of the pharmaceutical house.

REFERENCES:

1. Biomedical findings during the Apollo Program

2. Calmar Dispensing Systems, Inc. Lee's Summit, Missouri 64081, 816/524-4160, Mary A. Murray, Sales Representative.

BUDGET SOURCE:

SD2, Medical Operations, HMF Project.

PHOTOGRAPHS:

S90-33958
Chuck Lloyd is seen secured to the floor with the use of bungy cords over his legs. He is seen evaluating the function of the Cetacaine Spray container inside the Glove Box. The glove box is a clear plexglass box with rubber gloves on either end for the operator to work from. The Cetacaine bottle can be seen actuated with a fine white spray projecting across the box. The Cetacaine topical Anesthetic Spray bottle contains 56 grams of

14% Benzocaine, 2% Butyl Aminobenzoate, and 2% tetracaine hydrochloride with propellants. The spray is activated by pressing downwards on the arm of a Jetco nozzle. This container is designed to delivers 200 mg of medication per second. This device never appeared to fail in flight either early or late in the parabola. Walter Cunningham is seen looking on.

S90-33959
This photograph shows Chuck Lloyd operating the Ventolin (albuterol) Inhalation Aerosol device. This device holds 17 grams of a microcrystalline suspension of albuterol in a trichloromonofluoromethane & dichlorodifluoromethance propellant. The device delivers 90 mcg of albuterol at the mouthpiece per actuation. The shot does not show the actuation of the inhaler, however this device appeared to work properly throughout the flight as observed on high speed film.

S90-33961
John Gosbee is seen evaluating the function of a large spray bottle after the contains has been shaken and foam has formed inside the bottle. The photograph was taken with out a flash in an attempt to highlight the spray and the highlights from the fixed lighting. This photograph demonstrates how easy it is to cause foaming in microgravity. It appears that the device continues to work as seen by the faint white spray line in the center of the photograph. However, once no further liquid remains near the pickup straw in the bottle the device began to fail to product a full spray pattern. The Windex bottle could easily be operated with one hand.

S90-33962
In this photograph John Gosbee is seen operating the'Cetacaine Spray device with the Jetco nozzle under reduced lighting. As seen by the white spray line this device appeared to function throughout the flight. This device required the operator to use both hands, however it is believed that the operation of this device would be much easier if operated with out the large, bulky, rubber gloves. Once the gloves became wet the ability to hold onto items became harder.

S90-33988
This is another attempt at obtaining a photograph of the spray form the Ventolin Inhaler. During this attempt only the very beginning portion of the spray pattern can be seen at the opening of the inhaler mouthpiece.

S90-33989
Chuck Lloyd more clearly demonstrates the spray pattern obtained during

micro-gravity with the Cetacaine bottle. The spray pattern can be seen to cover from the nozzle opening to other side of the glove box, where the liquid coated the surface with benzocaine. The bottle required two hands to operate however it was easy to actuate the device.

S90-33990
Chuck Lloyd and Walter Cunningham evaluate the function of the Cetacaine Spray bottle during zero-g flight. The spray pattern can be seen from the opening of the nozzle to the other side of the glovebox.

S90-33992
From left to right, Kim Murray (Stella-Com), John Gosbee (KRUG), and Chuck Lloyd (NASA) floating during the last 5 parabolas of the Aerosol flight experiment. The set-up used for this experiment was placed in the front of the aircraft near where Kim is seen floating. The glovebox was secured to a table mounted to the floor up against one side of the aircraft. The high-speed camera was mounted on a pole in the center of the plane facing the center of the glovebox. A black sheet was hung from the ceiling in front of the camera so only the lenses struck through the sheet facing the glovebox. Lighting was placed around the end of the glovebox closest the front of the plane. The investigators performed their functions from the side furthest from the front of the plane. The camera and lighting was controlled form a rack near the front of the plane.

S90-33993
John Gosbee and Chuck Lloyd seen floating in the last 5 parabolas of the Aerosols experiment. The blackout curtain and the camera control rack can be seen in the background off to John Gosbee's right. The Medical Restraint System can be seen in the foreground to John's immediate right.

S90-33996
Chuck Lloyd more clearly demonstrates the spray pattern obtained during micro-gravity with the Cetacaine bottle. The spray pattern can be seen to cover from the nozzle opening to other side of the glove box, where the liquid coated the surface with benzocaine. The bottle required two hands to operate however it was easy to actuate the device.

S90-33998
Chuck Lloyd seen evaluating the standard nasal spray bottle during zero-g flight. The spray pattern can be seen as a broken white set of lines and drops from the nozzle of the bottle. The spray can be seen to about mid way in the glove box. This type of spray device appeared to work erratically.

It appeared to function best when the bottle was full based on its ability to delivery a mist type of spray pattern. By the time the bottle was 1/4 to 1/2 full the device began to only form bubbles at the nozzle tip or delivery a more liquid stream of fluid.

HIGH SPEED FILM

S90-023, 16mm, 200 feet, "A" Print, Aerosol Test, 1G.

S90-018, 16mm, "A" Print, Aerosol Spray Testing in Zero-G,Part 1 of 2.

S90-018, 16mm, "A" Print, Aerosol Spray Testing in Zero-G,Part 2 of 2.

VIDEO COPIES OF FILM:

Aerosol Spray Tests/ S90-023 & 018
Master Ref #118234
SMPTE (Window) time code.

code: AEROSOL1 on (NASA 10 disc OLD) NASA 16 9-17-89
Updated 2-26-90
Updated (Chg to AEROSOL2) 3-4-90
Updated 3-30-90
Updated 6-11-90 on NASA 19 disc
Updated 8-14-90
Updated 8-18-90 and moved to c:\word4\pcs\AEROSOL2 & NASA 19
Updated 11-29-90
Updated and reformated 4-8-91

TRANSPORT SUCTION APPARATUS AND ABSORPTION MATERIALS EVALUATION

PRINCIPAL INVESTIGATOR:	Debra T. Krupa
CO-INVESTIGATORS:	John Gosbee, M.D.
FLIGHT DATES:	March 28, 1990 April 19, 1990

TEST OBJECTIVE:

Evaluate the function of a battery powered apparatus, a manually powered apparatus, and various types of materials for the containment of bodily secretions in microgravity.

TEST DESCRIPTION:

The specific objectives of the experiment were:

- to evaluate the effectiveness and function of the hand held, manually powered v-vac for suction during micrgravity
- to evaluate the function of the battery powered laerdal suction unit in microgravity
- to compare the two units in control of various types of simulated bodily fluids
- evaluation of various types of tubing and attachments required to control the collection o bodily fluids during transport
- evaluation of various materials for absorption of simulated bodily
- identification of potential problem areas for waste management and containment of secretions and fluids during transport

STRUCTURAL LOAD ANALYSIS:

See memo from NASA structures for HMF glove box

ELECTRICAL LOAD ANALYSIS: no electrical power required

INFLIGHT TEST PROCEDURES (CHECKLIST FORMAT):

All procedures were completed within the closed environment of the glove box.

1. **Deploy the suction devices and fluids in containers**

   - fluids suctioned included water, milk, pudding, and canine blood
   - each fluid was placed inside the glove box in a separate container for the type of fluid
   - the containers were 60cc catheter tip syringes which allowed for containment of the fluid, and easy deployment of the contents within the box for attempts at suctioning
   - each container was restrained to the inner floor of the glove box by tape until needed for deployment within the box

2. **Attempt suction with the v vac on the various fluids**

   - use large and small bore suction tubing
   - use hard and pliable tip catheters

3. **Attempt suction with the laerdal on the various fluids**

   - utilize large and small bore suction tubing
   - utilize hard and pliable tip catheters

4. **Evaluation of various types and weaves of materials for absorption of fluids:**

   - tight and loose weave guaze
   - blotting and wiping motions
   - sponges, combine dressing, and abd pads

PARABOLA REQUiREMENTS, NUMBER AND SEQUENCING:

No special requirements for intervals and spacing between parabolas.

Parabolas 1-10

- Deploy and secure fluids and suction apparatus within box

- Suction of milk
  - v vac with large and small bore tips
  - v vac with hard and pliable tips
  - laerdal with large small bore tips
  - laerdal with hard and pliable tips

Parabolas 11-20

- Suction of pudding
  - v vac with large bore tips
  - v vac with hard and pliable tips
  - laerdal with large small bore tips
  - laerdal with hard and pliable tips

Parabolas 21-30

- Suction of canine blood
  - v vac with large and small bore tips
  - v vax with hard and pliable tips
  - laerdal with large and small bore tips
  - laerdal with hard and pliable tips

Parabolas 31-40

- Evaluation of absorption of various materials
  - loose weave guaze on blood, milk, and pudding
  - tight weave guaze on blood, milk, and pudding
  - abd pads on blood, milk, and pudding
  - sponges on blood, milk, and pudding
  - combine dressing on blood, and milk

- Evaluation of various methods of blotting and wiping for fluid absorption on blood, water, milk and pudding

- Repeat of any of the previous procedures which need further evaluation

TEST SUPPORT REQUIREMENTS (GROUND AND FLIGHT):

Space required: Full width of KC-135, and 10 feet of length.

Loaded at beginning of flight week: HMF glove box and table

Loaded on flight day:

- video camera
- restraints for investigators
- carry on bag containing waste disposal container, fluids in containers, suction devices, catheter tips, absorption materials,

DATA ACQUISITION SYSTEM:

In flight written check list self report post flight video

MANIFEST: Debra T. Krupa (KRUG)
John Gosbee (KRUG)
Roger Billica (KRUG) flight 1
Perry Bechtle (KRUG) flight 2
Dedicated photographer

PHOTOGRAPHIC REQUIREMENTS:

- Dedicated video photography
- Non-dedicated still photography

HAZARD ANALYSIS/SAFETY:

1. Potential Hazard: Fluids could become dislodged and float freely throughout the cabin

   Response: All fluids were placed within the glove box within their sealed containers before the parabolas began.

No protective covers were to be removed unless within the confines of the glove box.

2. Potential Hazard: Corners of box could scrape or contuse experimeters

   Response: Upper edges of the glove box are padded with foam as required on previous flights for protection of those around box area. See memo from NASA structures on HMF glove box.

INFLIGHT WORKSHEET KC 135 FLIGHT EVALUATION TRANSPORT SUCTION APPARATUS AND ABSORPTION MATERIALS

Principle Investigator: Debra T. Krupa (DK)

Co-investigators: John Gosbee (JG)
Roger Billica-flight 1 (RB)
Perry Bechtle-flight 2 (PB)

PREFLIGHT:

Load equipment onto KC 135 and secure:

- video camera
- restraints for investigators
- waste disposal containers
  - solid, wet, and sharp
- Laerdal suction
  - extra containers
- V Vac
  - extra containers
- suction catheters
  - yankauer
  - pliable small and large
- suction tubing
- absorption materials
- non-sterile gloves
- fluids
  - blood in syringes
- needles

- extra syringes
- chucks pads
- ice chest for syringe containment
- plastic bags for trash
- chicken breast
- duct tape
- scalpel
- needles
- windex
- paper towels

BEFORE PARABOLAS BEGIN:

Deploy suction devices from bags and place within glove box

This was easily accomplished. The laerdal was taped into place with duct tape against the wall of the glove box. The lid was propped open to allow access to the controls. The V Vac was taped to the side of the glove box.

Secure water and blood within glove box for first set of parabolas

The first syringes were placed within the glove box inside of the syringe covers. (See still photo 35939)

Remaining equipment and fluids to be secured to floor within ice chest at base of glove box for easy access within parabolas or at breaks

The syringes were separated by contents and placed within styrofoam boxes. The boxes were taped to the base of the glove box with the lids taped for easy and rapid, yet secure access. The extra attachments were placed within a bag below the glove box. The igloo cooler with the chicken was secured below the glove box also.

Position attachments within glove box for first set of parabolas

The yankauer tips and flexible tips were taped to each side of the box for access by each experimenter. The needles and tips for the syringes were secured to the inside wall of the glove box with double stick duct tape. This allowed the experimenter to acces them when required, and then replace them easily.

Position waste containers

The large trash bags were taped to the side of the aircraft for ease of access.

Recheck video placement

The NASA video camera focus was verified, and positioning checked prior to flight. A detail of what was to be accomplished was provided, with suggestions for camera angles.

BETWEEN SETS OF PARABOLAS:

Change out various fluids in preparation for next set as follows worksheet

As required during the sets of parabolas, as well as between sets, empty syringes were exchanged for new full ones.

Clear fluids out of suction tubing as required with water

This was often accomplished with milk as well as water. It was easy to clear the blood out of the tubing, however the pudding required water and milk to clear. A syringe of water/milk was kept within the glove box on each end for this purpose.

Dispose of used tubing in waste containers

This was accomplished as required.

Turn off laerdal when not in use to conserve battery life and decrease noise level.

This was very important, more for the noise level than for the battery life. The laerdal is very noisy, and, when added to the engine noise and noise created by other experiments, turning it off became mandatory.

KC 135 FLUID EVALUATION RESULTS

SUCTION WITH LAERDAL:

Yankauer tip:

Suctioned out of the cup and off of the wall very well, but a small amount travels up the sides of the catheter. It could not really "grab" globs or streams of blood out of the air.

Flexible tip:

Suctioned out of the cup well. Not as well off of the wall, due to the holes at the end of the catheter are misplaced for non-gravity depended drainage. It was not able to "grab" blood out of the air. It did an outstanding job on suctioning off of the chicken.

Funnel tip:

The blood that was squirted into the funnel stuck onto the inside surface of the funnel, but the suction wasn't powerful enough to remove it off of the funnel and into the suction hose.

SUCTION WITH V VAC:

Yankauer tip:

Fair suction off of the wall and out of the cup. Adequate suction off of the chicken. The experimenters each complained that their hands tired easily with this apparatus with long, slow squeezing; or with short, fast squeezing. The whole assembly was too long to direct the tip accuraely, and to use inside the glove box.

Flexible tip

Fair suction out of the cup. Fait to poor suction off of the wall, again due to poor hole placement on the catheter for zero gravity suction. Fair suction off of the chicken. Again, the hands became tired with long slow squeezing or short, fast squeezing.

Funnel tip

The blood that was squirted into the funnel stuck onto the surface of the funnel, but the suction wasn't powerful enough to remove it from the funnel and into the hose.

GAUZES:

4x8 Surgical Dressing

Stream of blood shot was soaked up to 90%, and the remaining 10% either stayed as a "bead" on the surface, or bounced off the surface of the dressing. Blotting the chicken was adequate, but a bit slow. When moving the dressing away in a "flicking" motion, some of the blood particles scattered in several directions from the surface of the dressing.

"Lap" sponges

No difference from the 4x8 above.

ABD pad

Stream of blood was soaked up to 80%, and the remaining blood beaded up in small globs (less than 1 cm) or bounced off of the pad. Blotting the chicken was unwieldy, and no more efficient than the 4x8 or lap sponges.

Kerlix roll

Excellent at all tasks (streams, blobs, chicken). The roll captured and soaked up the blood readily (very absorbent in microgravity). The roll retained the blood within the Kerlix even when it was forcibly shaken to dislodge the soaked blood.

PHOTOGRAPHY:

Video:

Dedicated NASA video was taken on both of these flights. At the time of the presentation of this report, neither video has been received for review.

Stills:

The number and quality of stills for both of these flight was below average.

S90-35931
DK is blotting with the kerlix as PB squirts the blood.

S90-35932
DK is preparing to blot the chicken as PB prepares the needle to simulate a bleeding wound.

S90-35935
JG is suctioning with the V Vac as PB simulates blood flow with the needle in the chicken.

S90-35937
JG is suctioning with the V Vac and the pliable catheter off of the wall of the glove box where PB has squirted blood.

S90-35938
PB is holding the cup of blood for JG to suction with the V Vac and yankauer tip.

S90-35939
JG is simulating blood flow through the chicken while PB suctions it with the laerdal and the pliable tip catheter. Note the manner of containment of the additional syringes along the inside of the wall of the glove box.

S90-33952
JG is squirting the pudding for RB to suction with the V Vac and the yankauer. DK is watching from over the glove box.

S90-33985
JG has squirted pudding on the wall of the glove box for RB to suction with the tip of the V Vac.

S90-33986
Same as 33985

CONCLUSIONS:

V Vac:

The V Vac was very tiring on the arm and hand. It required quite a bit of pumping to keep up with the laerdal. When the air port of the V Vac became wet, it would leak fluid out of the sides. This is unacceptable. There should be some method for delayed deployment of suction.

Laerdal:

The laerdal functioned as it did in one gravity as a pump. The difficulty was with the tips placed within or next to the fluid for suctioning.

Yankauer:

The tip tended to accumulate fluid around it. Fluid would travel up the sides of the catheter as well as up into it.

Pliable:

This catheter functioned well. It will benefit with different design for tips. This tip was unable to suction the pudding, and would not do well for thick tenacious bodily secretions (mucus). There should be further investigation into how we will do this in space station. This is a serious concern for suction of a patient on a ventilator.

Gauzes:

The kerlix roll worked by far the best of all types of material. It was able to absorb all fluids, and did not dislodge any fluid capture. Wiping tended to push the fluid along front of the material.

ADDITIONAL COMMENTS:

The chicken breat worked well for simulated flow, and did not smell too badly. The canine blood also worked well, and did not smell. The pudding was quite adequate at simulation of various bodily secretions.

We were able to instill water down at ETT very easily. However, this

required the entire ETT being filled with fluid prior to any drainage of fluid out of the distal end. This should be repeated with a bag valve mask.

RECOMMENDATIONS:

1. The gloves attached to the box are very thick and difficult to work with. It would be much more useful if a thinner glove could be changed for the present ones. Also, there was some difficulty in reaching across the box due to the length of the gloves. Longer ones would work much better.

2. The difficulty with suction in microgravity is related to the type of tip placed within the medium to be suctioned. New approaches to design of catheters is required. Possible areas for examination include: large bore catheter tips, funnel tips of various sizes, catheters with numerous holes up the side (as in abdominal surgical suction). This area of investigation is crucial to our ability to adequately provide airway management, surgical capabilities, and wound management. It should be followed up upon with new approaches to design of the tips which come into contact with the fluids.

3. A question was raised as to suction of a patient on a ventilator. A flight to examine different tips for this purpose will be required. Doubt as to the ability of present catheters to remove tenacious secretions is very strong. This should be examined with application of fluid instillation, and bag-valve-mask force applied to the tube.

4. The laerdal is easily used for suction in microgravity. Modifications to solve the EMI and battery problems should be pursued.

5. The V Vac functions adequately in microgravity. Modifications are possible to pursue development of this tool. This would require: a) ease of energy required to pump, b) a method for delay of presentation of the suction for use on slow suction situations, c) prevention of leakage of the fluid out of the air port when it becomes wet.

N91-32785

ATLS - STOWAGE AND DEPLOYMENT TESTING OF MEDICAL SUPPLIES AND PHARMACEUTICALS

PRINCIPLE INVESTIGATORS:	John Gosbee, M.D. (KRUG) Darren Benz (MDSSC)
CO-INVESTIGATORS:	John Gosbee, M.D. (KRUG) Charles Lloyd, Pharm. D. (NASA) Richard Bueker (KRUG) Debra Orsak (MDSSC)
FLIGHT DATE:	April 20, 1990

OBJECTIVE:

Evaluate stowage and deployment methods for the HMF during microgravity.

TEST DESCRIPTION:

The specific objectives of this experiment are: 1) to evaluate the stowage and deployment mechanisms for the medical supplies; and 2) to evaluate the procedures for performing medical scenarios. To accomplish these objectives, the HMF test mini-racks will contain medical equipment mounted in the racks; and self-contained drawers with various mechanisms for stowing and deploying items. The medical supplies and pharmaceuticals will be destowed, handled, and restowed.

IN-FLIGHT TEST PROCEDURES:

Each of the stowage mechanisms will be evaluated by performing the following procedures: 1) destowage; 2) deployment; 3) unpacking from card or container; 4) dispensing, assembling, or handling; 5) repacking onto the card or container, and then 6) restowage.

EQUIPMENT AND MATERIALS

Stowage Mechanisms

The card method (see diagram) used several foam core cards with different supplies and medications attached to them. The attachment methods were small bungee cords, cut-outs in the card, and glueing the overwrap material to the card itself. The container method used an empty plastic tray (4 x 8 x 2), with a sealed cover that could be partly opened to access the contents. These trays were restrained within the drawer with foam (see diagram).

Deployment methods

The cards could be restrained with velcro onto a MRS-mounted metal tray and other surfaces of the drawers. Some cards had notches to "snap" into the handles of the drawers. The plastic trays had velcro on the bottom to be deployed onto the velcro-covered metal tray.

Layout (see diagram)

- Space utilized: Full width of KC-135, and 10 feet of length
- Two metal racks (19"x30"x48")
- Four rack-mounted drawers
  Three - 5" x 17.5" x 30" drawers
  One - 10 x 17.5" x 30" drawer

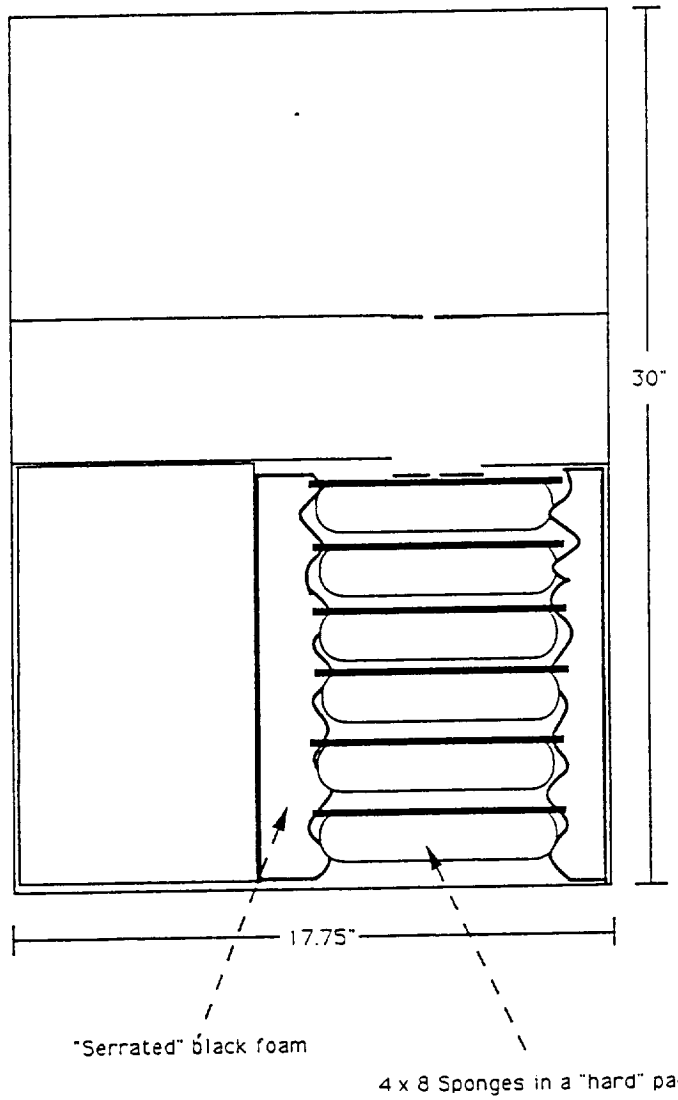
Inner drawer restraint devices

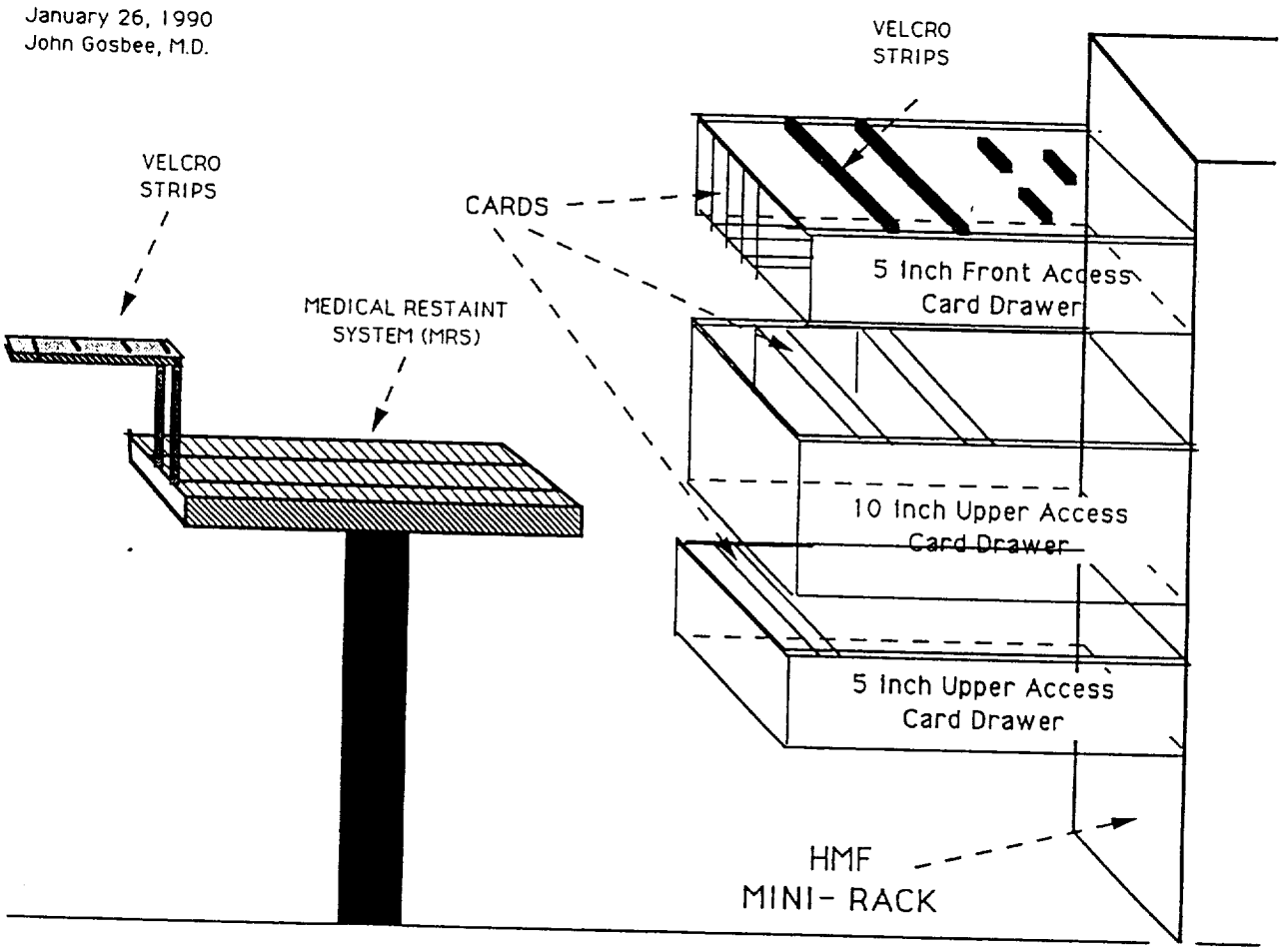
- Upper access cards with stowed items: 5 and 10 inch drawers
- Front access cards with stowed items: 5 inch drawer
- 4 x 8 inch trays within foam insets: 5 inch drawer

HMF prototype Medical Restraint System (MRS)

- Waist harness/straps for each "CMO"
- Rope around perimeter of MRS table
- One point tether straps attached to floor or base of racks

Plastic Tray Drawer Layout




January 26, 1990
John Gosbee, M.D.
VELCRO STRIPS
VELCRO STRIPS
CARDS
MEDICAL RESTAINT SYSTEM (MRS)
5 Inch Front Access Card Drawer
10 Inch Upper Access Card Drawer
5 Inch Upper Access Card Drawer
HMF MINI- RACK

Data acquisition

- In-flight written questionnaires
- Post-test debriefing
- Still and video photography

RESULTS

5-inch front access drawer

- Drawer front opened easily
- Tongue that was used to hold door open perpendicular worked great
- Cards slid out without trouble, but occasionally got jammed when putting them back in, or one of the items got cought up on the drawer opening.
- Pill bottles under loops were easy to remove, ONLY if the user held the unrestrained end of the card fixed.
- Pills went all over when trying to dispense into a baggy, or hand
- Bottles were hard to replace on the card under the loops
- Main deployment area used was the mountable card and the top of the drawer that had velcro.
- Cards and deployment surfaces didn't match up well, and therefore the cards were merely fixed loosely on one end, but not truly "restrained" so that items could be removed without holding onto the free edge of the card.
- This was true for the other 5 inch and 10 inch cards as well
- The shuttle-type, push up pill bottle failed. The only way to extract a pill was to "peel" back the plastic triangles and "flip" out one or more pills.
- The top of this drawer was used for deployment, but was unsatisfactory because it wasn't flush with the edges of the drawer.

10-inch upper access drawer

- The poor one-ended deployment was accentuated since these cards had more and larger items attached.
- Unpacking from the loops was good
- Unpacking from loops and an "edge" was no better, and a bit worse than loops alone for the 4x4's
- Again, with objects on both sides of the cards, they would never lay flat on any surface.
- In addition, you couldn't see what was on the other side of the card
- The "briefcase" type card that folded open onto the metal tray deployed very nicely, and stayed fixed upon the tray during the accessing of items under loops on the card.

5-inch upper access drawer:

- The cards slid out easily
- Poor deployment schemes, as above
- Some syringes and plungers were stowed separately in a standard box.
- There was no "clean" way to deploy these when assembling the syringes.

5-inch drawer with plastic trays:

- 4x8 plastic trays (packs) destowed easily with one hand
- Packs could be deployed onto the metal tray (with velcro) so easily, that they could be thrown onto the surface and stick down from a distance of 2-4 feet.
- Removal of one or more items from the packs was easy (Some packs were hard to tear open with the ad hoc use of staples)

- Sometimes the operator(s) would open the packs to much (90% of the way), which allowed all of the items out at once
- Restowage into the packs was easy, except for flexible items like sponges or cloth masks, which bunched up and had to be "stuffed" in.
- The packs restowed easily into the foam drawer with one hand.

SUMMARY OBSERVATIONS

1. All of the cards were easily destowed from the different drawer types. In restowing these cards, it was easy to misalign cards. This was partially due to the fact that the cards were constructed of foamcore, which is more difficult to maneuver. Also, this may be eliminated by making each card location specific.

2. There were problems in deploying the cards once they were removed from a drawer. It was somewhat of a hindrance to have velcro on the blind side of the card. It wasn't always obvious where the velcro would be, and as a result the card was often turned over to find out how to attach it. Lack of commonality continually caused a delay in deploying cards. When velcro was placed on the "blind side" of the card, or the side not facing the CMO when the card was destowed, the deployment attachment site was especially hard to spot. It was determined that restraint mechanisms for cards (velcro was used for this flight) must be uniform in location and method.

   The metal tray used on this flight had a raised surface around it's edge. This made it less appealing as a deployment surface. Firm attachment was impossible because the card couldn't lie flat. A level tray would be much more appropriate. Further thought would be required to determine the orientation for the velcro attachment points.

   Cards deployed to the front of the drawer had parallel attachment points, and were unstable. It was suggested that stability could be increased by attaching cards with parallel and perpendicular restraints.

   Use of the top of the front access drawer as a deployment surface was much the same as using the metal tray. Since this was not a flat surface area, cards didn't attach very well.

The card tray attached to the drawer front stuck fairly well, but lacked stability during unpacking. Once again, added perpendicular restraints could be used to increase the strength of this deployable surface.

The card tray "notched" to the drawer handle was completely unstable. This was partially due to the fact that it was constructed from foamcore, and wasn't as rigid as necessary. Even if the card was attached well, a torquing effect may still occur, making unpacking impossible.

3. Different containment methods were viewed as more advantageous than others.

   Items glued on cards worked well.

   Restraining items with loops received mixed reviews. This was an efficient method, but a CMO with larger hands would have some difficulty. A loop attached permanently on both sides tended to be easier to slip items out of, although it was harder to restow items into this restraint. A loop attached permanently on one side allowed free clearance to lift the item off of the card. These were cumbersome to detach, however, and also presented problems for restowage, especially when items required a certain orientation. Where multiple items were restrained under one bungee it was difficult to remove one item at a time.

   An easy method of stowage and unpacking was found with items fixed in slots which were attached to cards. These items were easy to unpack and to restow. This method, however, is only practical for flat items (such as gauze).

   Packaged items that were rolled up and attached to the card worked fairly well. If these items had any memory, however, they would tend to stay in their rolled configuration. Also, this method is only feasible for items which do not require to be kept flat.

   Individual items attached with velcro were easily unpacked and restowed.

   All of the items mentioned previously required two handed destowage. The "kits" with velcro on the bottom were very easy to destow one handed (deployed easily to the tray surface). They worked well even

without internal restraints, because items were densely packed within the kit. This packing tended to create a problem in restowing any unused portions. Also, only items that lent themselves to stacking could be restrained in this manner. Although more thought might be involved to fully develop this mechanism, it is seen as a viable stowage concept.

"Kits" made from cards worked fairly well. They presented a method of placing several items anticipated to be used repetitively in one convenient package. They were heavier than regular cards and therefore more cumbersome to handle. Because of the increased weight of the kit, it is more difficult to attach to the metal tray, and to restow in the drawer. Once again, this is partially explained by the material used in it's construction. Items within the Kit would most appropriately be placed in the order used.

Two sided cards were unsuccessful. Not only did they present a problem in seeing what was on the card, they could not be laid flat for restrain with velcro. Even if they were somehow restrained, they would have to be flipped after a period of time to access items on the other side. This problem could be solved if this card had another mechanism (beside laying parallel to a deployed surface) of restraint.

4. Items requiring assembly, such as syringes, generated a lot of trash. It was recommended that items such as these not be kept in a box (and then restrained to the card) if possible.

ISSUES AND RECOMMENDATIONS

1. Items need to be stowed on one side of card only. If items or kits excede the space available on one side of a card, a 'briefcase' card is a possibility.

2. Restraint mechanism for cards needs to be common in both method and location on the card.

3. The concept of having a work surface (ie either a separate pullout 'work tray' or a work card within a tray) is a good idea. The restraint of cards once deployed needs to be worked with the design of the MRS.

4. A method of restraining pills in bottles or in bags is necessary (e.g., the Freeman 1 device). A bottle alone with separate bags in which to place

the pills after dispensing is unacceptable.

5. 'Clips' should be used whenever possible. The use of rubber bands should be limited, especially in the case of bottles. Rubber bands (or bungees) might be suitable for some central supply items. Further research on the subject is needed.

6. The current Shuttle pill bottle should be redesigned. The Freeman 1 device needs to be explored.

7. Placing syringes in separate boxes is not optimal. This causes undo waste, takes up too much space, and is not easy to work with. Clips may be an adequate stowage and deployment device for pre-filled syringes.

8. Connections between loose items, such as the syringe and its cap, should be evaluated to decrease floating trash.

9. Plastic 'packs' need to be considered as a stowage and deployment device - possibly as a complement to the tray concept. It is possible the packs can be designed to restrain any amount of items.

10. Restowage a consideration that needs to be addressed? We need to see how it works once contents of the pack is low.

11. For visible aids, what about see through cards to allow CMO to see deployed restraint mechanism.

12. Human restraint is also a factor when exploring deployment and other restraint methods. This must be clearly defined to evaluate card restraint methods, areas for restraints, etc.

13. Cards must have a flat surface to restrain them in a stable fashion with velcro, or be bungeed down on either end of the card.

14. Additionally, it is inconvenient and difficult to "see" both sides of the card at once. A card that "folds out" like the Foley card may be better if you plan to use every item on the card in rapid sequence.

15. Cards or deployable tray cards need to have a more stable attachment mechanism than just a few strips of velcro on one end.

16. It was not obvious preflight, but it seemed that there are some inherent

problems involved in trying to restow used (or partially used) items on cards. It is almost always true that the shape of the item before unpacking and use differs from the shape of the replacement item.

17. It was apparent that deployment should be an integral part of the Medical Restraint System (MRS).

18. By placing deployment surfaces on the MRS, CMOs of varying stature could comfortably use these work surfaces.

NASA PHOTO REFERENCE

S90-35999 - 36000
Demonstrating weightlessness

S90-36015
Transfer of pills from bag to container in 0-g

S90-36022 - 26
Deployment of medical supplies from stowage

S90-36035 - 38
Deployment of medical supplies from stowage

S90-36050 - 51
Demonstrating weightlessness

S90-36055
Deployment of medical supplies from stowage

S90-36066 - 73
Deployment of medical supplies from stowage

MINOR SURGERY IN MICROGRAVITY

PRINCIPAL INVESTIGATOR:	Roger Billica, M.D.
CO-INVESTIGATORS:	Debra Krupa, BSN, MS; Robert Stonestreet; Victor Kizzee
FLIGHT DATE:	April 23, 1990

PURPOSE:

To investigate and demonstrate equipment and techniques proposed for minor surgery on Space Station Freedom.

OBJECTIVES:

- Test and evaluate methods of surgical instrument packaging and deployment.
- Test and evaluate methods of surgical site preparation and draping.
- Evaluate techniques of sterile procedure and maintaining sterile field.
- Evaluate methods of trash management during medical/surgical procedures.
- Gain additional experience in techniques for performing surgery in microgravity.

OVERVIEW:

A KC-135 parabolic flight test was performed on March 30, 1990 with the goal of investigating and demonstrating surgical equipment and techniques under consideration for use on Space Station Freedom (SSF.) The flight followed the standard 40 parabola profile with 20-25 seconds of near-zero gravity in each parabola. Four experimenters were involved in the study, two who were from practical clinical backgrounds, one biomedical engineer

and one video-technician.

To accomplish the study the medical restraint system (MRS) was deployed as if for surgical use and the mini-racks were employed as the SSF Health Maintenance Facility (HMF) equipment-containing racks. A standard simple laceration scenario requiring suturing was used to step through the medical/surgical procedures, and in doing so highlighted the desired objectives of the study. The two clinical experimenters served as Crew Medical Officers (CMO's) 1 and 2, while the other two provided support and recording.

The sequence for the study was as follows (all procedures were first performed in the ground HMF lab to establish proficiency) :

- Parabolas 1-10: Deploy equipment tray(s)
  Don sterile gloves
  Prep arm using different methods
  Drape with Incise drape

- Parabolas 11-20: Inject local anesthesia
  Make incision and suture
  Evaluate instrument restraints
  Prep arm using different methods
  Drape with paper fenestrated drapes

- Parabolas 21-30: Suture with OTS prepackaged instrument set
  Drape with towels and clips
  Suture using preferred methods

- Parabolas 31-40: Repeat of necessary steps.

BACKGROUND:

Several previous KC-135 microgravity investigations have been conducted regarding the capabilities needed to perform surgery in space. Most of these centered around the considerations for major surgery employing traditional methods of prepping, draping and gowning. Work has also gone forward in establishing the needs for patient and operator restraint. For the most part, these studies have confirmed that with proper restraint for the people and the equipment surgery can be performed in similar fashion as on Earth.

As would be expected, these studies also found that the more complicated the procedure became (such as in major surgery with extensive gowning and draping), the more difficult the situation was to manage in zero-gravity. At the conclusion of these studies, several areas of investigation remained including techniques for minor surgery, hemostasis and fluid management, and sterile field techniques.

The focus of the present study was to build on the previous efforts by considering the support needed to conduct simple minor surgical procedures. This sort of event is considered by some to be much more likely on SSF than elective or trauma surgery. Indeed, the current planning for SSF HMF in the area of surgery is directed mostly in support of the more common and immediate types of procedures that are encountered in standard medical practice. However, this study is also directed at continuing the foundation of knowledge and expertise required to develop the sort of medical/ surgical support that will be needed for long term space exploration and colonization.

MATERIALS:

- Prototype MRS with restraints
- Mini-racks with stowage drawers
- Instrument tray with attachments
- Training suture arm (mannequin arm)
- Waste containers - dry, wet, sharp
- Drapes - Incise adhesive, paper fenestrated, towels with clips
- Suture sets - disposable off-the-shelf, custom (needle holder, iris scissors, adson forceps, suture scissors, curved mosquito clamps, towels clips, skin retractors, scalpel)
- Metal tray, magnetic mat
- Prep sponges (betadine swabsticks, betadine wipes, alcohol wipes, Frepps, iodoform sponges, Durapreps)

- Gauze, tape, syringes, gloves
- Support materials (tape, cords, towels, etc.)
- Video camera

PERSONNEL AND SUPPORT:

- 4 Investigators (two CMO's, one support, one recorder)
- Video recording performed by recorder; still photography performed by non-dedicated NASA photographer. Post-flight worksheets completed by all.

TEST PROTOCOL: **(See "Flight Worksheet" appendix.)**

RESULTS AND DISCUSSION:

Instrument Deployment and Restraint

Several different methods of instrument deployment and restraint were used during the flight. To begin with, a metal tray was attached in a secure manner to one end of the MRS. This tray served as a non-sterile attachment point. Initially a sterile wrapped minor surgery kit (custom made) was secured to the tray using simple clamps (see photo 1.) The sterile wrapping was carefully folded back while avoiding contact with the contents and inner surface. These flaps were secured to the undersurface of the restraint tray using clamps for half of the flaps, and adhesive material for the other half. This method of deployment functioned very well, but required a mechanism to secure the sterile kit AND the wrapping to the tray.

Through careful deployment as described, the inner contents of the surgery kit were exposed in a sterile manner. The kit was custom made with two types of surface: 1) a magnetic mat ("Mag Mat" - plastic mat containing magnetic strips) was glued to half of the kit surface, and 2) a cardboard surface with evenly spaced elastic bands was attached to the other half of the kit. In this manner the metallic instruments could be held against the magnetic surface, and the other materials such as gauze and syringes could be secured with the elastic bands. This functioned very effectively. CMO2 was able to present sterile supplies and instruments to the gloved CMO1,

who then could restrain these items to the kit surfaces. It was possible to gently propel the metallic instruments towards the Mag Mat in zero-G and have the Mag Mat "capture" the instrument. This method of instrument restraint proved to be the preferred method.

A second type of instrument restraint was tried using an off-the-shelf disposable suture set (see photo 2.) The thin plastic container for this suture set was placed against the Mag Mat to determine if the metal instruments would hold the kit against the mat. This did occur, but the hold was tenuous and any jostling or removal of instruments caused the restraint to be broken (see photo 3.)

It was felt that the best arrangement for instrument deployment and restraint would provide a mechanism for securely holding the instrument kit while exposing the contents in a sterile manner (which will require an additional mechanism for holding down the wrappings.) This should remain as simple as possible and should be able to be performed by a non-gloved individual. The instrument kit surface itself worked best by providing an open magnetic area for the instruments and an area with some sort of elastic bands or clips to hold miscellaneous supplies. It was noted that with the elastic bands, a variety of lengths and widths should be provided to accommodate different sized supplies. Whenever a larger item was restrained under a band, any previously placed smaller items would tend to float free. An open magnetic area for instrument restraint was preferred over a mechanism of groves or clips for two reasons: 1) the instruments could be placed randomly without effort to fit them into specific locations or grooves, and 2) the open surface was easier to clean up during and after the procedure (which would be even more important if these kits are to be cleaned and repackaged for repeat use.)

Methods of Site Preparation

Four different methods of site preparation were investigated during the study: Surgical sponge with povidine solution, Betadine Swabsticks (package of three), Frepps, and Durapreps. All of these were provided in a sterile container. Since the purpose of this study was to investigate minor surgical techniques, only a small area of site prep was performed as appropriate for simple suturing.

1. The surgical sponge with povidine was adequate for the job and perhaps more than needed for a simple procedure. (See photo 4.) If the

area had been dirty and required more thorough cleansing, a sponge such as this would perform nicely (although a different type of soap may be preferred for tissue cleansing.) For maximum benefit, the sponge would require additional wetting which was viewed as a disadvantage compared to the other methods.

2. The Betadine Swabsticks functioned quite well and were the preferred method for a simple procedure. (See photo 5.) They were ready to use as soon as the package was opened, and there was no spillage of fluid from the package even with vigorous shaking.

3. The Frepps were functional and simple to use. (Not pictured.) However, they did require that the fluid package be ruptured and vigorous squeezing and maneuvering was necessary to propel the fluid into the sponge portion. Once the fluid made its contact through the sponge, the Frepp worked well and additional fluid continued to be present through the wicking action of the sponge.

4. The Durapreps were the most difficult to use. (See photo 6.) Without gravity, the effort needed to force the fluid into the sponge was too much, and in some cases, never accomplished successfully.

It is felt that for most simple surgical procedures to be performed on SSF, the site can be thoroughly cleaned using the available washing facilities, anesthesia provided in an appropriate manner (usually local), and the site can be prepped for sterile procedure using a very simple technique (such as the betadine swabsticks). This mirrors accepted practice in terrestrial emergency rooms and should be equally effective in space.

Methods of Site Draping

Three different methods of site draping were investigated during this study. Again, the intent was to evaluate support for minor surgery, and therefore only single unit drapes were employed to establish sterile field for the immediate site only.

1. Incise adhesive drapes were the preferred method. These are clear stretchable plastic drapes with an adhesive surface. (See photo 7.) They required some practice and familiarity to employ properly, and do require two people for placement (only one of whom needs to be gloved.) However, once the proper placement technique was accomplished, they proved to be the simplest to use and the most

effective. The transparent material provided good view of the whole surgical area, the elastic nature provided ready conformity to any surface, the adhesive surface eliminated the need for additional restraint, and the non-fenestrated surface allowed the surgeon to create the exact opening desired. (See photo 8.)

2. A fenestrated paper drape with adhesive tape under the four corners was tested. (See photo 9.) This provided acceptable function, but did not conform to the surface without gravity and the premade fenestration was too large. If something like this were to be used, it would need additional adhesive and a smaller premade opening (or none at all.)

3. Traditional sterile cloth surgical towels were used during one procedure (not pictured.) This method required for separate towels and towel clips. The technique was cumbersome to perform and the towels tended to intrude due to zero-gravity. Additional restraints would be required for this method, which is not recommended.

Methods of Waste Management

As an aside during the study, simple methods of waste management were employed and provided some comment:

1. Dry trash - (see photo 10.) was contained in the "fish trap" basket that has been used on many previous flights. This is a wire mesh basket with a spring loaded lid. Attached to the MRS, it is fairly easy to use although smaller items tended to escape due to the diameter of the mesh. It was also somewhat difficult to empty due to the loose contents, and might be more effective if some sort of liner was employed. It was noted that this container needed restraint both at the top to the MRS and the bottom to the floor if it was to be stable enough for easy use.

2. Wet trash - was contained in standard "zip-lock" bags. This seemed to work pretty well and after a couple uses could be closed off and placed in a more permanent container (or even the dry trash container.) The best method of restraint for these bags was not established (attempted were use of tape to the edge of the MRS and held to the MRS surface with an elastic band.) There was an obvious need for some sort of completely enclosed container that could be restrained near the MRS for disposal of wet trash (sponges, wipes, gauze, etc). It should be small or collapsible to minimize volume and more than one may be needed for

any given procedure.

3. Sharp trash - was provided by typical hospital "sharps containers." These were fairly large and cumbersome for the small volume of sharp items (needles and scalpels) used in a simple procedure. The revolving lids were fairly effective if the container was placed on its side, otherwise items tended to escape. It was obvious that a more elegant, smaller and simpler design would suffice for HMF use.

Observations on performing Minor Surgery

The actual surgical part of the study was quite simple to perform in zero-gravity. (See photo's 11 - 16.) Control of suture material and maintenance of sterile field was easier to accomplish than in terrestrial practice. Of critical importance was providing secure but comfortable CMO restraint to the MRS for a prolonged procedure. Once this was effected, the surgical technique was little different from that on earth. Lighting, exposure and hemostasis were concerns not investigated during this study.

During this flight test there were several previous findings confirmed:

1. Even the most simple surgical procedures will probably require two operators. Once the surgeon is gloved and restrained to the MRS, a second CMO is required to provide assistance and support for many aspects of the procedure often taken for granted on earth.

2. Donning sterile gloves is very difficult to perform unaided and should be considered a two-person procedure.

3. Restraint for the patient, surgeons and equipment are key issues and must be adequately resolved before any procedure can be safely performed.

4. CMO2 can function similarly to a surgical assistant by presenting the gloved CMO1 with instruments and supplies (using sterile technique.) Once all materials are provided, CMO2 can then don gloves to assist in the actual procedure. In more complicated procedures when both CMO's are involved, a third crewmember may be required to assist as the "circulating nurse" role.

NASA PHOTO REFERENCE

S90-36882 - 83
Suction and entrainment of surface fluids

S90-36869 - 71
Suction of fluids on 0-g

S90-36853 - 54
Demonstrating a cautery device in 0-g

S90-36873
Using the laminar flow/particle containment system

S90-36876
Spurting blood in 0-g

S90-36888 - 89
Suturing in 0-g

S90-36891
Making an incicsion in 0-g

RECOMMENDATIONS:

Additional study needs to be performed on lighting, exposure and hemostasis. As the information accumulates, the identified preferred methods and techniques should be assembled into integrated procedures for further study and confirmation. The composition of the surgical kits needs investigation. Concern over SSF air-particulate level and possible wound contamination needs follow-up and evaluation of possible containment-isolation chambers and laminar flow devices should continue.

Surgical equipment and techniques should be designed for simplicity and flexibility so they can be adapted to a wide variety of uses. This will be especially true if volume remains constrained and no method of cleaning and repackaging of instruments is supplied. Surgical procedures for SSF should be patterned after those seen in remote facilities and emergency rooms rather than hospital surgical suites, although serious attention must be given to provision and maintenance of sterile field and cleanliness in the dirty SSF environment. It is planned that as the resources for medical care

in space grow, a more developed surgical capability will evolve based upon the knowledge and experience gained from preparing for and performing minor surgery aboard SSF.

EVALUATION OF PROTOTYPE ADVANCED LIFE SUPPORT (ALS) PACK FOR USE BY THE HEALTH MAINTENANCE FACILITY (HMF) ON SPACE STATION FREEDOM (SSF)

PRINCIPAL INVESTIGATOR:	Debra T. Krupa, B.S.N., M.S.
CO-INVESTIGATORS:	Debra T. Krupa, B.S.N., M.S. John Gosbee, M.D. Linda Murphy Victor Kizee
FLIGHT DATE:	April 24, 1990

JUSTIFICATION:

Evaluation of the prototype ALS pack which has been developed for the HMF. This pack will enable the Crew Medical Officer(CMO) to have ready access to advanced life support supplies and equipment for time critical responses to any situation within the Space Station Freedom.

OBJECTIVES:

1. **Evaluation of the design of the pack.**

   This will include evaluations of:

   - exterior design and function
   - access to individual sections within the pack
   - access to contents within each section of the pack
   - restraint of the pack to the patient restraint and mini racks
   - restraint of each section within the pack to the patient restraint and the mini racks.
   - positioning the pack at various locations
   - access to contents within each compartment for deployment and utilization

2. **Collection of comments for revisions to design of the pack.**

   - entire pack

- sectional compartments
- restraint mechanisms within each compartment
- restraint mechanisms for each compartment within the pack
- restraint mechanisms for entire pack

INFLIGHT TEST PROCEDURES (CHECKLIST FORMAT):

APPROACH:

Operators will deploy the pack and each compartment within the pack independently for evaluation. They will then simulate deployment of the pack for a medical emergency and evaluate function in a time critical scenario.

1. Pack deployment

   - deploy pack from mini rack
   - restrain to patient restraint
   - restrain to rack

2. Compartment deployment

   - removal of individual compartments
   - restrain each compartment to patient restraint
   - restrain each compartment to work surface

3. Equipment and supplies access

   - removal of individual items from within each compartment
   - utilize equipment in succession from compartment
   - deploy multiple items at a time from compartment and secure for ready access

4. Transport of pack

   - access to pack from racks
   - move through area with pack
   - restrain pack to floor
   - access pack and contents

PARABOLA REQUIREMENTS, NUMBER, AND SEQUENCING:

No special requirements for intervals and spacing between parabolas.

Parabolas 1 - 10
- Deploy pack from rack
- Restrain pack to patient restraint
- Restrain pack to mini rack
- Restrain pack to floor

Parabolas 11 - 20
- Restrain pack to worksurface
- Access internal compartments individually (remove and replace)

Parabolas 21 - 30
- Access internal supplies and equipment within each compartment
- Remove contents and replace

Parabolas 31 - 40
- Simulate actual time critical deployment of pack
- Removal of pack from mini racks
- Transport to sim area
- Restrain pack
- Restrain CMO
- Access contents of pack

TEST SUPPORT REQUIREMENTS (GROUND AND FLIGHT):

Space Required:
Full width of KC-135, and 10 feet of length

Load flight week:
Mini Racks:
- HMF Prototype Patient Restraint

Loaded on flight day:
- video camera
- ALS pack containing medical supplies

Power requirements: 110 VAC for patient restraint

DATA AQUISITION SYSTEM:

- In flight written checklist
- Self report post flight
- Video

MANIFEST:

Debra T. Krupa:	DK (KRUG)
Victor Kizzee:	VK (KRUG)
John Gosbee:	JG (KRUG)
Linda Murphy:	LM (MDSSC)

PHOTOGRAPHIC REQUIREMENTS:

- Non-dedicated still photography
- Video photography provided by examiners

PROJECTED RESULTS:

The safe provision of medical care for all portions of the Space Station requires that the HMF provide a means for rapid access and transport of life saving medical supplies. The ALS pack is required to fulfill this need. We hope to evaluate the current prototype design for function and performance, and then determine any needed alterations to the design of the pack. The size, shape, and form will be examined, as well as the utility. The placement of time critical medical supplies will be examined and decisions made as to placement within the pack or the racks at the HMF.

STRUCTURAL LOAD ANALYSIS:
See HMF Mini-Rack Experiment (1-24-90)

ELECTRICAL LOAD ANALYSIS:
See HMF Mini-Rack Experiment (1-24-90)

HAZARD ANALYSIS/SAFETY:

Potential Hazard: Loose items may float free from pack

Response: Only one item at a time will be deployed from the pack. All items will then be restrained for use. Items which become loose will be retrieved by a designated operator before they float free from the experiment area.

RESULTS:

Photography:

Stills:

The number and quality of stills received with this flight were substandard. A majority of the additional information was gained from review of the video tape and written comments.

S90-36477
The airway management kit of the pack is destowed by LM and opened by DK. Attempts at access to various areas within the kit are performed.

S90-36479
The airway management kit is velcroed to the work surface by the strips along the posterior spine of the kit and work is attempted without holding the kit in place. An endotracheal tube is removed by DK and handed to LM from within the kit. In the foreground the entire ALS pack is seen as opened and secured to the patient restraint.

S90-36483
The suction kit is deployed from within the pack and the mesh top unzipped by LM. The contents are exposed by DK.

S90-36485
The PASG bag is destowed, secured to the patient restraint, and then opened by DK. Upon opening, the length of tubing which had been coiled within the kit rapidly expanded and began to float away. It was grabbed by DK to contain.

S90-36488
Various kits within the pack are destowed by JG and LM. In the foreground, the IV section of the pack is secured to the work surface by the velcro strips along the posterior of the pack. LM is deploying the waste management kit. JG has deployed the HAL kit (right hand) and the assessment kit (left hand) from within the pack.

S90-36495
A photo of the internal contents of the ALS pack with each kit placed internally. LM is opening the zipper compartment located on the inferior surface of the face of the pack. DK is replacing the IV kit within the pack.

S90-36496
The face of the pack which has a large velcro strip for closure or securing is lifted and displayed by DK and LM.

S90-36499
The entire pack is secured to the face of the mini racks to assess zero gravity access in a possible intended deployed position. DK is positioned with her feet bracing her between the miniracks and the patient restraint for stability. The face of the pack is unzipped and dropped to allow viewing of the internal kits within the pack. DK has destowed a gauze roll and the intubation roll from within the pack and handed it to JG who is restrained to the MRS in the background.

S90-36504
JG is securing the pack to the front of the mini racks with interlocked D rings.

S90-36505
The entire pack and accessory transport equipment containers are connected by D rings and DK is attempting to move through the aircraft with the collection of equipment using the ropes as a translation aid.

S90-36506
A repeat of 36505 from the front view.

Video:

NASA master reference #903507. Video was reviewed by the experimenters. Quality was acceptable and provided excellent additional data. Observations from video are included in this report.

CONCLUSIONS:

This flight provided a very successful evaluation of the first prototype of the ALS pack for the HMF. It was able to evaluate various designs for containment, restraint, securing, deployment, restowage, and movement of supplies and groups of supplies.

Evaluation of the design of the pack.

Exterior design and function:

The exterior of the pack functioned well through all testing. The backpack straps of the pack were not utilized, as this type of securement is not required for ease of movement in microgravity. If the pack is to be used in a one gravity environment after return however, the backpack straps might become a useful item. If not, they are unnecessary. There should also be additional loops, or hooks to allow ease of access to rack restraint throughout the station.

Access to individual sections within the pack:

There were no difficulties with access to individual kits within the pack. The large open pack design allowed ease of access. The color coding and labeling of each kit were very useful in identification by the experimenters as to which kit was to be removed. The side pockets within the pack itself were very small and tight. If these are retained, they should be designed for specific items only, or should be removed. The interior surface of the pack being covered with velcro was very useful as a work surface. This allowed deployment of numerous loose parts and containment. The interior area of the flap of this pack was covered with potential securing mechanisms. The loops which held the cylindrical objects worked very well. The loops with the snaps were ideal to dispense tape. The loops around the tongue depressors did not function well. As one was removed, they all became free. The pocket with flat supplies contained worked well for access and restowage. It was felt however that this area should be used for other purposes, and for future packs should not contain the items that this pack did.

Access to contents within each kit:

Assessment kit (yellow bag)
Performed well. All instruments were held inside until needed. Velcro loops held the large bulky items well, and the bands held the cylindrical items.

Waste management kits(small navy kit with small orange kit inside)
It was a very good idea to place one kit within the other kit, within the other kit. This saved space, and there were no difficulties in deployment of the kits.

IV kit (long navy kit with mesh top, zipper opening and open interior)
Grouping of each set of supplies for the start of an IV into a bag within the kit seemed to work well. However, there was no way with this kit to deploy 3 - 4 loose items to allow a procedure to occur.

Airway/breathing kit (hot pink)
There was not an area of velcro to restrain this kit to. It was difficult to hold the kit open to maintain access to the interior. A bungee cord was used to hold down the kit for evaluation. Each of the items within the kit were held inside well without coming loose. Items which were held in place by elastic straps required two hands to access/restow. The pockets with the velcro tops also required two hands, but appeared to secure items well. The mesh covering allowed easy identification of items.

Roll
The roll seemed to work well, however it needs to be designed around the supplies which will be included within it. The tape roll which was placed within the velcro loop came loose, and should be possibly placed within a snap loop. It proved to work well for dispensing tape to have it in an apparatus which allowed "loose rolling". The corners of the roll were difficult to contain and secure. Clips were used, and each end folded down to allow securing. Each corner of a roll will have to be secured. The pouches on the sides with netting were very useful. Rolling the kit back up took both CMOs. This may have been due to the kit not being designed with the equipment it contained. However, this difficulty should be avoided.

Drug kit (orange bag with cards)
The large amount of velcro on the back held this kit in place well. This needs to be available on both sides of a kit which zips open on three contiguous sides. It was very easy to move the syringes in and out of the tight loops with one hand. It occasionally took two hands to replace.

Light green kit with miscellaneous supplies
This kit held to the work surface well. Upon shaking and jostling the kit, there were no dislodges of contents. The lid was that of two zippers (one down either side), and this proved to constantly get in the way once the kit was opened. A method for restraint of the lid should be provided. Items

which were a tight fit were difficult to get in and out. Some of the loops were too loose or too long for items, and did not hold the securely. The card concept worked well, but the exterior design of this kit did not work well with the interior design.

PASG bag (orange bag)
Upon destowage, the tubing of the PASG became a projectile and leaped out of the container. Both CMOs had to race to grab sections of the equipment before it floated away. Upon restowage, the tubing was uncontrollable, and frequently hit the experimenters in the face. (It was comparable to attempting to stuff one of those spring/coil snakes back into a peanut can.) There should be some sort of design for a coil on a card mechanism to destow and restow this heavy tubing.

Oxygen tank case
The tank easily slides into and out of this design. The case was easily attached to the pack bottom, but was too loose to allow coordinated movement of the entire collection.

Restraint of the pack to the patient restraint and mini racks:

Restraint to the patient restraint
The pack was secured to the patient restraint with buckle straps and bungee cords. It was recommended that there should be better and firmer tie downs for the entire pack. It made the pack very immobile to have it restrained well to the MRS, and this would not be possible if there were a patient on the MRS. The pack is so large that it appears to be a better option to secure it to a pole or the rack front.

Restraint to the mini rack front
The D rings at the four corners of the pack allowed for fairly quick attachment to the rack front. This did not hold the pack tightly enough for it to be used as a work surface, but it did allow an adequate access surface for interior kits. After the pack was opened, there was no method of securing the flap and it tended to float up in the way. Upon opening the pack, a loose roll of tape floated out. It had been restrained with a velcro strip. Arm boards also floated out which had been placed in the pockets on the side of the pack. All CMOs agreed that mounting the pack to the rack front was the preferred method of deployment for the pack. This allowed easy removal and restowage of kits. The kits not in use remained secure within the pack due to the interior of the pack being covered with velcro. These all remained in place with attempts by the CMO to jostle them loose.

The only difficulty was in closure of the front flap of the pack. It required two hands and proper positioning of the CMO for bracing between the rack and the MRS. It was possible to do, but difficult. This should be avoided in future packs.

Restraint of kits to the patient restraint, and work surface:
Those kits which had large areas of velcro were much easier to secure to the work surface. It was difficult to match up the various shapes of velcro strips with work surface velcro strips. The spread out strips did not keep kits secured when items were deployed from within the kits. A large area of velcro to deploy the kits to is required. This could be provided by an additional area or use of the inside of the main pack flap. This will be very important for use the pack away from the HMF where there may not be an available adequate work area. Any large items within the kits or pack could be secured to the work area by velcro strips which would wrap around them. Rolls or cards deployed from the kits would be attached directly to the work area. If velcro is not desirous, the kits should have some method of secure attachment which will allow the CMO to access interior compartments and remove supplies without the kit becoming loose from its restraint.

Positioning the pack:
During this flight the pack was mounted on the front of the racks in a very low position. This should not be done on the space station. This position caused great difficulty in positioning the CMO to provide access to the contents of the pack. The pack should be mounted within arm reach (in any direction), of the CMO as they are restrained to the MRS. We placed one CMO down in an area as to allow access to the pack, and had them pass contents to the other CMO. Placement of the pack for rapid access for repetitive procedures is paramount, as this pack is designed to aid the CMO through life saving steps which are very time critical. We highly recommend rack mounting the pack, however not in an out of reach position.

Transport of the pack and possible accessories:
In an attempt to simulate transport of the pack and possible accessory items to a remote location within the station, all pieces were connected together with existing D rings and clips. This connection of separate units made them very difficult to control. All of the pieces need to be secured together to prevent each floating separately. The collection was easy to move around, and size was not a problem. Pulling the collection was much easier than pushing it along in front. A pole might prove to be a useful tool in this scenario, as when you arrive to where you are moving the collection, you

must have somewhere to place all of the packs. As these individual units are attached, the securing mechanism cannot interfere with the access to equipment in the main pack.

RECOMMENDATIONS:

An overall comment from each of the experimenters was that the ideal pack will be designed around the specific equipment to be contained within each kit. This will allow greatest access, conservation of stowage, ease of restowage, and confidence in usage by the CMO.

1. The entire bottom of each kit within the pack should be velcro as to allow better securement upon deployment.

2. Each kit with a flap which opens upon access should have a method for securement so as not to interfere with equipment access. This also includes the flap of the pack itself.

3. The interior of the pack and the flap should be covered with velcro to allow immediate access to a work surface. All examiners felt very strongly that the interior area covered with velcro worked very well.

4. The entire pack is so large that is should be restrained to the surface of the HMF or adjacent racks rather than the MRS. It should be restrained in an area of a rack which will allow easy access, i.e. not down too low or out of reach from where the CMOs are restrained with the patient.

5. The capability for securing the entire pack to a rack anywhere within the SSF is required for emergency deployment. The mechanisms for securing the pack are in need of further examination.

6. Transport equipment must be capable of securing together adequately to allow ease of movement. Pulling the pack was much easier than pushing the group. The pole or some similar method for coordinated movement should be pursued. This method cannot interfere with access to any segment of the pack for access.

7. Evaluation of various shapes and types of zipper openings should be performed. Openings which produce a long flap of material, must be secured. A U shaped zipper was suggested for evaluation.

8. Top flaps of kits should open such that practically the entire top of the kit is exposed. Items which are secured under a corner or strip of material are difficult to access (required two hands). Packs with one zipper in the center required two hands to access items - one to open and separate the halves of the kit and another to access the supply.

9. The roll provided the easiest access to equipment. The size of the roll should be no larger than the work surface area available to secure it upon. Each corner of the roll should have some method of securement. The roll should be designed around the equipment which will be placed within it, and the equipment should be placed in order of operational requirements. The roll should be designed as to allow one CMO to re-roll.

10. Stiffened cards should be evaluated. These could be backed with velcro to secure to a work area, or function as the work surface for other supplies. These might be designed as a "book". This method appears to work well for small items.

11. The use of mesh/net for covers of containment areas works well and should be maximized.

12. Elastic bands for containment of cylindrical items works well for one hand deployment or restowage.

13. Velcro strips which secure around large or odd shaped items works very well.

14. Placement of the waste containment kits one within the other worked well, and saved a large amount of space.

15. The IV kit should contain separate sections with all supplies for each IV start.

16. Pockets, if used at all, should not be deep.

17. See through fabric should be used as much as possible.

18. The pockets on the sides of the current prototype are too tight. If they are retained, they must be made somewhat looser.

19. When zippers are used, they should be easy opening (not sticking).

20. Numerous small items should not be placed within a pocket or container. If one is removed, they all float out.

21. The design of the drug kit (book with bands) worked very well and should be evaluated for other applications.

22. The PASG must be secured within its container as to allow controlled deployment and access. Possibly evacuation of some type of surface to coil the tubing around.

23. If the pack is mounted to the front of the rack, it should be secured tightly, and placed in a position to allow body level access. This position was preferable for access to the pack.

24. The backpack straps are not useful in microgravity and are not required for the pack.

25. The coding with bright colors of each kit was very helpful and is highly recommended.

26. Loops were very functional for access to rolls of tape. Snap loops appeared to function better than velcro ones.

27. Design of kits should allow for ease of access to all areas within the kit upon opening. Those kits which had a center zipper only did not allow for ease of access to all areas of the pack. (see hot pint kit)

28. If the use of velcro to secure kits to a work surface is not possible, the method of securing the kit has to allow for the CMO to access supplies within all areas of the kit, remove them, and the kit not become dislodged from its restraint.

29. A future flight with an actual operational use of the pack in an end to end deployment, transport, securing, access, and restowage will be required after further refinement of the prototype. (sometime in FY 92).

VENIPUNCTURE AND INTRAVENOUS INFUSION ACCESS DURING ZERO-GRAVITY FLIGHT

PRINCIPAL INVESTIGATORS:	Debra T. Krupa
CO-INVESTIGATORS:	John Gosbee Roger Billica Perry Bechtle Gerry Creager Joey Boyce
FLIGHT DATE:	April 27, 1990

JUSTIFICATION:

This experiment will establish the difficulty associated with securing and intravenous (IV) catheter in place in zero-g flight and the techniques applicable in training the Crew Medical Officer (CMO) for Space Station, as well as aiding in the selection of appropriate hardware and supplies for the Health Maintanence Facility (HMF).

OBJECTIVES:

- To determine the difficulties associated with venipuncture in a zero-g environment.
- To evaluate the various methods of securing an IV catheter and attached tubing for infusion with regard to the unique environment.
- To evaluate the various materials available for securing an intravenous catheter in place.
- To evaluate the fluid therapy administration system when functioning in a complete system.

INFLIGHT TEST PROCEDURES (CHECKLIST FORMAT):

Approach:

Set up of hardware including priming of the IV infusion set and infusion pump, sterile preparation of the selected infusion site, venipuncture and methods and materials for securing the IV catheter in place.

1. Hardware Deployment:

   - set up of IV fluid and administration set
   - set up of trash containers (sharp, wet and dry) restraint of patient
   - restraint of CMO
   - priming of administrating set
   - priming of infusion pump with set and fluid

2. Preparation of Insertion Site:

   - selection of appropriate peripheral vein for access
   - evaluation of appropriate method for restraint of extrmity for insertion
   - preparation of associated insertion supplies
   - aseptic preparation of the site

3. Insertion of the Catheter

   - venipuncture
   - evaluation of appropriate method for CMO restraint for insertion of catheter
   - attachment of the admisistration set
   - infusion of fluids

4. Securing the Catheter

   - selection of appropriate method for securing catheter
   - selection of appropriate method for securing tubing

5. Evlauation of system function

   - as a complete system from pump to patient

6. Discontinuation of Infusion

- the infusion will be discontinued and an appropriate dressing applied
- prior to landing
- restowing of equipment, supplies and trash

PARABOLA REQUIREMENTS, NUMBER AND SEQUENCING:

No special requirements for intervals and spacing between parabolas.

Parabolas 1-10

- Deploy and set up hardware and supplies
- Restraint patient
- Restaint CMO
- Priming of lines
- Evaluation of containment of supplies for access

Parabolas 11-20

- Preparation of insertion site and insertion supplies
- Insertion of catheter
- Connection to system
- Evaluation of restraint of CMO for insertion positioning

Parabolas 21-30

- Evaluation of placement and system function
- Securing of catheter by various methods
- Securing of tubing by various methods

Parabolas 31-40

- Repeat of any previous procedures which need further evaluation

TEST SUPPORT REQUIREMENTS (GROUND AND FLIGHT):

Space Required:	Full width of KC-135, and 10 feet of length
Load flight week:	One Mini Rack

Load flight day: video camera
carry on bag (ALS pack) containing medical supplies,
IV fluids, attachments, and catheters
IV pump
ambulance stretcher

Power requirements: 110 VAC for IV pump backup capability

DATA ACQUISITION:

- In flight written checklist
- self report post flight
- videos

MANIFEST: Debra T. Krupa-DK (KRUG)
John Gosbee-JG (KRUG)
Roger Billica-RB (KRUG)
Perry Bechtle-PB (KRUG)
Joey Boyce-JB (NASA)
Stan Koszelac-SK (NASA)

PHOTOGRAPHIC REQUIREMENTS:

Non-dedicated still video photography

PROJECTED RESULTS:

The requirements of adaptation to microgravity may require some changes in technique for both venipuncture and securing in place an indwelling IV catheter and tubing. We expect to determine appropriate techniques for placement and securing them. We expect also to document the correct function of the IV fluid therapy system in a simulated clinical situation of zero gravity.

STRUCTURAL LOAD ANALYSIS: See HMF Mini-rack experiment (1-24-90)

ELECTRICAL LOAD ANALYSIS: See HMF Mini-rack experiment (1-24-90)

HAZARD ANALYSIS/SAFETY:

1. Potentail Hazard: Loose items may float free from drawer or pack

   Response: Only one item at a time will be deployed from the draweror pack at a time. All items which are deployed will berestrained to the patient restraint. Items which become free incidentally will be retrieved by a designated experi-menter before they float from the area.

2. Potential Hazard: Fluid could float free from insertion site

   Response: One experiment will be designated to remain at insertion site with access to area to contain released fluids with guaze pads. The IV set will be flushed into a guaze pad to clear the line and prevent any fluid from being released into the environment.

3. Potential Hazard: Catheter has needle for insertion which could causepuncture wound to experimenter

   Response: All catheters will be standard medical equipment which comply with medical and surgical safety standards. The catheter will be restrained in its packaging when not in use, and will be deployed by an experienced medical care provider who is trained in its use and has had years of experience of use with this instrument in an aviation environment. The used needle will be disposed of in a specified "sharps" container.

INFLIGHT WORKSHEET KC 135 FLIGHT EVALUATION VENIPUNCTURE AND INTRAVENOUS INFUSION ACCESS DURING ZERO GRAVITY FLIGHT

PREFLIGHT:

Load equipment onto KC 135 and secure

- video camera
- restraints for investigators
- waste disposal containers solid, wet, and sharp
- IMED pump
- IV section of ALS pack containing:
  - IV solution (ringer's lactate)
  - IV catheters x 4
  - fluid administration sets x 2
  - site prep
  - tape
  - 4 x 4
  - tourniquet
  - bandaid
- ambulance stretcher
- sterile gloves

Bungee cords were placed on the floor of the aircraft in the appropriate position for restraint of the CMO, the photographer, and assistants. Each person in the team reviewed the portions of the flight that they were responsible for, and a dry run through of the procedure occurred with each CMO. The restraints for the patient were reviewed and adjusted. Padding was placed within the litter for comfort of the patient.

The introductory video portion was recorded prior to take off after securing the equipment and supplies.

BEFORE PARABOLAS BEGIN:

Deploy ALS pack and supplies, and secure to side of stechter

The ALS pack and IV pump were destowed and secured to the area right next to the stokes litter. They were secured into place with tie down straps

and rings. The ALS pack was opened and held in place with bungee cords.

Secure patient to stretcher

The patient (RB) chose not to remain within the litter during the set up procedures. He chose to wait until after the pump was set up before being secured within the litter. One last review was made of the placement of the restraint straps.

Secure waste containers within easy access of CMO

The waste container was placed along side of the mini-racks. An assistant will remain next to the CMO to manage trash. A large waste bag was taped to the side of the aircraft for wet trash.

Secure CMO and assistants

After a last check of placement of all equipment, the CMO and assistants gained their positions for the flight. The CMO (DK) was restrained by bungee cords over her heels, and had access to a waist restraint to the side of the litter if required. The camera operator was placed on the opposite side of the litter with similar restraints. Various restraint straps were placed to allow movement of the assistants around the experiment area.

Recheck video placement

The camera operator once again reviewed distance and placement to assure optimal recording of events.

BETWEEN SETS OF PARABOLAS:

Dispose of waste materials

There was some difficulty with the waste container chosen for the flight. It was made of large wire mesh, and did not contain many of the numerous small (2-5cm) items generated by this experiment. The pockets of the flight suit were often used for this purpose.

Alter CMO and protocol as required

- After successful insertion of the catheter by DK, PB was positioned to

attempt the second placement.

- Due to difficulty with purging the tubing, it was decided to use the same fluid bag and tubing on the second attempt.

- There were also changes in the sequencing of parabolas, and various procedures were completed in other parabolas than those scheduled. All procedures were completed.

- Due to the second patient becoming ill during the flight, RB was the patient for both insertions.

- There was a difficulty with the function of the IV pump during the second insertion attempt, and the set was not run on the pump for this insertion. The bag was placed in a pressure bag rather than on the pump.

KC-135 VENIPUNCTURE WORKSHEET:

Procedures were completed only within the microgravity portion of flight except where stated otherwise.

Parabolas 1-10

Deploy Supplies

DK accessed the ALS pack for the supplies for insertion. The IV fluid and administration set were removed. The IV pump was turned on and appropriate settings placed. The pump was set for administration of a 500cc bag of ringer's lactate at 125cc/hour. There were no difficulties with this procedure.

IV administration set up and prime lines

DK removed the fluid and the administration set from the storage bags. The bags were handed to the assistant for disposal. The tubing was then uncapped at the spike end, and the fluid bag insertion port uncovered. The cap covers were released to float free, as there was no method for containment of such small items. The tubing was then connected to the fluid bag with the clamp in place. During this attempt, the tubing, which is quite long, floated rather freely and followed the air currents of the aircraft. This could prove

to be a problem with certain procedures.

The line was opened to permit priming the administration line (IV tubing). This was more difficult than anticipated. It was very hard to squeeze the bag to force the fluid throught the tubing. The purging of the tubing took 3 parabolas. The set was then placed within the pump and placed on standby for insertion.

The fluid bag was velcroed to the side of the pump, which worked very well. The tubing was allowed to float free until needed. (As it was connected to the pump, there was no danger of losing access to the tubing.)

At this point the patient (RB) secured himself within the litter.

Parabolas 11-20

Preparation of site and insertion supplies

The start kit was velcroed to the pump for ease of access to its contents. The tourniquet was removed and placed on RB's left arm the elbow. Strips of transpore tape were prepared, and placed on the pump for easy access after insertion. The site was prepped following standard medical protocols with a betadine swab and an alcohol swab. The catheter was removed from the package, and protective cover. These were handed to the assistant. A #18 guage angiocath was used for the insertion.

Insertion of catheter

The catheter was placed by DK in a vein in the dorsal vein of the hand. There was rapid blood return into the catheter hub. DK held 2x2 of guaze in place in preparation for control of blood return, however this was not needed. The catheter was threaded into place over the needle with no difficulty. The insertion occurred on the first attempt.

Connection to system

The tourniquet was released and DK accessed the end of the tubing for connection to the catheter. DK placed her left thumb over the insertion site to hold pressure, and then removed the needle from the catheter with her right hand. The needle was placed (inserted) into the cloth of the litter for

containment and protection. The tubing was then connected by DK with her right hand onto the catheter. Upon securing the connection of the tubing and the catheter, a small amount of IV fluid was released onto RB's forearm which was absorbed by DK with the guaze.

Activation of the system

The catheter was taped into place with a preliminary strip of tape across the catheter. DK then activated the pump. The pump infused well at the set rate of 125 cc/hour, and no problems were noted.

Securing of catheter and system

The catheter and tubing were then secured into place by DK. Transpore tape was placed by DK following standard medical procedure. Betadine ointment was placed over the site and a bandaid for coverage. The tubing was secured to the forearm.

Evaluation of the system

RB then moved his arm through all axis of rotation and movement. He placed his arm in various positions relative to the pump, and no difficulty in function was noted. RB denied any pain or discomfort. The pump functioned properly through all movements and continued to administer fluid as programmed.

Evaluation of restraint of CMO and patient

The restraint of the CMO in a kneeling position beside the patient worked well. DK reported that one heel was placed within the bungee cord and one remained free. DK reported that with the sloped side of the stokes litter, she was able to additionally stabalize her position by bracing her left leg against the litter. RB reported that the buckle straps across his legs and hips held him well in proper position. RB was able to hold his arm in the proper position for insertion, and the padding on the side of the litter prevented any discomfort.

Parabolas 21-40

Removal of catheter

The pump was placed on standby, and the clamp closed on the tubing. DK

removed all of the tape except the last strip over the catheter. DK then placed a 2x2 on the insertion site with her left hand. As the catheter was slid out of the vein by DK with her right hand, the 2x2 was placed over the site with pressure by DK with her left hand. There was no blood loss, and no fluid leakage from the catheter.

Dressing placement

A small pressure dressing was placed over the site in RB's left forearm.

Repositioning of CMO and patient

RB was then released from the litter while an alteration of CMOs and supplies was performed. Wet and sharp trash was disposed of properly. The IV pump was turned off. During this period there was an unplanned change in sequencing of parabolas which allowed ample time for exchange of CMOs.

PB assumed the role of CMO, and RB repositioned himself in the litter to allow access to his right arm. Due to the difficulty with priming the bag and tubing, it was agreed upon by the gruop that the same IV administration set and bag would be used for the second attempt.

Preparation of site and supplies

The same procedure as above was followed for preparation of the insertion site for the second attempt.

Insertion of catheter

A different catheter was used for the second attempt. A #18 guage atheter with needle/guidewire was used. This type of catheter protects the CMO from any contact with the patients body fluids.

Again there was no difficulty in insertion of the catheter. A rapid blood return was noted into the tubing of the catheter, and the guidewire was removed.

Connection to system

The fluid port was connected to the system, and the fluid bag squeezed to initiate fluid passage. There was no difficulty in administration of the fluid.

Securing of catheter

The catheter was secured following standard medical procedures.

Evaluation of system

The IV pump was not used on this attempt due to mechanical difficulty. The istillation of fluids occurred easily with pressure placement upon the fluid bag. No difficulties were noted with the administration of fluids through the tubing, catheter and into the vein.

Removal of catheter

PB placed a 2x2 over the insertion site and removed the catheter as done in the previous attempt. No loss of fluids was noted.

Dressing placement

A small pressure dressing was placed over the insertion site by PB.

Repeat of previous procedures as required for further evaluation

Multiple attempts were made throughout the remainder of the flight by all experimenters to have the IV pump function. No success was achieved. It was decided that this would be discussed post-flight with the subsystem engineer.

Stowage of supplies and equipment

The waste (all types) was disposed of appropirately. All supplies were replaced within their containers. The ALS pack was closed, and the IV pump turned off.

RESULTS AND OBSERVATIONS:

Photography:

Stills:
Still photography of this flight provided numerous photos, however numerous of them are from too distant a viewpoint to provide adequate resolution of the IV access area.

S90-36478
The HMf miniracks with our stowed equipment. The drawers are interchangeable, and those in place for this flight contain the equipment and supplies we need for the IV flight.

S90-36466
Photo of the setting for the IV insertion. The litter is secured to the floor of the aircraft with padding for comfort of the patient, and the IV pump is secured to the floor adjacent to the head of the litter. DK is performing a preflight check of the pump prior to the start of the experiment.

S90-36547
DK is preparing the IV fluid and tubing for insertion. DK is restrained by bungee cords across her ankles. The IV pump is secured by bungee cords and floor holds. In the background is the transport pack with the equipment required for the flight restrained by bungee cords.

S90-36546
DK is attempting to insert the IV tubing into the fluid bag. Note the velcro on the IV bag to allow ease of securing the bag to the side of the IV pump. The tubing is free floating, and frequently got in the way. Management of the various cap covers was difficult.

S90-36545
DK is preparing to spike the fluid bag with the IV tubing.

S90-36539
DK is flushing the tubing with IV fluid prior to placement on the pump. The IV bag is squeezed to push the fluid through the tubing in zero gravity. RB is in the foreground.

S90-36491
RB is secured into the stokes litter. DK is placing the tourniquet on his left arm. PB is in position on the left of the photo for video of the experiment. PB is held in place by bungee cords over his ankles, as is DK. JB is watching from in front of the mini racks. The trash container (fish trap) for the flight is in the right side of the photo.

S90-37536
RB is secured into the stokes litter. His left arm has been prepared for insertion and the tourniquet is in place. DK is opening the package of the catheter.

S90-36535
DK is inserting the 18 guage catheter in RB.

S90-36534
DK has inserted the catheter into the vein and is threading the catheter into position. Note the blood return is visible in the catheter hub.

S90-36533
DK is holding RB's hand steady. The catheter is in position with the needle remaining in the hub as the tubing is prepared for connection. The tourniquet has been released. DK is removing the tip cover from the tubing to connect it to the catheter.

S90-36532
DK is securing the catheter in place with tape as RB looks on. (poor camera position). The tubing has been connected to the catheter.

S90-36487
DK has inserted the catheter and is completing securing the tubing into place. Betadine ointment was placed over the site and covered with a band aid and tape. Transpore tape was used to enable veiwing of the site.

S90-36530
PB is attempting insertion of the catheter in RB right hand. DK is preparing the pump.

S90-36531
PB is threading the catheter into position.

S90-36529
PB is connecting the IV tubing to the catheter tubing.

S90-36528
PB has released the tourniquet. The catheter butterfly is taped into place. The remainder of the tubing is free floating.

Video:

NASA master reference #117806. Video was reveiwed by the experimenters. The quality of the film was good. Observations derived from the video are included with discussion in this report.

CONCLUSIONS:

The placement of an intravenous catheter in microgravity is easily accomplished by someone who is well trained and current in the skill. The procedure is a representative task of one very likely to occur on the space station, and would be easily utilized for micrgravity training for the CMO prior to duty on the space station. It will give the crew a good perspective of integration of procedures in zero gravity, and can be easily accomplished with the restraints imposed by parabolic flight. It utilizes the understanding and techniques required for CMO restraint, equipment access and utilization, supply management, waste disposal, fluid containment, trouble shooting, human-machine interface, and patient positioning.

1. **Determine the difficulties associated with venipuncture in a zero-gravity environment.**

   The proper placement and restraint of the CMO and patient for this procedure are essential for successful completion of the skill. If these are provided, the skill itself is dependent upon the CMO's capabilities for performance. The technical performance of the insertion of the catheter is not different than in one gravity. Due to the microgravity environment, it requires that the CMO be very organized, and maintain all possible supplies required within easy reach. The venipuncture itself is highly dependent upon the current tchnical skill of the CMO for successful completion.

2. **Evaluate the various methods of securing an IV catheter and attached tubing for infusion with regard to the unique environment.**

   There appeared to be no unique method required for securing the catheter and tubing in microgravity. The techniques used for securing the IV which are used prior to terrestrial based transport are appropriate for use in the microgravity environment. The tubing floats free where not restrained, but unless there is an area of which it should not enter, or the patient will be moving around a great deal, this should not be a problem. If there is a possibility of the tubing becoming. If there is a possibility of the tubing becoming entangled in another piece of equipment, or becoming dislodged; the tubing should have extra tape placed for security. If preferred a guaze roll could be placed on the arm to hold extra tubing in place.

We also felt that placement of velcro on the IV fluid bag worked very well for securing the fluid in place.

3. **Evaluate the various materials available for securing an intravenous catheter in place.**

   We recommend the use of transpore tape. This tape is easily torn to the preferred size and shape for application and it is transparent. It also is easily removed, but has appropriate sticking ability.

4. **Evaluate the fluid therapy administration system when functioning in a complete system.**

   The two major difficulties with the flight were: 1) the difficulty in priming the fluid administration set with the fluid bag, and 2) the mechanical problem of the IV pump on the second insertion attempt. Other than those two occurrences, the flight went very well. The system works well from end to end. After insertion of the catheter, the pump functioned well with installation of fluid during various movements of the patients extremity. There were no problems. The pump was easy to set up and activate. The fluid administration set was simple to use and install into the pump. Both IV catheters functioned well. Preference of the CMO appeared to be the only difference in use. The guidewire catheter did appear to contain all fluids well. The angiocatheter did not contain the drainage of fluids, the technique of the CMO prevented the fluid drainage.

RECOMMENDATIONS:

1. There must be a method for collection and management of the numerous small tip/cap covers on the various ends of tubing and fluid bags. This should be incorporated into any future flights which deal with fluid administration. Possible areas of investigation are use of double stick tape or a foam block with slits.

2. It is recommended that all future filming of a flight have a breif introduction by the PI prior to the flight. This sets the tone for the video and explains what will occur throughout the video. It aids the veiwer in understanding the content of the flight, and alleviates the need for a script or worksheet to follow the purpose of the actions which are occurring.

3. The tubing for the administration set floated very freely, and if this had been a sterile procedure would have contaminated the area. A method for control of the tubing should be pursued.

4. There should be a method of securing the fluid bags to the pump. Velcro placed on the exterior of the fluid bags and on the side of the IV pump worked very well.

5. The fluid bag was difficult to purge, and this should be investigated further to discover the cause. This should be designed out of all bags for use at the HMF.

6. The venipuncture itself was no different than a venipuncture in one gravity.

7. One important factor in assurance of success of the venipuncture is the stable restraint of the CMO and the patient.

8. Use of an extension set at the catheter site would facilitate exchange of various tubing sets.

9. Turn the IV pump off prior to removal of the catheter. The surface tension of the fluid in the line will prevent fluid drainage or escape.

10. The pump failure on the second insertion attempt was later discovered to be related to placement of the pump on the floor of the aircraft, and pressure against the audio switch. This feature placement on the posterior of the pump should be removed from the design. A similar situation could easily occur on space station. All switches and buttons should be on the front, and should be protected from accidental activation.

11. The access to the numerous small items required for venipuncture preparation requires the appropriate packaging and collection of contents. This should be investigated with one-gravity simulations to determine the exact content of such a collection. The collection will have to be placed within easy reach of the CMO. A method to assure this access should also be determined. We were able to velcro the start kit to the pump, and had pre-taped all of its contents inside in the appropriate order of use. This should be followed upon for future flights.

12. The guidewire catheter functioned very well for intravenous access, and offers the added assurance of fluid containment. It should be considered stongly for use at the HMF.

13. Training of the CMO for this skiln be accomplished easily in one-gravity. However, this is an ideal skill for instruction in microgravity which integrates numerous concerns for restraint, supply access, waste management of all types (wet, dry, and sharp), fluid containment, equipment activation, and patient positioning.

EVALUATION OF CARDIOPULMONARY RESUSCITATION TECHNIQUES IN MICROGRAVITY

PRINCIPAL INVESTIGATOR:	Roger Billica, M.D.
CO-INVESTIGATORS:	John Gosbee, M.D. Debra Krupa, B.S.N., M.S..
FLIGHT DATE:	May 1, 1990

PURPOSE:

To investigate cardiopulmonary resuscitation (CPR) techniques in microgravity with specific application to planned medical capabilities for Space Station Freedom (SSF.)

OBJECTIVES:

- Evaluate CPR using the variety of techniques that have been envisioned as possible aboard SSF, including utilizing the medical restraint system (MRS), a flat surface, and free-floating.
- Compare the effectiveness of the studied techniques in both subjective and measureable ways.
- Provide additional information on interfaces and requirements that will assist in current planning and design of medical equipment and facilities for SSF.
- Specifically evaluate the use of a cardiac compression assist device (CCAD) as a means of increasing crew mechanical efficiency in 0-G and as a way to reduce fatigue while performing CPR.
- Begin to establish operational protocols for the performance of basic life support aboard SSF.

OVERVIEW:

A KC-135 parabolic flight test was performed on May 4, 1990 with the goal of evaluating and quantifying the efficacy of different types of microgravity CPR techniques. The flight followed the standard 40 parabola profile with 20-25 seconds of near-zero gravity in each parabola. Three experimenters were involved in the study. Each one was chosen for their clinical background, certification and practical experience in basic and advanced life support, and their experience in prior KC-135 parabolic flight.

The CPR evaluation was performed using a standard training mannequin (recording resusci-Annie) which was used in practice prior to the actual flight. Aboard the KC-135, the prototype medical restraint system (MRS) for the SSF Health Maintenance Facility (HMF) was used for part of the study. Standard patient and crew restraints were used for interface with the MRS. During the portion of the study where CPR was performed without the MRS, a set of straps for crew restraint similar to those currently employed for the Space Shuttle program were used. The entire study was recorded via still camera and video.

The sequence for the study was as follows:

- 1-gravity (1-G) one-man and two-man CPR using MRS aboard KC-135 to establish baseline.
- 0-G one-man and two-man CPR using MRS in traditional method.
- 0-G two-man CPR using patient straddle technique
- 0-G two-man CPR using MRS with cardiac compression assist device (CCAD) prototype.
- 1-G one-man and two-man CPR using the KC-135 floor (without MRS) to establish baseline.
- 0-G one-man and two-man CPR using KC-135 floor and variety of restraint positions (lateral and patient straddle).
- 0-G one-man and two-man CPR during free float (using Heimlich-type technique.)

The major conclusions resulting from the study include:

- A reaffirming of the fatiguing nature of performing CPR in 0-G and of the difficulting in attempting CPR without adequate patient and rescuer restraint.

- With proper training, restraints and experience (including 0-G) it appears possible to provide adequate CPR using a variety of techniques and positions.

- A properly designed CCAD could have a definite role in improving the rescuer's ability to provide effective CPR in 0-G especially over extended periods of time.

BACKGROUND:

The possibility of sudden cardiac death aboard Space Station Freedom, although remote, should be considered and prepared for as much as reasonable resources will allow. With the initiation of prolonged stays in microgravity it is anticipated that there will be some degree of fluid and electrolyte changes and cardiovascular deconditioning in the crew. Coupled with the chance of trauma, burns or decompression sickness, the risk of a significant cardiac insult or arrythmia becomes one that warrants preparation.

Historically through the current Space Shuttle program, the degree of emergency cardiac care available consisted of Basic Life Support (BLS). BLS either (1) prevents circulatory or respiratory arrest through prompt intervention and early entry into higher levels of medical care or (2) externally supports the circulation and breathing of a victim of cardiac and/or respiratory arrest through CPR. CPR that is performed properly and promptly can give victims the time to receive treatment by advanced medical techniques. With the SSF HMF, for the first time in the US space program, resources are being planned that will provide the capabilities to carry on from BLS into advanced life support (ALS).

To maximize chances of survival, the delay from onset of cardiac arrest until CPR and definitive care should be kept as short as possible, ideally to less than 4 and 8 minutes, respectively. The outcome for cardiac arrest, whether or not CPR has been applied, is dismal if ALS is delayed beyond 8 minutes. CPR should be initiated only when a defibrillator is not immediately at hand or after initial shocks have failed to restore spontaneous circulation.

The Space Shuttle program currently employs a system for performing CPR that has been tested on manikins aboard KC-135 by physicians and physician-astronauts. (No formal documentation of this testing is available other than video tapes of the flights.) This system has also been evaluated informally during actual Shuttle flight. The Shuttle CPR system consists of a standard anesthesia breathing mask attached to a pressurized oxygen system that will initiate air flow with a simple trigger mechanism. It requires that mannual airway positioning be accomplished with each breath. The actual performance of external cardiac compression is assisted through use of straps to secure the patient to a flat surface and an adjustable waist harness to secure the rescuer in close proximity to the patient. As with all restraint mechanisms, time is required to utilize them properly and is dependent upon operator familiarity.

Concerns reported about the Shuttle CPR system focus around the rapidly fatiguing nature of the system, the awkwardness of the rescuer positioning, and the lack of any advanced life support resources to follow-up with.

The SSF Health Maintenance Facility is currently planned to include portable monitoring, defibrillation, external cardiac pacing, IV fluids and medications consistent with American Heart Association Advanced Cardiac Life Support (ACLS) standards. Resources will also be provided for airway stabilization, intubation and mechanical ventilation.

With these advanced medical resources available, it is more imperative than ever that the techniques and protocols for adequate CPR in microgravity be established in order to lay the foundation for effective ACLS should ever the need arise.

MATERIALS:

- Recording Resusci-Annie (standard CPR mannequin)
- Medical Restraint System for SSF HMF (prototype)
- Cardiac Compression Assist Device (CCAD) (prototype)
- Straps for mannequin and rescuer restraint
- Photography and other recording materials

PERSONNEL AND SUPPORT:

- 3 investigators and 1 recorder

- Video recording performed by recorder, still photography performed by non-dedicated NASA photographer.

TEST PROTOCOL:

All procedures were performed first in the HMF ground lab for familiarization.

CPR using the MRS
Mannequin is strapped to the flat MRS in a supine position with the MRS positioned at just below waist height for the operators. Operators are initially restrained using foot loops attached to the floor grid and with waist restraint straps attached to the edge of the MRS.

- *MRS CPR in 1-G*
  Prior to the 0-G parabolas, one and two-man CPR is performed and recorded to establish baseline measurements.

- *MRS CPR in 0-G*
  With operator positioned at side of mannequin in the tradional CPR location, perform one-man CPR. Second operator joins and performs respirations while first operator continues chest compressions. (Each operator has opportunity to try various skills.)

- *Straddle MRS CPR in 0-G*
  With mannequin still strapped to MRS, operator approaches MRS without using restraints and positions himself by straddling MRS at the manikin's thighs and by holding on to the edge with one hand at the level of the manikin's sternum. Chest compressions are performed by applying pressure with the single free hand in proper sternum position (using the restraining hand for leverage.)

CPR with CCAD
With mannequin still strapped to MRS, attach prototype CCAD to edge of MRS at right of manikin's sternum. One operator continues ventilation while second operator uses lever system of CCAD to perform external cardiac compression.

CPR using floor of KC-135
Strap mannequin to floor of KC-135 and perform CPR using a variety of

positions and restraint techniques.

- *Floor CPR in 1-G* — perform one and two-man CPR during 1-G portion of flight to establish baseline measurements.

- *Floor CPR in 0-G in side position* — perform one and two-man CPR with the chest compressions given from the side of the mannequin using waist harness restraints similar to the current Shuttle system.

- *Floor CPR in 0-G in straddle position* — perform two-man CPR with chest compressions performed by the operator straddling the mannikins thighs. Attempt to find best restraint arrangement. Compare two-handed to one-handed chest compressions.

CPR Free-Floating
loosely restrain one of the operators to the floor of the KC-135 and allow that operator to manually maintain control of the free-floating mannequin.

- *One-man CPR Free-Floating* position the mannequin as if performing a Heimlich maneuver but position the hands properly to perform external cardiac compressions. In proper sequence with the compressions ventilate the patient by acquiring control of the head/neck and airway, then return to chest compressions.

- *Two-man CPR Free-Floating* - with the first operator and mannequin positioned as before, have the second operator assist by giving the respirations while unrestrained.

RESULTS:

1. **MRS CPR in 1-G** (Fig. 1 and Fig. 2) – As in the ground lab, effective CPR using the MRS was fairly simple and straight forward. No difficulties or complications occurred in 1-G aboard the KC-135 as opposed to in the ground lab.

2. **MRS CPR in 0-G** (Fig. 3, Fig. 4 and Photo 1) – Effective CPR was accomplished using the MRS with the standard technique. Since the operators required restraint to the MRS, there was increase time delay in changing from chest compression to ventilation during the one-man effort. Since body weight was not a factor in delivering the cardiac compressions, it was necessary to lower the MRS to a height equal to mid-thigh to obtain the most efficient leverage for cardiac compresssion.

(In 1-G much of the force for cardiac compression comes from the rescuer's body weight. Therefore, with no gravity and no body weight, all the force must be delivered through use of the rescuer's muscles. With the table lowered, the leverage and the the larger muscles of the abdomen and thighs could be used to assist in delivering compressions, as opposed to relying solely on the arm and shoulder muscles with the MRS at the standard height.)

3. **Straddle MRS CPR in 0-G** (Fig. 5, Fig. 6 and photo 2) – The straddle technique proved to be quite effective in delivering rapid and reliable cardiac compressions. By grasping the edge of the MRS with one hand, the rescuer could use his complete upper body as a fulcrum to deliver compressions through the other hand (keeping the arm locked in a fully-extended position.) Hand position over the sternum did not appear to be a problem.

4. **CPR with CCAD** (Fig.s 7,8,9 and photo's 3 and 4) – It was readily noticed in the previous techniques that the rescuer performing chest compressions became fatigued quite rapidly due to having to rely solely on muscle strength and endurance (in the absence of gravity.) It was also noticed that having to be restrained next to the mannequin to perform standard two-handed chest compressions made it difficult to perform the alternating compressions and ventilation in one-man CPR (although not impossible.) The CCAD prototype made it possible to perform the cardiac compressions while using only one hand. This leverage system not only reduced fatigue and made it more likely that CPR could be continued for prolonged effort by the same individual, but if freed up the rescuer's other hand to perform airway stabilization and ventilation using a bag-mask system.

   The difficulties encountered with the CCAD prototype centered mainly on the awkwardness of maintaining the pad's contact with the manikin's chest. This resulted in the need to frequently reposition the lever pad to maintain proper sternum alignment. In the absence of gravity, the pad tended to float free from the chest between compressions unless the operator maintained a certain amount of sternal pressure with it throughout the cycle. In doing so, the recordings indicated that there was not always complete relaxation of the thoracic pressure in between compressions.

   The bouncing nature of the CCAD also tended to move the mannequin around on the MRS even with the restraining straps. The movement

was not a lot, but it was enough to require the operator giving ventilations to reposition the head/neck and airway frequently.

- *Floor CPR in 1-G* (Fig. 10 and 11) – There was no difficulty performing standard CPR in 1-G with the mannequin strapped to the floor of the KC-135.

- *Floor CPR in 0-G in side position* (Fig 13, 15 and photo 5) – It was possible to perform adequate CPR on the floor in the standard position using the shuttle strap system. However, this proved to be the most fatiguing of all the techniques. It was difficult to find the best alignment of the straps to enable efficient leverage and use of the body muscles. It was also quite hard on the knees.

- *Floor CPR in 0-G in straddle position* (Fig 12, 14 and photos 6-10) – A variety of techniques were attempted using different angles and combinations of restraints. Most efficient was placing a restraint strap across the calves in addition to the waist straps (photo 6) but this took longer to set up. Using one hand as restraint and one hand for compression was also effective and less fatiguing (photo 7 and 8). Overall this method was fairly equivalent to the floor-side technique, was more tiring than others, and the exact technique of preference varied between the different operators.

- *One-Man CPR Free Floating* (Fig 16 and 17, Photo 11 and 12) – Once the hand positioning was established this method proved to be equally effective as standard techniques. It required a greater amount of physical effort but was less fatiguing in other ways (less strain on the back and hamstrings.) Control of the unrestrained mannequin was achieved without great difficulty, and as long as contact was maintained, it was simple to establish head/neck and airway control for delivery of ventilations. Giving ventilation this way created minimal stability of the neck and clearly would be inappropriate for any patient with possible head or neck injury.

- *Two-Man CPR Free-Floating* (Fig 18, Photo 13 and 14) – With one operator controlling the patient and giving chest compressions, the second operator was able to assist with adequate ventilations. Some team work and coordination was required, but within a few practice sessions this method was accomlished with good efficiency. Less strain on the patients neck was delivered with the two-man method because the first operator always provided a stable support of the mannequin with his own body as a stabilizing surface.

DISCUSSION:

The key concerns in providing effective CPR are those of quick response and adequate technique. Both of these issues are especially challenging in the zero-gravity environment. First of all, it is imperative to stabilize the patient to establish an airway and restrain him or her against a firm surface in order to administer cardiac compressions. To accomplish these tasks in a rapid manner the SSF crew will have to be very familiar with CPR principles and acquainted with optional methods that can be adapted to the variety of locations and situations that might occur aboard Space Station Freedom. This study has shown that all of the methods tested were able to produce effective results on the mannequin, especially after brief practice and orientation to the new positions. It is conceivable that several of these methods might be employed in any given scenario as the situation progresses from initial discovery of the victim, to provision of restraints, throughrelocation to the MRS at the Health Maintenance Facility. Therefore it seems prudent to include a variety of methods in crew training to allow for greater flexibility in emergency response.

In the majority of the medical studies done on the KC-135 it has become abundantly clear that the need for adequate and adaptable restraint for both the patient and medical officer(s) is a priority. This point holds true for administration of CPR as well. However, this study demonstrated that it appears feasible to perform CPR for limited periods while free-floating using a Heimlich-type position for patient stabilization and cardiac compressions. This situation may be encountered during initial contact with the victim while awaiting provision of restraints or relocation to the HMF.

One other significant concern revisited in this study is that of operator fatigue while performing CPR. Fatigue is reached quite rapdily in 0-G due to the lack of weight for force and due to the sole reliance on muscle strength. All of the operators tired in a matter of a few minutes, and this occurred in fit individuals who have not been deconditioned due to prolonged spaceflight. With the provision of ACLS resources on SSF, it is critical to be able to support the patient with CPR for prolonged periods while the advanced techniques have time to create effect. Therefore it was interesting to see the possible uses of a prototype Cardiac Compression Assist Device. The concept of a CCAD appeared to be very valuable in increasing the mechanical efficiency of cardiac compressions, thereby reducing fatigue. A secondary benefit was realized of leaving one hand free that could be used to administer ventilation with the bag/mask, thus freeing up the second

crewmember for other medical tasks. There were some problems with the prototype used especially in maintaining adequate contact and position with the patient's sternum. These issues would benefit from further investigation.

Overall this evaluation of cardiopulmonary resuscitation techniques in microgravity reaffirmed the concerns about operator fatigue and the need for adequate restraint, demonstrated that a variety of CPR methods and positions appear feasible for SSF, and illustrated the potential benefits of a cardiac compression assist device to increase mechanical efficiency.

RECOMMENDATIONS:

- It is recommended that prototypes for a CCAD be included in further evaluation and developmental effort. A CCAD should be considered strongly as a component of the emergency medical equipment for SSF. Adequate testing would be required to assure compliance with American Heart Association standards and patient safety issues.

- It is recommended that the crew receive CPR training that includes familiarization with the variety of methods and positions that could be adapted for SSF scenarios.

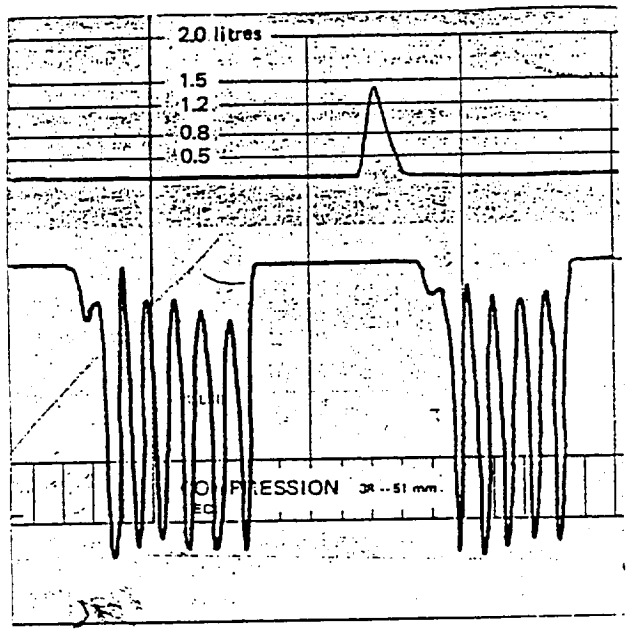


Figure 1.

One-man CPR using the MRS in 1-g during flight.

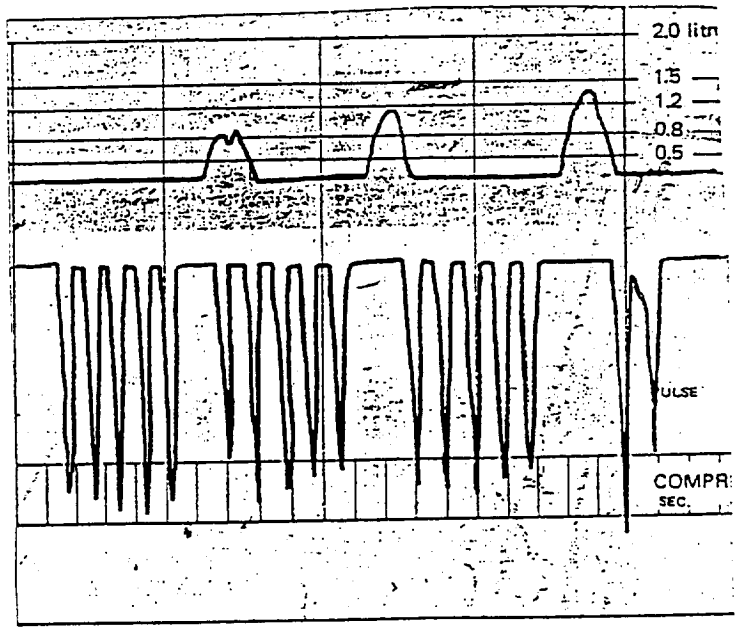


Figure 2.

Two-man CPR using the MRS in 1-g during flight.

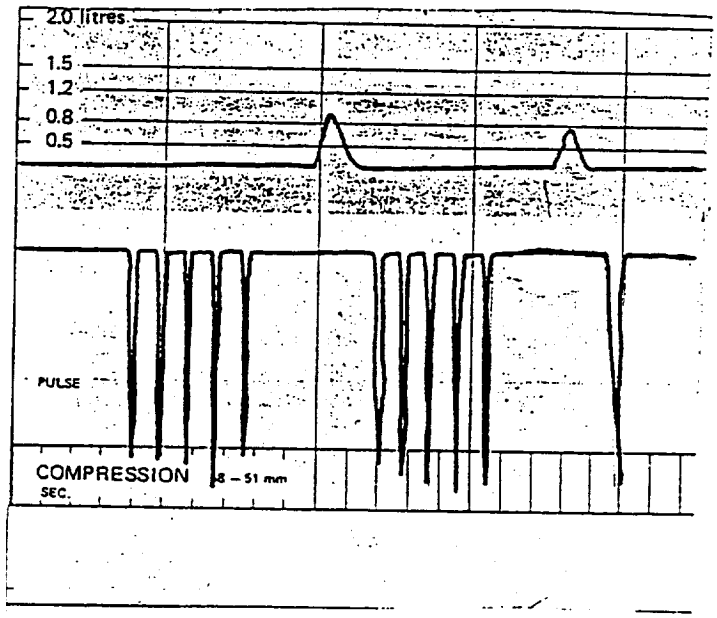


Figure 3.

One-man CPR using the MRS in 0-g. Notice the slight delay in giving ventilations after stopping chest compressions.

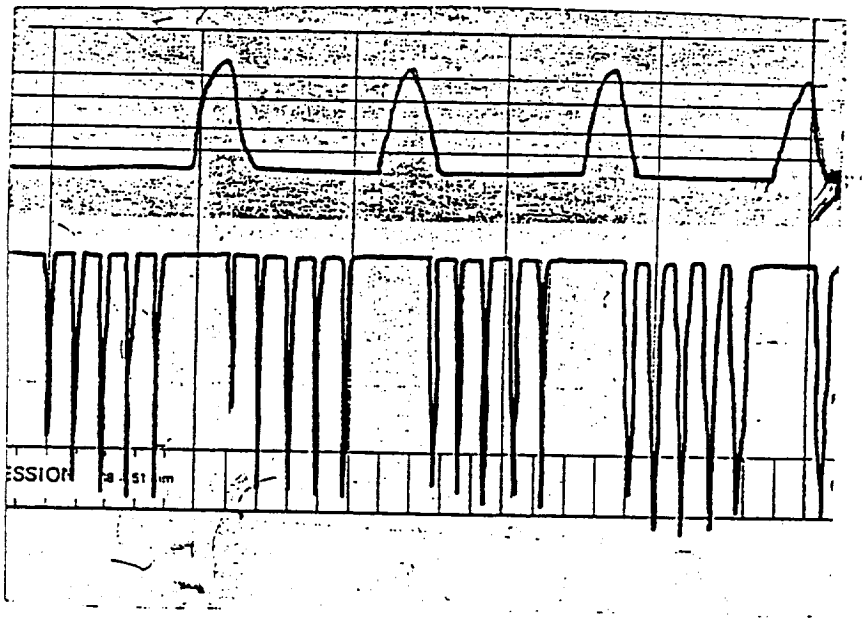


Figure 4.

Two-man CPR using the MRS in 0-g during flight.

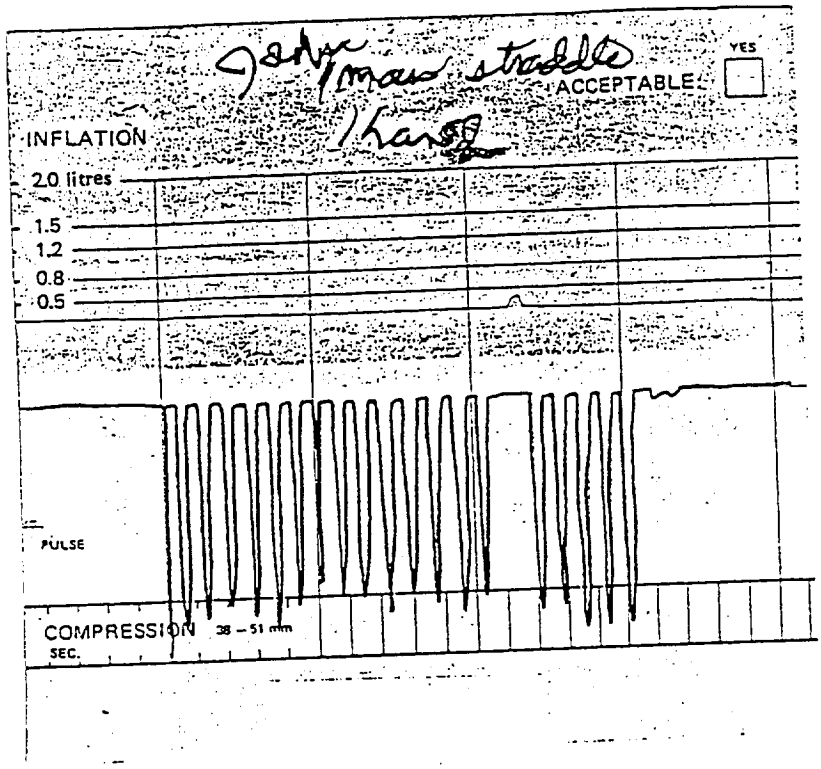


Figure 5.

Chest compressions in 0-g while straddling the MRS.

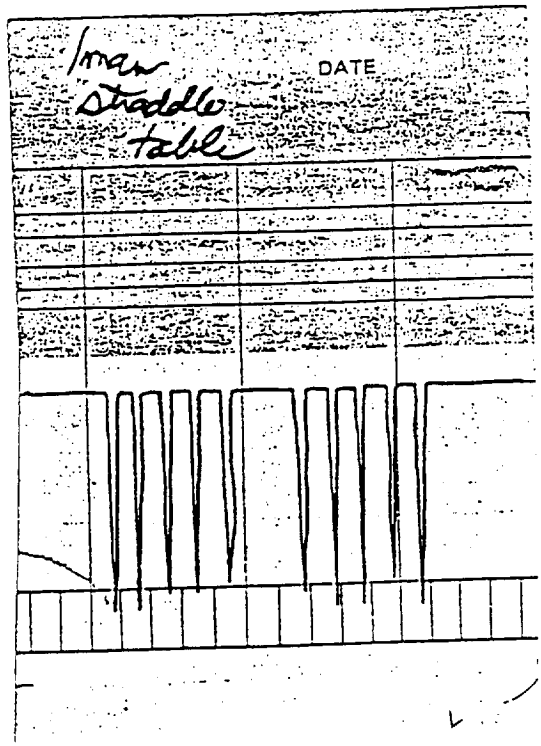


Figure 6.

Chest compressions in 0-g while straddling the MRS

Figure 7. CPR using the Cardiac Compression Assist Device attached to the MRS during 0-g.

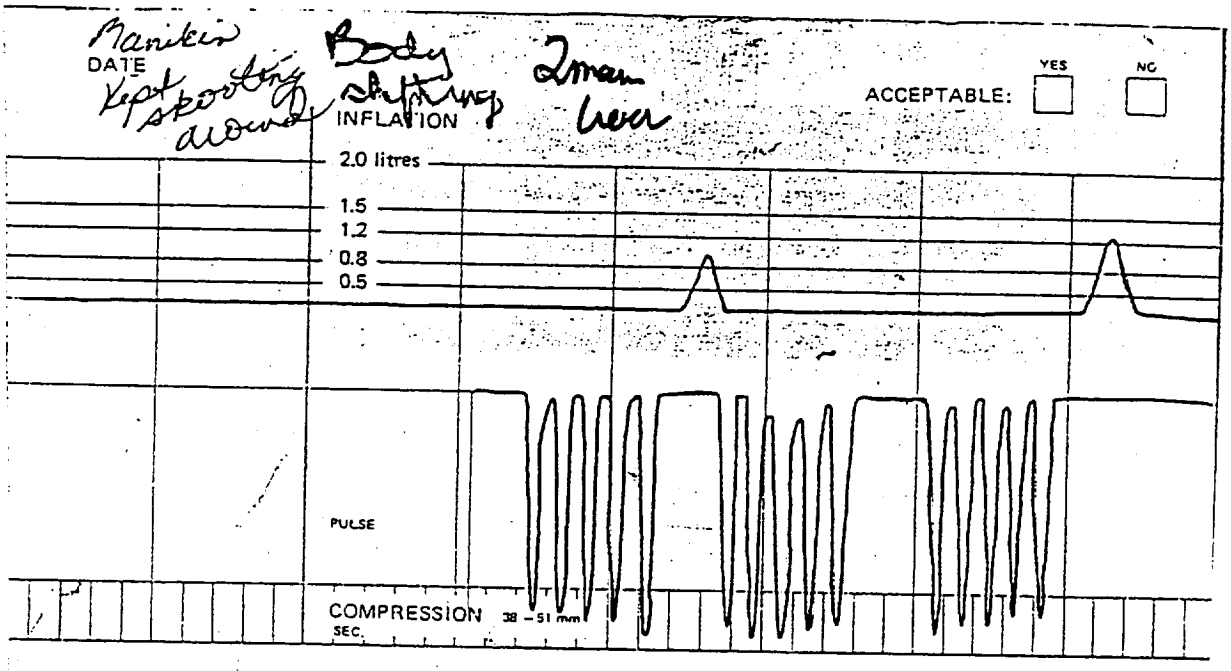


Figure 8. CPR using the Cardiac Compression Assist Device attached to the MRS during 0-g. Notice the incomplete thoracic relaxation in order to keep the CCAD from changing position.

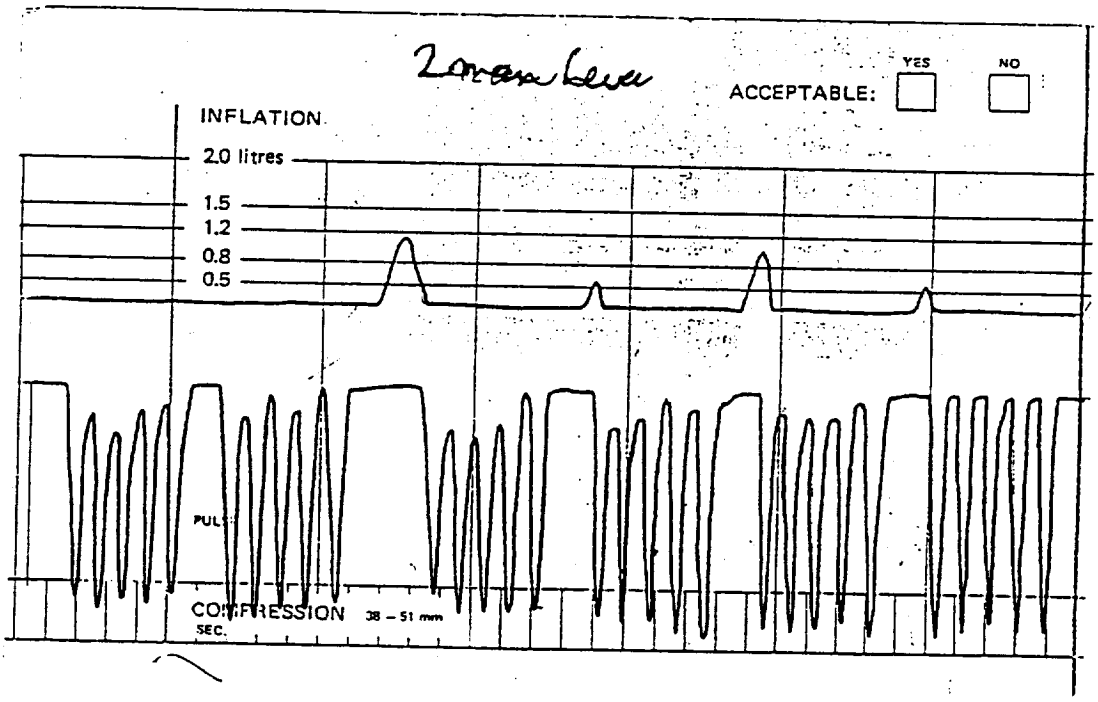
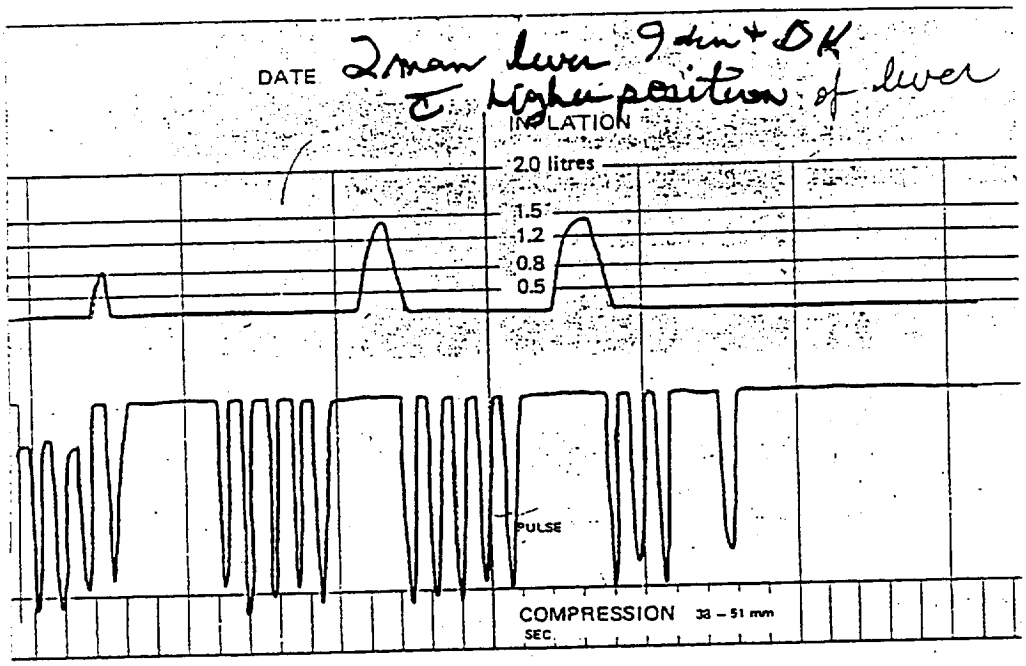


Figure 9. CPR using the Cardiac Compression Assist Device attached to the MRS during 0-g.



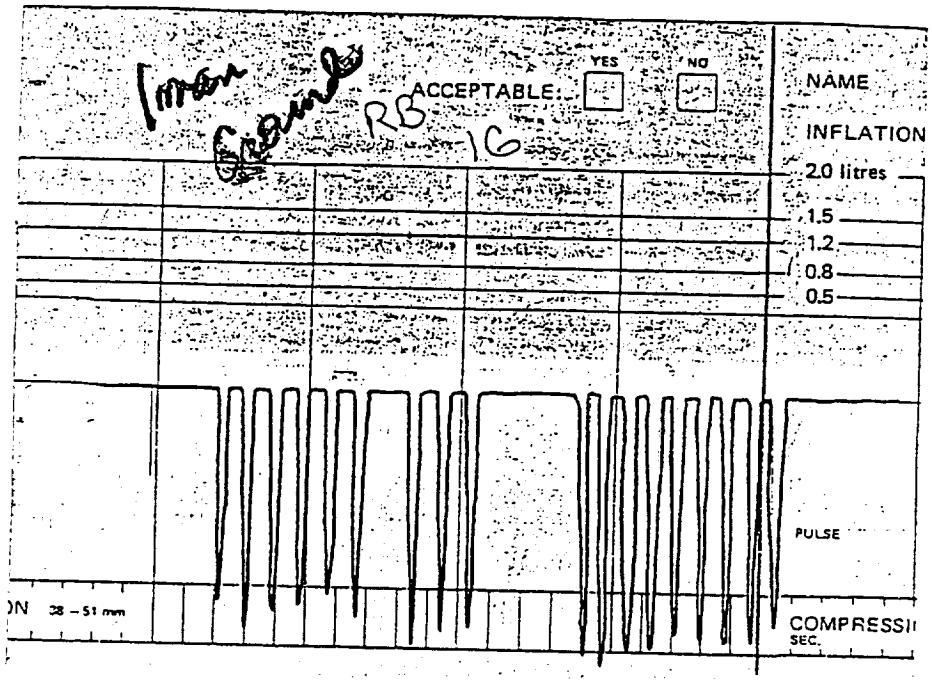


Figure 10.

Chest compressions with the mannequin on the KC-135 floor during 1-g

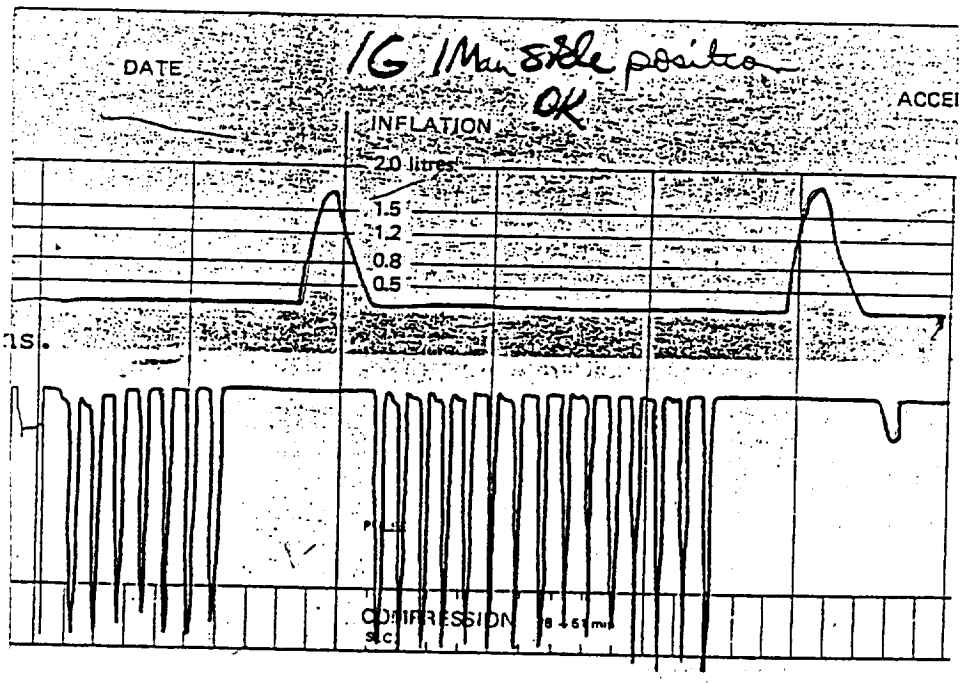


Figure 11.

1-g CPR on the KC-135 floor using the standard side position for chest compressions.

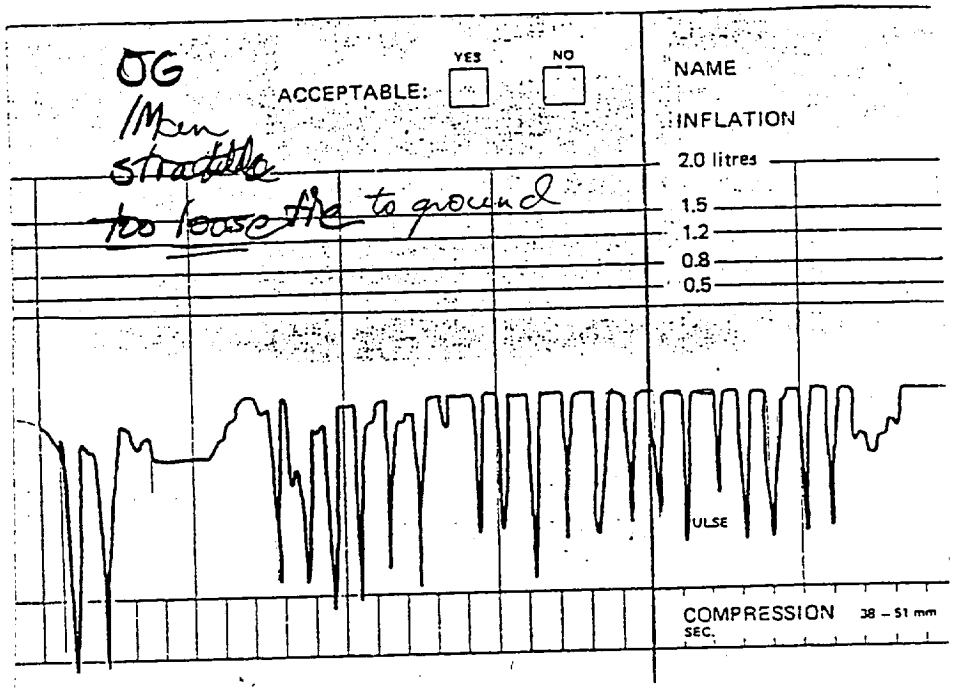


Figure 12.

0-g CPR on KC-135 floor. Difficult chest compressions because of restraint straps being poorly positioned.

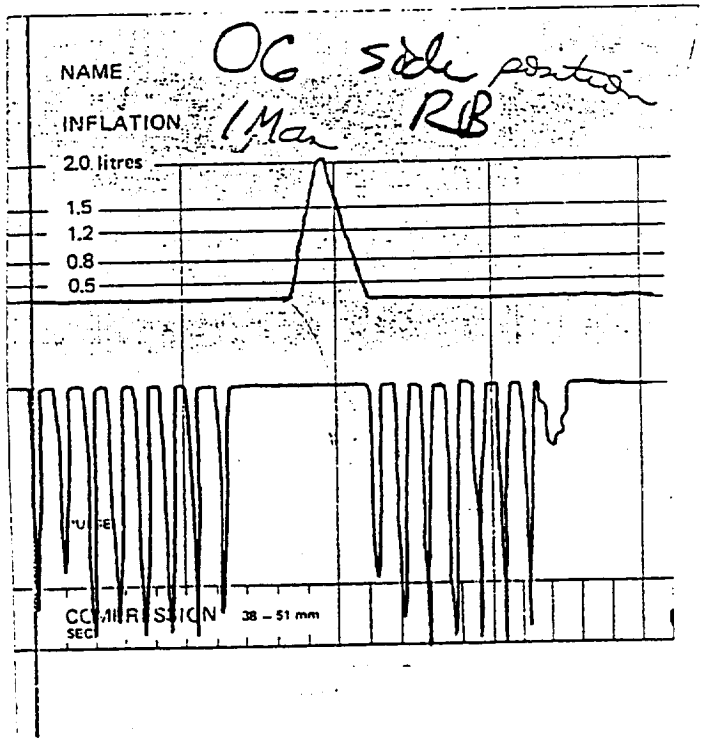


Figure 13.

0-g CPR on KC-135 floor with chest compressions given from the standard side position.

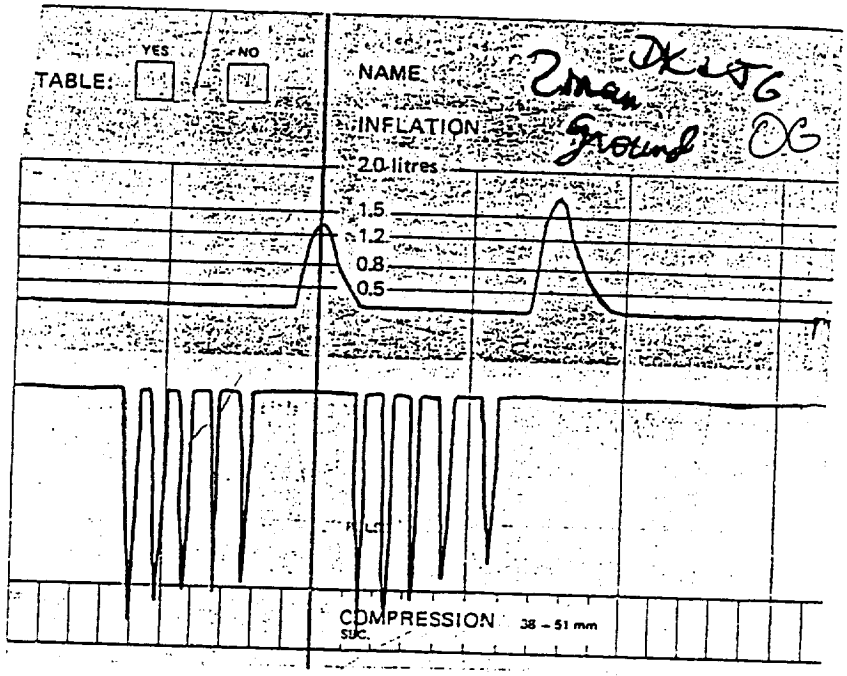


Figure 14.

0-g CPR on KC-135 floor using two-man technique. Chest compressions given from the straddle position.

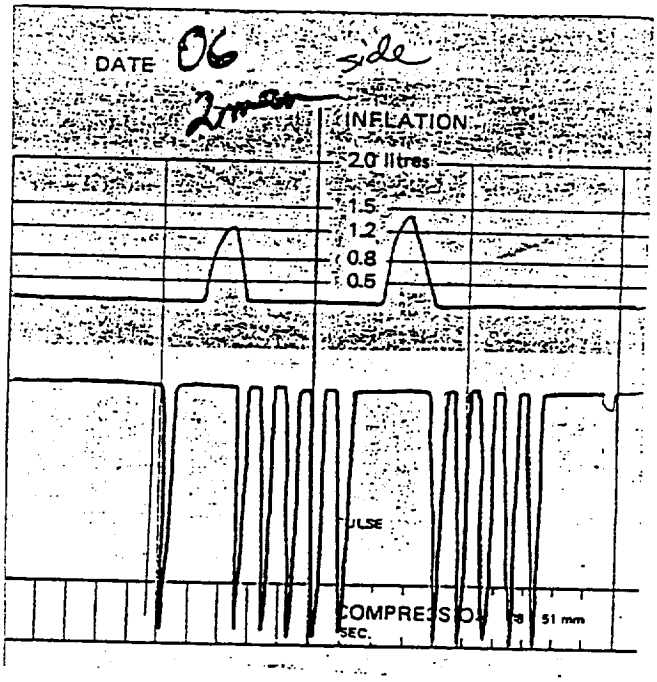


Figure 15

0-g CPR on KC-135 floor using two-man technique. Chest compressions given from the standard side position.

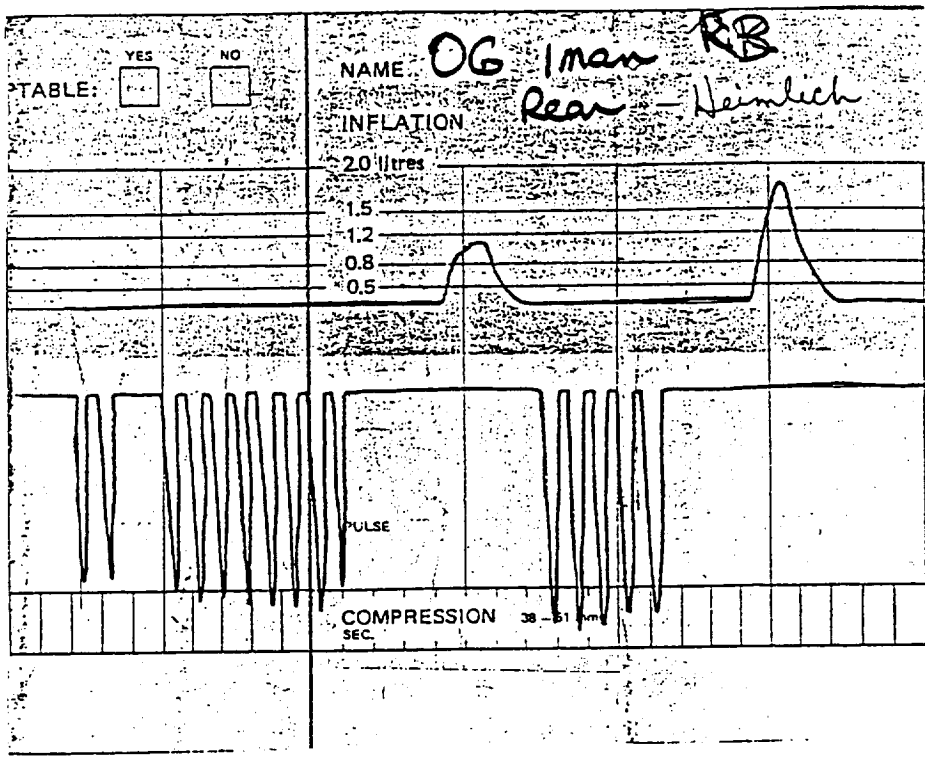


Figure 16.

0-g CPR by one man using the Heimlich position.

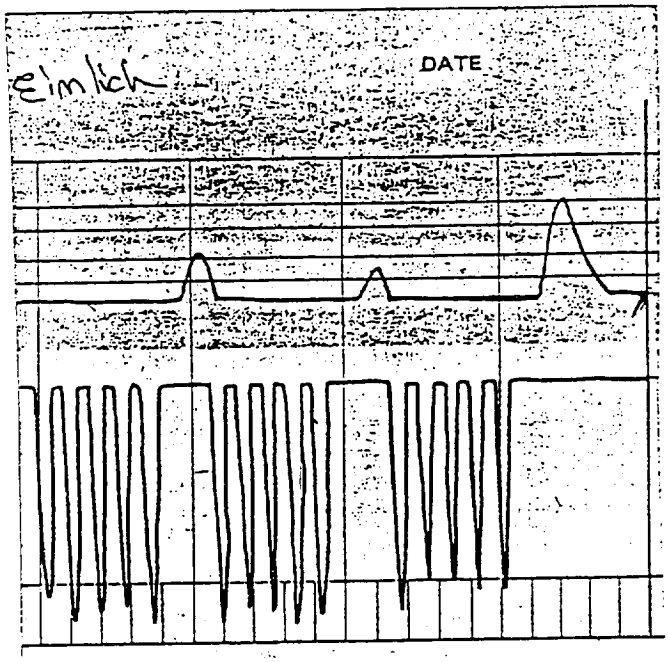


Figure 17.

0-g CPR by one man using the Heimlich position. Notice the improved ventilation with practice.

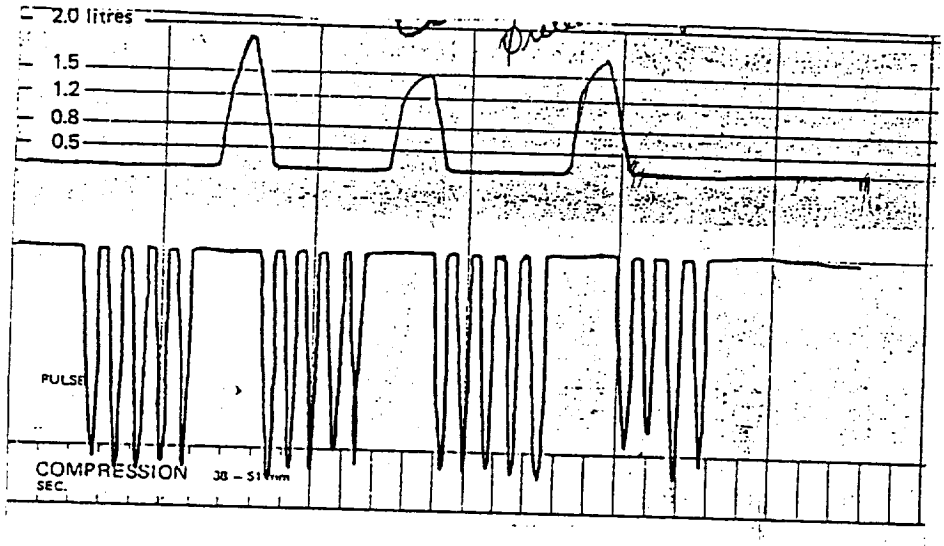


Figure 18. 0-g two-man CPR with chest compressions performed in the Heimlich position and ventilations performed by an unrestrained operator.

REFERENCES:

1. Heartsaver Manual: A Student Handbook for Cardiopulmonary Resuscitation. Dallas, American Heart Association, 1987.

2. Textbook of Advanced Cardiac Life Support. Dallas, American Heart Association, 1987.

3. Standards and Guidelines for Cardiopulmonary Resuscitation (CPR) and Emergency Cardiac Care (ECC). JAMA, 255:2905-2989, 1986.

4. Ornato JP, Garen EJ, Nelson N, et al: The impact of emergency cardiac care on the reduction of mortality from myocardial infarction. J Cardiac REhab 3:863-866, 1983.

5. Cummins RO, Eisenberg MS: Prehospital cardiopulmonary resuscitation: Is it effective? JAMA 253:2408-2412, 1985.

6. Roth R, Stewart RD, Rogers K, Cannon GM: Out-of-hospital cardiac arrest: Factors associtated with survival. Ann Emerg Med 13:237-243, 1984.

7. Weaver WD, Cobb LA, Hallstrom AP, Fahrenbruch C, Copass MK, Ray R: Factors influencing survival after out-of-hospital cardiac arrest. J Am Coll Cardiol 7:752-757, 1986.

8. Cobb LA: Prehospital cardiac care: Does it make a difference? Am Heart J 103:316-318, 1982.

FLUID HANDLING 2: SURGICAL APPLICATIONS

PRINCIPAL INVESTIGATOR:	Roger Billica, M.D.
CO-INVESTIGATORS:	John Young, DDS Doug Rushing Victor Kizzee
FLIGHT DATE:	May 1, 1990

PURPOSE:

To investigate and demonstrate the methods proposed for managing fluids and particulate debris during minor surgery on Space Station Freedom (SSF.)

OBJECTIVES:

Using simulated capillary, venous and arterial bleeding in a minor surgical setting,

- Evaluate and test methods of local barrier and fluid absorption.
- Evaluate and test local mechanical suction.
- Evaluate and test laminar flow with suction.
- Evaluate and test use of an absorbant barrier curtain.
- Evaluate and test laminar flow/suction containment of cautery fumes.

OVERVIEW:

A KC-135 parabolic flight test was performed on May 1, 1990 with the goal of investigating proposed techniques for fluid management during minor surgical procedures aboard SSF. The flight followed the standard 40 parabola profile with 20-25 seconds of near-zero gravity in each parabola. Four experimenters were involved in the study. The equipment being

evaluated (suction and laminar flow device) had flown previously in evaluation of a dental procedure scenario. Two of the investigators were participants of that earlier flight. While the equipment performed satisfactorily in the dental simulation, the purpose of the current flight was to reconfigure the equipment in support of a minor surgical situation in order to evaluate its efficacy and establish clear requirements for the actual flight hardware.

To accomplish the study the Health Maintenance Facility (HMF) medical restraint system (MRS) was deployed as for surgical use and a mannequin suture arm was restrained to its surface. The surgical area was established as for performing minor surgery with standard tray and suture instruments employed. (See photo 1.) No prepping or draping of the arm was done.

In order the simulate the various types of bleeding, two long intracath catheters were placed into the suture arm at different angles with the tips positioned at the laceration opening. One catheter was angled as if running parallel to the surface and the second catheter was angled as if coming from deep within the tissue. Colored water was placed into 60cc syringes which when attached to the intracath catheters could be used to simulate different types of bleeding depending on the degree of force applied. (See photo 2.) In this manner the investigators were able to reproduce small to large amounts of fluid at different pressures originating from different aspects of a laceration. This technique was practiced in the lab prior to flight and proved to be an effective although simplistic simulation.

The laminar flow/suction particle containment device used was the prototype developed for KRUG Life Sciences by Dr John Young. (For specific description and specifications see the earlier flight report submitted by Dr Young "Dental Simulation using Laminar Flow" January 1990.) The device consisted of a hand-held suction device with on/off control similar to most surgical suction (see photo 2) and a laminar flow device. The laminar flow device directed a current of horizontal air flow above and across the surgical site. Directly opposite to the air originator was a suction funnel trap that collected fluid and particulates from above the site. These devices were adjustable in height and were bracketed around the surgical site while leaving enough room for the surgeons to maneuver without compromising the sterile field.

The sequence for the study was as follows:

Parabolas

1 - 5 Demonstrate use of local absorbant barrier
6 - 10 Demonstrate use of local suction
11 - 15 Demonstrate use of laminar flow/suction
16 - 20 Demonstrate use of barrier sheet
21 - 25 Evaluate integrated system for capillary flow
26 - 30 Evaluate integrated system for venous flow
31 - 35 Evaluate integrated system for arterial flow
36 - 40 Evaluate integrated system with cautery fumes

BACKGROUND:

In performing surgical procedures, whether major or minor, there are several basic principles that should be adhered to in order to meet today's standards of medical practice. Included among these are the principles of sterile technique, proper exposure and visibility, and hemostasis and fluid management. In previous zero-gravity experience it has been found that actual surgical technique is not difficult to perform once the surgeon has acclimated his or her fine motor skills to the absence of gravity. Other challenges that have had to be met are those of operator and equipment deployment and restraint, and these have been done using the medical restraint system with various attachments.

Some KC-135 flight experience has been accumulated in the handling of fluids in medical scenarios and with the use of suction. (See KC-135 reports for Fluid Handling and Transport Suction.) It has been found that medical fluid management is not a simple matter due to the unusual behavior of fluids in zero-gravity. Consequently there has been concern over the ability to maintain a clear and sterile field during surgical procedures. The capability to provide proper hemostasis must be developed to keep the operating field clear, to limit the need for blood and fluid replacement, and to minimize the chances for wound infection. It is hoped that with simple surgical procedures (with limited bleeding, fluid loss or contamination) very basic methods of barrier and suction will suffice to provide proper control. However, it is realized that preparation must be made for more complicated or contaminated situations in which greater flexibility for hemostasis and containment is required.

This flight experiment was designed to study some basic methods of surgical fluid management both independently and in an integrated fashion. Based on the dental scenario experience in zero-G using the laminar flow device, it was felt worthwhile to adapt that equipment for use in a minor surgical simulation and test its effectiveness with varying degrees of bleeding. Separate flight studies are being performed looking at an inclusive operating canopy or enclosed bubble concept.

MATERIALS:

- Prototype MRS with restraints
- Mini-racks with stowage drawers
- Instrument tray with minor surgical instruments, suture
- Laminar flow/particle containment device with power sources
- Suction tubing with various tips
- Mannikin suture arm with pre-placed catheters
- Syringes and pre-made simulated blood
- Various towels, drapes, gauze
- Cautery device and orange
- Waste containers
- Misc. support materials (tape, straps, etc.)
- Video

PERSONNEL AND SUPPORT:

- 4 investigators (one physician, one dental surgeon, one biomedical engineer and one video-technician)

- Video recording performed by technician; still photography performed by non-dedicated NASA photographer. Post-flight worksheets completed by all.

TEST PROTOCOL: *(See attached "Fluid Handling 2: Worksheet")*

RESULTS AND DISCUSSION:

Local Absorbant Barrier *(See photo 3.)*

Two types of absorbant gauze were used - sterile 4X4's and loosely wadded Kerlix wrap. Both worked fairly well although the rapid wicking action of the Kerlix made it perform in a superior manner. As with previous fluid handling flights, the wicking action was the main determinant of utility since rapid blotting caused the fluid bolus to fragment and escape. For simple capillary and venous bleeding the local barrier functioned similarly to terrestrial practice and could be used for a majority of the fluid management needs.

Local Suction *(See photo 2.)*

The use of local suction was simple and effective for capillary and venous bleeding. It was the preferred method of fluid management in simple situations, especially when combined with local barrier. In previous attempts with suction it was found that the larger suction tips performed better at collecting fluid. (With very small suction catheters, the fluid tended to migrate up the outside of the catheter.) To test this finding, a large suction cone was attached to the hand-held suction to see if it was easier to use that the standard tip (see photo 4.) It was found that the larger cone negated the suction force and did a poorer job than the standard tip. Indeed, some of the fluid would simply stick to the cone interior due to surface tension (see photo 5.) Using the cone to capture escaped fluid boluses was less effective than allowing the laminar flow/suction to work.

Laminar Flow/Suction

The laminar flow/suction device functioned well for dislodged fluid droplets. In the bleeding model used, surface tension kept most of the capillary and venous bleeding pooled on the surface of the arm. However, if during movement or blotting any fluid boluses were dislodged, they were easily caught in the laminar flow and collected in the suction trap. This was especially useful during times when there was only one surgeon who could not pause to use handheld suction to keep the operating field clear.

More vigorous (arterial type) bleeding was too forceful to be captured in the laminar flow and would pass directly through it. (See photo 6.) However it was noted that without the laminar flow, such bleeding would escape in random and unpredictable fashion. But with the laminar flow present, even though the fluid was not contained, the force of the air flow was sufficient to direct the fluid flow in a predictable direction that subsequently could be captured by an external barrier.

Barrier Sheet

As part of the study, a hyper-absorbant commercially available cloth ("Camel cloth") was evaluated for use as an external barrier. (See photo 6.) This material has pronounced wicking and absorbant properties, especially after being moistened. With the laminar flow device functioning, the direction of fluid escape could be predicted fairly easily and the external barrier positioned to absorb any excess fluids. Something like this was felt to be useful in temporary situations where the degree of fluid escape was greater than anticipated. For excessive fluid loss, a more permanent solution would be preferable.

Integrated System

During an actual suturing scenario with simulated bleeding, the two experimenters worked as a team to accomplish the procedure. It was found that with most of the capillary and venous-type bleeding, local barrier and hand-held suction functioned extremely well to control the bleeding and keep the operative site clear. (See photo's 7 and 8.) When fluid loss became more pronounced, the laminar flow device worked nicely as a back-up to the local methods. (See photo 9.) This integrated system proved to be a simple and effective means of supporting the type of simple procedures anticipated for SSF. Only when forceful fluid loss was present did this system fail in complete containment and another level of support was obviously required.

Cautery Fumes

Using a hand-held disposable cautery device, an orange was cauterized to produce fumes similar to actual surgery. (See photo 10.) These fumes were readily visible and were easily removed with the laminar flow/suction device. With such a device, these types of fumes should not represent a hazard or view obstruction during surgery.

SUMMARY AND RECOMMENDATIONS:

The results of this study and previous investigations show that performing surgical procedures in zero-gravity is feasible provided certain types of restraint and support. The issue of sterile field and hemostasis remain a concern, although this evaluation demonstrated the utility of a modular control system containing local barrier, local suction and laminar flow/ suction. It is felt that a laminar flow device might provide an added benefit

of reducing environmental contamination of the operative site.

Due to the obvious limitations of simulated surgical models, it is recommended that these investigations proceed to include live animal subjects in a completely integrated study. This study should be performed using a multi-tiered surgical support system that incorporates local containment, laminar flow and an overhead canopy. The model should investigate hemostasis for all bleeding sources (capillary through arterial) and should be performed in close approximation of actual sterile surgery planned for SSF.

NASA PHOTO REFERENCE

S90-36401 - 02
Preparation of mannequin arm for surgical technique

S90-36404
Surgical trays in microgravity

S90-36412 - 13
Suturing in microgravity

S90-36418 - 19
Suturing in microgravity

S90-36429
Suturing in microgravity

S90-36436
Preparation of sterile surgical field

S90-36438
Suturing in microgravity

S90-36440 - 41
Preparation of the surgical area

S90-36443
Deployment of the surgical tray

S90-36445
Preparation for suturing

S90-36520 - 22
Making an incision

S90-36525 - 27
Preparing the arm for surgery

EVALUATION OF PROTOTYPE AIR/FLUID SEPARATOR FOR SPACE STATION FREEDOM HEALTH MAINTENANCE FACILITY

PRINCIPAL INVESTIGATOR:	Roger Billica, M.D.
CO-INVESTIGATORS:	Maureen Smith Linda Murphy Victor Kizzee
FLIGHT DATE:	May 2, 1990

PURPOSE:

To evaluate a prototype air/fluid separator suction apparatus proposed as a possible design for use with the Health Maintenance Facility (HMF) aboard Space Station Freedom (SSF.)

OBJECTIVES:

- Evaluate the effectiveness and efficiency of the prototype design at producing medical-quality suction for a variety of types of fluids (representative of body fluids.)
- Evaluate the effectiveness and efficiency of the prototype design at separating the fluid collected from air in the collection system.
- Assist in defining the functional and performance requirements and feasibility for the HMF Air/Fluid Separator through use of the prototype in zero-gravity (0-G.)

OVERVIEW:

A KC-135 parabolic flight test was performed on May 2, 1990 with the goal of evaluating a prototype suction apparatus and air/fluid separator in microgravity. The flights followed the standard 40 parabola profile with 20-25 seconds of near-zero gravity in each parabola. Four investigators were involved with the study.

The study was performed using a prototype developed by Dr. Bruce Houtchens under contract with KRUG Life Sciences. The prototype represented the evolution of several designs and was known to have difficulty with air/fluid separation in some modes of operation. (Data from Dr. Houtchens' investigations are pending at the time of this report.)

The investigation team prepared a protocol to evaluate the device in several regulator modes (or suction force), using three fluids of varying viscosity, and using either continuous or intermittent suction. It was felt that a matrixed approach would best approximate the range of utilization anticipated for medical suction on SSF. The protocols first were performed in one-gravity in a lab setting to familiarize the team with procedures and techniques. Identical steps were performed aboard the KC-135 during parabolic flight.

The prototype was found to function fairly efficiently (although not 100%) at the high regulator settings for the fluids of lesser viscosity. Lower suction settings produced less efficient air/fluid separation. In 0-G at altitude the suction was not strong enough to pull the higher viscosity fluids into the apparatus.

The study concluded that the concept of combined suction and air/fluid separation is feasible for medical use on SSF, but that further design development is needed to improve efficiency in function and performance.

BACKGROUND:

Current plans for crew health care aboard SSF call for the capabilities to perform minor surgical procedures, advanced life support, trauma management and airway support. All of these capabilities require the provision of medical suction ranging from low intensity (5-10 mm Hg) to high intensity (250 mm Hg) and may include either constant or intermittent suction flow.

Due to the fact that SSF will be a closed system with regards to life support, the utilization and reprocessing of valuable resources (air, water) becomes a critical issue. Minimizing volume for waste stowage and protection of the SSF environment from contamination are equally important concerns. Therefore, there is a need to carefully contain suctioned waste fluids while returning any air collected back to the environment (both to reduce stowage volume and to recirculate the resource).

To meet these needs, the HMF requires equipment that will function both in providing variable suction for a variety of sources and for producing air/fluid separation. In 1988 Dr. Houtchens initiated some investigations into possible design solutions for this equipment and delivered a prototype for the air/fluid separator in April 1990.

MATERIALS:

1. Houtchens Prototype Air/Fluid Separator
2. HMF Medical Restraint System (MRS) (prototype)
3. Bags and containers for various fluids, all marked for quantities
4. Straps, cords, tubes, attachments, clamps, markers
5. Pre-mixed fluids placed in containers
   - Colored water (low viscosity)
   - Whole milk (medium viscosity)
   - Chocolate pudding (thin) (high viscosity)
6. Clean-up materials (towels, water with clorox)
7. Recording materials (VHS video, still photography, written notes)

PERSONNEL AND SUPPORT:

Four investigators were involved; three operated the equipment as a team and one served as the video recording technician. Still photography was provided by a non-dedicated NASA photographer.

TEST PROTOCOL:

1. All procedures were performed first in the HMF ground lab for familiarization. The fluids were pre-packaged into measured IV bags or see-through plastic jugs. Receiving containers were either empty IV or foley catheter bags that were pre-labeled and clamped shut (so that the only volume in the bag would come from the air/fluid separator.)

2. During the flight there was only sufficient time to accomplish the specific protocols. General observations were made during flight, but the actual measurements were performed after return to ground. The receiving bags were carefully labeled, clamped-off and placed in ice-chests to insure accurate measurements after the flight.

3. The test protocol was as follows:

   A. Evaluate the efficiency of air/fluid separation using continuous suction at different regulator settings.

      - set-up 10 numbered bags of 500ml colored water
      - attach bags to suction in sequential fashion
      - attach empty collection bags to output.
      - process the fluid through the air/fluid separator
      - A1 & A2: 60 mm Hg suction
      - A3 & A4: 100 mm Hg suction
      - A5 & A6: 140 mm Hg suction
      - A7 & A8: 180 mm Hg suction
      - A9 & A10: full suction

   B. Evaluate the efficiency of intermittent suction and air/fluid separation using fluids of different viscosity.

      - use the most efficient regulator setting from step #A (above.)
      - set up two large bags for colored water and whole milk; set up two numbered receiving bags.
      - attach the suction to the large fluid bag and suction for a total of four 18 second parabolas using a 3 second cycle of on-off suction (using the suction finger valve.)
      - after test fluids, flush system into waste bag.

C. Determine the volume of different fluids that can be suctioned continuously during a 20 sec. time and note the efficiency of air/fluid separation.

- use the most efficient regulator setting from step # A.
- set up three jug containers for colored water, milk and pudding; set up six numbered receiving bags, use a suction catheter tip.
- process the fluid through the air/fluid separator:

C.1 20 sec colored H_2O
C.2 20 sec colored H_2O
C.3 20 sec milk
C.4 20 sec milk
C.5 20 sec pudding
C.6 20 sec pudding

- after test fluids, flush systen into waste bag.

D. Evaluate the efficiency of intermittent suction and air/fluid separation using different fluids from on open system.

- use the most efficient regulator setting.
- perform intermittent suction of 3 second cycles using three 18 second parabolas for each type of fluid.
- set up three jug containers for colored water, milk and pudding; set up 3 large labeled receiving bags; use suction catheter tip.

RESULTS:

- Evaluate the efficiency of air/fluid separation using continuous suction at different regulator settings (See Figure 1).

The efficiency of air/fluid separation increased with the higher regulator settings (higher suction force.) The full suction setting was therefore chosen for the remainder of the tests.

Regulator	Fluid	Air	Avg. Efficiency
60 mm	300 ml 500	110 ml 180	73.2%
100 mm	500 500	85 120	83.0%
140 mm	500 500	130 100	81.3%
180 mm	500 500	100 80	84.7%
full	360 480	20 20	94.8%

- Evaluate the efficiency of intermittent suction and air/fluid separation using different fluids (See Figure 2).

Type of Fluid	Fluid	Air	Efficiency
18 sec X 4 of H2O	1800 ml	40 ml	97.8%
18 sec X 4 of Milk	1400 ml	60 ml	95.9%

Suction speed and volume was acceptable for medical purposes. Air/fluid separation was accomplished with a ratio of 1:45 for water (efficiency of 97.8%) and 1:23 for milk (efficiency of 95.9%.)

- Determine the volume of fluids that can be suctioned continously during a 20 sec time and evaluate the efficiency of air/fluid separation. (See Figure 3).

The volume and rate of suction was acceptable for medical purposes for the first two fluids of lower viscosity. The higher viscosity fluid (pudding) was unable to be suctioned into the apparatus. The pudding under suction would advance into the suction tubing, but there appeared to insufficient force to bring the pudding into the air/fluid separator.

Type of Fluid	Fluid	Air	Efficiency
20 sec colored H_2O	820 ml	10 ml	98.8%
	750 ml	10 ml	98.6%
20 sec whole milk	700 ml	20 ml	97.2%
	650 ml	15 ml	97.7%
20 sec pudding	0 ml	0 ml	

- Evaluate the efficiency of intermittent suction and air/fluid separation using different fluids in an open system (See Figure 4).

Type of Fluid	Fluid	Air	Efficiency
18 sec X 3 of H_2O	1600 ml	50 ml	96.9%
18 sec X 3 of Milk	1420 ml	55 ml	96.3%
18 sec X 3 of Pudding	0 ml	0 ml	

Intermittent suction from an open system appeared to have sufficient volume and rate for medical purposes. Again, the higher viscosity pudding was unable to be suctioned into the apparatus.

DISCUSSION:

Prior to flight it was anticipated that this prototype would work less efficiently at the lower regulator settings. This was noticed in the one-G lab tests and was explained by Dr Houtchens to be due to the physics of the separator blade design. Dr Houtchens felt that this could be corrected in a next generation prototype he was working on.

The air/fluid separation functioned with reasonable efficiency at the higher regulator settings and provided sufficient suction to perform most anticipated medical tasks. It was felt that this accomplished the goal of demonstrating feasability of the concept and program requirement for SSF Health Maintenance Facility.

The difficulty in creating enough suction to process the more viscous pudding aboard the KC-135 was felt to be secondary to the decreased atmospheric presssure during flight resulting in less efficient compressor function. (KC-135 flies at cabin altitude of 4,500 feet which is equal to approximately 12.5 psi. This effect has been noticed on previous KC-135 experiments by the flight crew.) If the SSF cabin pressure is reduced to 10.2 psi, this will need to be considered in the design of the HMF suction equipment.

RECOMMENDATIONS:

- It is recommended that the current HMF Systems Requirements for the Air/Fluid Separator be retained.
- It is recommended that should Dr Houtchens produce a further prototype of the Air/Fluid Separator, that it be re-evaluated in a similar manner.
- It is recommended that the issue of bladder drainage in zero-gravity without the use of extrinsic suction be evaluated. (i.e. Is the intrinsic pressure of the bladder enough to produce catheter drainage without the use of suction and without residual bladder volume of clinical significance.)

FIGURE 1.
Continuous Suction at Various Regulator Settings

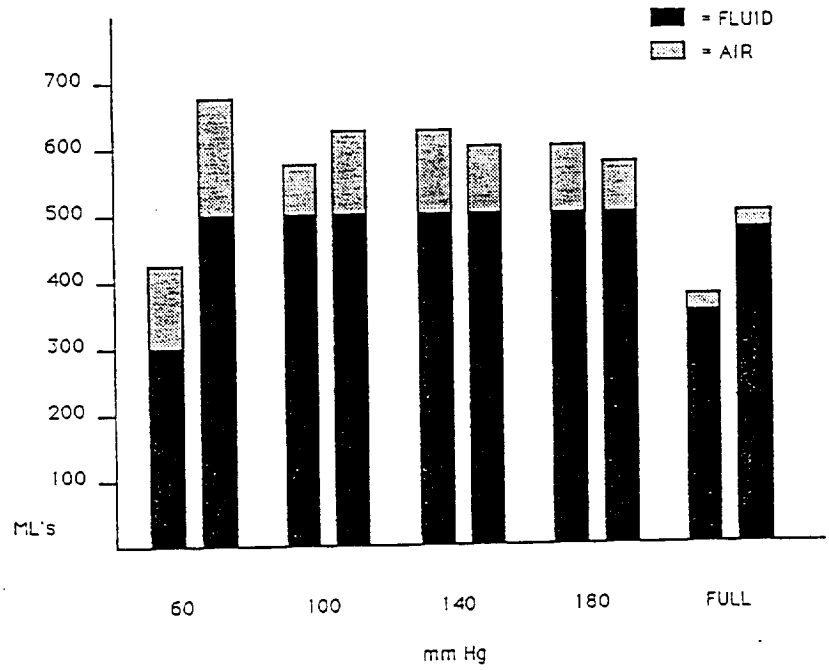


FIGURE 2.
Intermittent Suction Using Different Fluids
(18 seconds X 4 at Full Suction Setting)

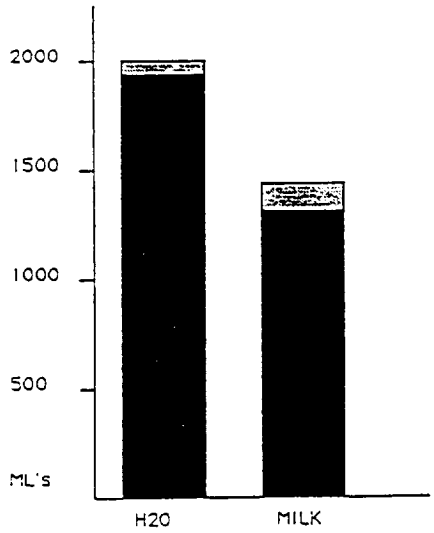


FIGURE 3.
Continuous Section for 20 seconds
at Full Regulator Setting

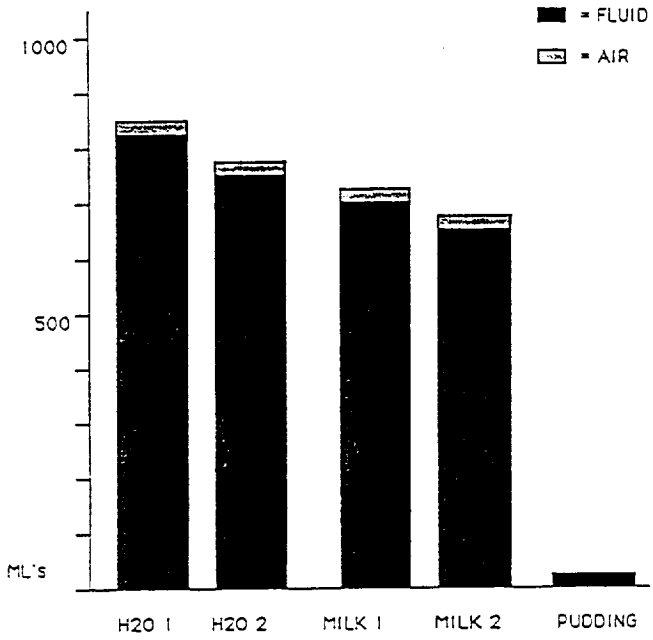
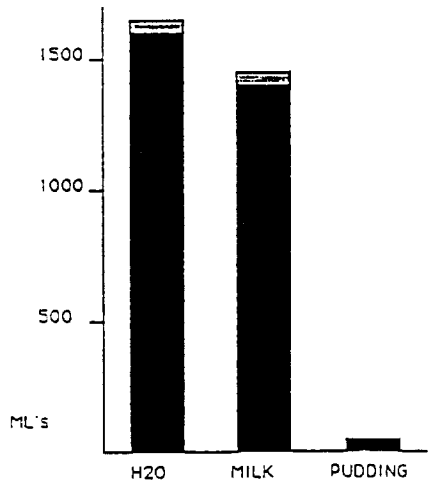


FIGURE 4.
Intermittent Suction of Different Fluids
From an Open System



NASA PHOTO REFERENCE

S90-36941
Collection of liquids for the air/fluid separator

S90-36943
Separation of air from various liquids

S90-36946
Collection of fluids from the air/fluid separator

S90-36953
Effects of 0-g on a flier

S90-36956 - 58
Containment of liquids from the air/fluid separator

S90-36960 - 63
Filling bags with fluid from the air/fluid separator

S90-36966
Separation of air from various liquids

PRECISION METERING OF MICROLITER VOLUMES OF BIOLOGICAL FLUIDS IN MICRO-GRAVITY

PRINCIPAL INVESTIGATORS:	R. L. Columbus (Eastman Kodak Co), H. J. Palmer (Univ of Rochester), B. A. McKinley (KRUG Life Sciences, Inc)
CO-INVESTIGATORS:	WT Norfleet, VD Kizzee (KRUG Life Sciences, Inc)
FLIGHT DATES:	May 3, 22, and 24, 1990

SUMMARY:

Eastman Kodak Company has served as a supplier of experimental diagnostic equipment for the SSF HMF, including a clinical chemistry analyzer. An important part of the clinical chemistry analysis process is introduction of a sample of the biological fluid of interest, usually whole blood, plasma or serum, to the sensor for the chemical constituent of interest. The potential difficulty associated with fluid handling in absence of gravity or in microgravity environments was recognized early in the process for design and development of a clinical chemistry analyzer useful in microgravity, but was incorporated only as a research topic within a contract for development of a medical development unit. Kodak and KRUG had discussed plans for KC135 experiments to investigate liquid fluid handling since 1986. Focus on this problem was offered by Kodak following requests by KRUG in 1989. During early 1990, a KC135 flight was scheduled and Kodak proceeded with experiment design and equipment fabrication in cooperation with KRUG. Conventional and experimental devices were planned to be tested. Experiments were designed that would test extreme cases of fluid and surface behavior anticipated for clinical chemistry system design and that would be able to be performed in the unusual and unstable laboratory setting of the KC135. The experiments aboard the KC135 were performed by Dr. Bill Norfleet (KRUG) with inflight assistance of Mr. Victor Kizzee (KRUG) and preflight instruction of Mr. Richard Columbus (Kodak), Dr. Harvey Palmer (Univ of Rochester) and Ms. Deborah Freyler (Kodak).

The experiments were able to be conducted generally as planned, but unplanned effects of cabin pressure changes during parabolic maneuvers confused results of initial automated pipet tests. Results of experiments showed that precision metering of microliter volumes of biological fluids is possible in microgravity environments and indicated that fluid handling is best addressed using developing integrated blood collection system technology. Further development and testing of discrete sample container technology using similar test protocol and addition of other processing steps is recommended. Video record of results is in preparation by Kodak.

Note: The primary record of results of these KC135 flight tests is video casset records obtained during the experiments aboard the KC135 aircraft. An edited record that focuses on important liquid transfer processes and demonstrations of proposed concepts is in preparation by Kodak. This record should be obtained and reviewed in cooperation with the principal investigators as the primary report of experiment results.

OBJECTIVE:

Demonstrate and investigate concepts for transferring accurately known and reproducible microliter volumes of biological fluids from sample containers onto dry chemistry slides in a microgravity environment. Compare specific liquid transfer tip designs. Obtain information for design of a liquid sample handling system to enable clinical chemical analysis in microgravity.

METHOD:

Disposable pipet tips and pipet devices that were designed to transfer microliter volumes of biological fluid from a (test tube) sample container onto dry chemistry slides in 1-g environment were used during micro-g periods of parabolic trajectories of the KC135 aircraft. The transfer process was recorded using charge couple device camera and video casset equipment. Three specific disposable pipet tip designs their function during micro-g exposure were compared. Metering behavior of water, a synthetic aqueous protein solution, and anticoagulated human whole blood was compared. Transfer of these liquids to 2 substrate materials representative of rapidly wettable and slowly wettable dry chemistry slide surfaces was compared. Checklist protocols were developed by Kodak to assist during preflight training, preparation for flights and in flight.

EQUIPMENT:

An electrically powered pipet, rigid holder, dry slide substrate material, camera, light, video recorder and power supplies were assembled on a mechanical plate and frame "breadboard" to be operated by a single experimenter and to be transported as a single unit. Micro-g compatible holders for liquid sample vials and pipet tips were also attached to the breadboard to be accessible to the experimenter/operator. The breadboard was attached to a workstation table with four bolts through the plywood table top; the table was anchored to the aircraft floor with tension straps over the table attached to anchor studs. A second video casset recorder (Sony hand held VHS) with a small flat screen monitor was attached to the table using Velcro so that the camera's close up view of the pipet tip and the liquid metering process was available for the experimenter/operator during the experiment.

Modification of the original equipment was made to incorporate an experimental liquid container and metering tip system on the second flight. The basic layout of pipet, camera, recorder and light were unchanged. A manually actuated pipet was used. The shape of the pipet tip was the same as one of the 3 previous designs. The third flight incorporated a modification of the pipet used for the first experiment, which permitted venting of the air column within the pipet between the liquid sample and solid bellows/piston to prevent displacement of the liquid in the pipet tip due to ambient pressure changes.

When actuated in the aspirate mode, the pipet would aspirate 110 microliters of liquid. When actuated in the dispense mode, the pipet would dispense a volume of 10 microliters.

[Note: A structural load analysis was prepared for the breadboard. The equipment, material and procedures were approved by NASA KC135 program personnel prior to the first experiment. Permission was obtained from NASA/SA/SLSD to use the 1-2 milliliter volume of human whole blood required for the experiments. Copies of Kodak's proposal for KC135 experiments, test plan and hazard analysis, structural analysis of the KC135 metering breadboard, and of a memo indicating permission from NASA/SA for use of human blood (plasma) in the experiment, are attached.]

PROCEDURE:

The experimenter/operator placed pipet tips on the pipet, filled pipet tips from the sample vial, positioned substrate under the pipet tip, and pressed a button to actuate the pipet to dispense liquid onto the substrate. For certain experiments, a manually actuated pipet was used. Placing and filling pipet tips and placing a substrate strip mounted on a plate under the pipet on a slide rail was done prior to a set of 10 parabolic maneuvers. After each parabola and pipet actuation/liquid dispense process, the substrate was advanced one detent lock position on the slide rail. A pipet tip was replaced and filled and a substrate strip was replaced on the slide rail following completion of 10 parabolic maneuvers.

RESULTS:

The function of the electrically powered pipet and different pipet tip designs to transfer microliter volumes of liquid onto slide substrate material during micro-g was recorded on video casset, which is in preparation by Kodak. Observations of the experimenter/operator, Dr. Norfleet, are described below:

Flight 1 (May 3, 1990):

Function of the pipet to meter accurate volumes of fluid was affected by changes in cabin pressure of the aircraft as engine power was changed during parabolic maneuvers. The change in ambient pressure caused the liquid column in the pipet tips to change position either up or down, with the result that accurate volumes of fluid were not transferred onto the substrate material. An important finding was demonstration of the ability to make and break a column of liquid between the pipet tip and the slide substrate in micro-g. A concern of principal investigators was that fluid columns would form but would not break in micro-g: Once a column formed between the tip and the substrate, all of the liquid in the pipet tip might be drawn from the pipet tip onto the substrate or to the extent that the substrate became saturated. Columns of water and protein solutions were shown to form and break during micro-g periods.

Flight 2 (May 22, 1990):

The experimental liquid container and metering system was used and functioned well during the flight to contain the blood sample and to meter

accurate volumes onto the slide substrate. The experimental container was filled with anticoagulated whole blood prior to the flight. The metering device was a manually operated volumetric pipet which contacted the container at a metering port. The design of the tip to transfer fluid from the container to the substrate used concentric ring edges in "stair step" arrangement to limit and direct fluid motion from the pipet tip onto the slide substrate. Accurately directed, reproducible volumes of blood appeared to transfer from the container onto the substrate on demand. There were no obvious problems handling and dispensing small blood volumes in micro-g using this system.

Flight 3 (May 24, 1990):

The modified pipet from flight 1, modified to vent during cabin pressure changes to equalize pressure above and below the liquid column in the end of the pipet tip, did not seem to solve the problem encountered on flight 1. No significant difference was noted, indicating that venting was ineffective or that other effects, e.g. surface tension, were dominant. Ability to form and break fluid columns in micro-g was confirmed.

CONCLUSIONS:

The basic mechanism of a pipet that displaces air to displace the liquid of interest from a pipet tip can function to transfer an accurate, microliter volume of blood, plasma or water liquid in micro-g. Liquid reservoir and dispense methods, however, may require special design to limit liquid volume transferred or/and pressure capacitance effects. These liquid transfer functions, which are normally performed in a clinical laboratory work bench setting with stable work bench and generous work area, can also be performed in suboptimal settings such as the KC135 aircraft with rapidly changing ambient pressure, temperature and gravitational acceleration at the work station. The experimental container that was specially designed to maintain an integral liquid column within the container and an extended liquid column length functioned well to transfer accurate, limited volumes of blood. Conventional pipet designs did not perform well to meter accurate liquid volumes. Formation and breakage of liquid columns (or bridges) between pipet tips and slide substrates, occurred in microgravity, whether the liquid was a protein solution, blood or water and whether the substrate was readily or slowly wettable. Transfer of accurate, microliter liquid volumes is possible in micro-g environments.

Analysis of video data by Kodak and may provide more information regarding transfer processes for blood, plasma, serum and possibly other biological fluids in micro-g.

RECOMMENDATIONS:

The integrated blood (biological fluid) collection, processing and metering system should receive further development and test. Rate of liquid metering and length of the liquid column within the sample container might be compared with metered volume accuracy in micro-g. A similar test protocol should be used and should add other necessary liquid handling or processing steps that are needed for laboratory diagnostic procedures in micro-g environments, e.g. preparation of quality control fluids.

Attachments:

Proposal for KC135 experiments: Testing strategies for metering microliter volumes of biological fluids in microgravity, RL Columbus and HJ Palmer.

Test plan for KC135 experiments: Precision metering of microliter volumes of biological fluids in microgravity (including hazard analysis/safety certification considerations and equipment sketches).

Supplement to test plan for KC135 experiments (description of experiment 4 to include use of human blood plasma).

Structural analysis of KC135 (liquid) metering breadboard. (letter and attachments from Kodak/J. Quenin to KRUG/B. McKinley, April 7, 1990.)

Memorandum for record, re: use of human blood plasma in proposed precision fluid metering experiments aboard the KC135, April 25, 1990.

NASA PHOTO REFERENCE

S90-39608
Setup of the experiment workstation

S90-39611
System for delivery of volumes

S90-39775
Preparing a sample

S90-39780 - 82
Performing various steps in monitoring the instruments

5/1-54

N91-32793

P 24

SHUTTLE ORBITER MEDICAL SYSTEM EQUIPMENT/SUPPLIES EVALUATION

PRINCIPAL INVESTIGATOR:	Kristin Maidlow
CO-INVESTIGATOR:	John M. Schulz, M.D., Charles W. Lloyd, Pharm. D., Tiffany Breeding
FLIGHT DATE:	May 3 and 25, 1990

K64S1054
K6481054
ND1832000
K6481054

GOAL:

To evaluate the effectivity in zero gravity of several medical equipment and supply items flown in the Shuttle Orbiter Medical System (SOMS). Several procedures listed in Medical Operations Medical Checklist, JSC 1732 were also evaluated.

BACKGROUND:

A reevaluation of the SOMS kits was initiated in January 1990. The effectivity in microgravity of several items was in question so they were drawn out of the kits and tested on the KC-135. Two different KC-135 flights were dedicated to this procedure; FLIGHT ONE on May 3,1990, and FLIGHT TWO on May 25,1990. In these flights, the following elements were examined:

1. Measuring IV Flow

The Cutter brand Primary Additive Nonvented IV Set is flown in the SOMS medical kit. The set contains all of the necessary components for successful zero gravity operation, however, the set also contains extraneous components. Although the set has proven effective in one G, effectivity in microgravity was placed in question following an equipment evaluation by Dr. James Bagian on STS-29. The set includes the following components in series:

- spike for IV bag penetration
- drip chamber

PAGE 212 INTENTIONALLY BLANK

- one way check/flow valve
- upper medicinal entry with swab pad injection site
- 0.22 micron filter for air/fluid separation (referred to hereafter as the air/fluid separator)
- safticlamp roller clamp
- ower medicinal entry with swab pad injection site
- luer adapter
- 86" of tubing length

In zero gravity, air contained in the IV bag becomes evenly distributed throughout the fluid. The air must be removed prior to IV administration. The effectiveness of the Cutter set in zero gravity is based on the operation of three components:

Drip Chamber:

- not necessary in zero-gravity

One Way Flow Valve

- The effectiveness of the valve is questionable when located above the air/fluid separator due to the compressibility of the air/fluid mixture flowing through this region.

- If the valve is ineffective, the force applied to the IV bag must be adequate to overcome central venous pressure (CVP) at the patient end of the IV line. If pressure is not maintained, blood flows into the IV tubing.

Air/fluid Separator:

- The efficacy in microgravity is in question following evaluation on STS-29.

- The necessity of this feature has been questioned when alternative IV administration techniques are used.

On STS-29, Dr. James Bagian set up the IV infusion set and reported a blockage of flow at the air/fluid separator. The equipment was tested postflight and performed within expectations. Dr. Bagian also attempted an administration technique which eliminates the necessity of an air/fluid separator. Dr. Bagian swung the IV bag over head in a circular

motion to separate the air out of the IV fluid. The weight of the IV fluid causes it to travel to the outer portion of the bag forcing the air to the inner portion where the bag opens to the tubing. When flow was initiated, the air travels out of the bag first, leaving the fluid behind to be administered intravenously.

To further evaluate the failure experienced in STS-29, during STS-32, mission Bonnie Dunbar set up the IV administration set. The IV set operated successfully.

2. **Chemstrip Protocol for Urine Analysis in Zero-gravity**

Although the effectivity of the chemstrips is not altered in zero gravity, the technique of liquid application must be altered.

Under "Bladder Infection" in the medical checklist, p.2-13, chemstrip use is suggested, however, no urine application technique is listed. To develop a technique suitable for zero gravity, several different application materials were tested on the KC-135. All materials were drawn from the SOMS kits.

3. **Tamper Resistant Seals for Injectable Medications**

The use of tamper resistant seals for injectable medications has recently been suggested.

The appropriate product produced by United States Clinical Products (USCP) was selected and the ease of use in microgravity was tested on the KC-135.

OBJECTIVES:

This experiment was designed to:

1. **Measure IV Flow Rate**

The effectiveness of the Cutter brand Primary Non-vented IV administering set was analyzed by observing the following:

Drip Chamber

- flow through the chamber in correspondence with the resultant flow from the terminal end of the IV line
- how the initial condition of a full or empty drip chamber effected the IV flow
- project how removing this component would alter IV flow

One Way Flow Valve

- flow immediately before and after the valve
- project how removing this component would alter IV flow
- project how altering the location of the valve would alter IV flow

Air/fluid Separator

- the effectiveness of the air/fluid separator by monitoring the fluid flow immediately before and after the component
- alternative methods of air/fluid separation

The experiment was also designed to test the procedure listed in the Medical Checklist for IV use and alter if need be. The experiment measured flow rates produced by using the procedure listed in the Medical Checklist (see appendix B).

2. **Chemstrip Protocol**

Several techniques designed for chemstrip use were tested with the intention of incorporation into the Medical Checklist. The following materials were analyzed:

- cotton balls
- gauze pads
- calgiswabs

3. **Tamper Resistant Seals**

USCP tamper resistant seals were tested using the following criterion for evaluation:

- surface tension:was it relatively easy to puncture the seal with the Tubex injector
- did the seals inhibit injectable removal from the kit , impacting emergency situations

4. **Identify other components of the SOMS kits that should be reevaluated.**

MATERIALS:

1. Measuring IV Flow

- Cutter brand Pureflo IV Filtration System 86" Primary Additive Nonvented IV Set (described in the background),located in the Emergency Medical Kit (EMK) D1-8
- blood pressure cuff, EMK C1-1
- 250cc saline pouches (dyed for video purposes), EMK D1-8
- receiving bags, saline bags emptied
- towels
- duck tape
- dermacil tape, Medications and Bandage Kit (MBK) F1-4, EMK B1-8
- stop watch
- 2x3 foot table
- scissors

2. Chemstrip Protocol

- Urine Test Package, containing 12 chemstrips, EMK B2-2
- 60cc syringes
- colored water for urine simulation
- calgiswabs, MBK F1-1
- cotton balls, EMK C1-2
- gauze pads, MBK F2-1, MBK F2-2, EMK P1
- towels

- ducktape
- absorbant field

3. **Tamper Resistant Seals**

- Tubex injector syringes
  - prefilled
  - partially filled
- metal Tubex injector
- USCP tamper resistant seals
- cotton wad to absorb the discharged liquid

PREFLIGHT PROCEDURES:

Flight One

1. **Measuring IV Flow**

This portion of the experiment was designed to measure the flow through the air/fluid separator.

Four different set ups were used, each consisting of:

- 250 cc saline bag, injected with blue dye for video purposes
- Cutter IV administration set
- blood pressure cuff
- 3 liter receiving bag attached to the terminal end of the IV line

A single IV administration set was setup preflight and it was determined that in order to prevent preflight wetting of the filter, the IV line needed to be clamped before the air/fluid separator as well as having the pinch roller valve closed.

The following saline bag masses were recorded preflight(in gms):

#1 298.14
#2 297.14
#3 297.68
#4 298.55

The following equations were suggested to measure flowrate postflight:

- inflight flow time = t
- change in mass = preflight mass - postflight mass = m (gms)
- flow volume = v (ml), v= m*specific volume of the fluid where the specific volume is defined as the volume per unit weight, for water =1 ml/gm = m*1ml/gm.
- flowrate = volume/time = ml/sec

2. Tamper Resistant Seals

Partially filled and prefilled Tubex syringes were obtained and USCP tamper resistant seals were placed over the end of the syringe. Preflight analysis proved the seals to be an adequate product. Hypobaric chamber testing was also conducted to evaluate the seals in low pressure situations. Results are described in appendix B. Offgassing tests were also performed prior to the flight, see appendix C.

Flight Two, May 25,1990

1. Measuring IV Flow

Three set ups identical to those used in flight were used, however, two set ups used a presaturated air/fluid separator.

Preflight saline bag masses were recorded as (in gms):

#1	568.9
#2	298.6
#3	297.2

2. Chemstrip Protocol

To simulate urine flow, a 60cc syringe used. To saturate the chem strip, two techniques were proposed:

- "controlled method"
  - wetting the material with approximately 5cc of fluid

- holding the syringe approximately 3mm away

- "free flowing method"
  - holding the syringe at least 6 cm away
  - a large amount of fluid was directed toward the material to simulate conditions in which a urine sample is obtained during a space shuttle mission.

The following materials were used to apply the liquid to the chemstrip:

- cotton balls
  - one and two cotton balls

- gauze pads
  - one and two gauze pads

- calgiswabs
  - one and two calgiswabs

The water in the syringe was dyed blue for video purposes. All materials were tested before flight, the calgiswabs had the best results.

POSTFLIGHT PROCEDURES:

Flight One

Measuring IV Flow

All four sets were laid out on a table and analyzed separately. Dr. Schulz recorded flow time during the flight, giving the "GO" when zero gravity was obtained during each parabola. Ms. Maidlow controlled the pinch roller valve, and Dr. Lloyd observed flow through the air/fluid separator making oral observations on a micro casette recorder.

During the first two sets of parabolas (1-20), a quantitative and qualitative analysis of IV flow was done on all four sets.

IV Set #1 - Pre-zero gravity conditions

- filter inadvertently saturated when the pre-air/fluid separator clamp fell off

- this set was set aside for later observation

IV Set #2 - Pre-zero gravity conditions

- air vent of the air/fluid separator pointed upward in relation to the table
- 250cc saline bag
- Drip chamber contained approximately 5ml's of fluid, 75% empty
- Pressure cuff inflated to 40mmHg, had difficulty maintaining pressure with the cuff, through out the flight had to keep pumping up the cuff
- air/fluid separator dry prior to flow initiation
- IV line clamped off prior to the air/fluid separator and at the roller clamp
- Ms. Maidlow controlled the pinch roller valve

Inflight observations

Parabola #1

- drip chamber took a long time to fill
- extremely slow flow
- a lot of air in the air/fluid separator
- 21.79 seconds flow time recorded

Parabola #2

- Air/fluid flowing into the air/fluid separator,fluid flowing out
- 20.57 seconds flow time recorded

Parabola #3

- continuous fluid flow post air/fluid separator despite excessive air coming from the IV bag

- continuous flow for the duration of the parabola
- 21.58 seconds flow time recorded

IV Set #1 - Pre-zero gravity conditions

- air vent of the air/fluid separator pointed downward
- 250cc saline bag
- drip chamber approximately 1/2 full prior to flow initiation and remained at this level during flow
- blood pressure cuff inflated to 150 mmHg

Inflight observations

Parabola #4

- 19.96 seconds flow time recorded

Parabola #5

- 23.00 seconds flow time recorded

Parabola #6

- 23.15 seconds flow time recorded

IV Set #3 - Pre-zero gravity observations

- air/fluid separator oriented in a vertical plane with the north side of the filter pointed upward

Inflight observations

Parabola #7

- 23.68 seconds flow time recorded

Parabola #8

- flow initiation slow due to difficulty in opening the pinch roller valve
- 23.34 seconds flow time recorded

Parabola #9

- 24.54 seconds flow time recorded

IV Set #4 - Pre-zero gravity conditions

- air/fluid separator oriented in a north south plane with the north side of the filter pointed downward

Inflight observations

Parabola #10

- 17.3 seconds recorded flow

Parabola #11

- 24.84 seconds recorded flow

Parabola #12

- 23.39 seconds recorded flow

Parabola #13

- 22.38 seconds recorded flow

Parabola #14

- qualitative analysis was done on IV set up #4 for the remainder of the IV flow portion of the experiment
- flow consistent, air/fluid flowing into the air/fluid separator, fluid flowing out

Alternative IV Administration Technique

Part I - Deployment of the IV Administration Equipment

During the third set of parabolas, the IV line was modified to test the air/fluid separation technique used by Dr. Bagian in STS-29. This was done by cutting the air/fluid separator off the IV line and moving the pinch roller clamp valve to the end of the remaining portion. Holding the roller clamp, the IV bag was swung overhead.

Preflight conditions

The IV administration set, saline bag, and blood pressure cuff was deployed from the SOMS medical kits during this portion of the experiment.

Inflight observations

Parabolas# 15-20

- IV administration set, saline bag, and blood pressure cuff were deployed from the SOMS kits
- difficult to get into the kits and deploy the medical items in the time frame of one parabola
- difficulty getting the protective pouch around the saline bag open causing the bag to be shaken up quite a bit, evenly distributing the air bubbles
- flow started immediately after the spike of the IV set was inserted into the saline bag
- following Medical Checklist procedures, the blood pressure cuff was wrapped around the saline bag and inflated to 160 mmHg pressure found it very difficult to inflate the cuff to 300 mmHg and maintain that pressure
- pressure of the blood pressure cuff was increased to 170 mmHg pressure
- it took a full 10 parabolas to deploy the IV set, saline bag, and set up for IV administration (estimated 230 seconds or approximately 4 minutes)

- after flow was initiated, the pressure was increased to 300 mmHg, the bag seemed fine
- flow appeared similar to the other three sets

Part II: Attempting the Technique

Pre-zero gravity conditions

- the air/fluid separator was cut off of the IV line
- pinch roller clamp moved up just below the air/fluid separator

Inflight observations

Parabolas#21-30

- Dr. Schulz attempted the technique with success
- air displaced from the liquid, moved to the interior portion of the IV bag
- as roller clamp valve was opened, the air traveled out of the bag mixed with a small portion of liquid
- time limitations prohibited removal of all of the air, however, it appeared as thought a majority of the air had been removed from the IV bag

During the fourth and finial set of parabolas, the tamper resistant seals were analyzed along with other items in the SOMS kits.

Flight Two

Measuring IV Flow

The first set of parabolas was dedicated to measuring IV flow both quantitatively and qualitatively. Ms. Maidlow recorded flow and made oral observations in a micro cassette recorder. Ms. Breeding controlled flow by the pinch roller clamp valve.

IV SET #1 - Pre-zero gravity conditions

- 500cc saline bag
- Drip chamber totally full
- Pressure cuff inflated to 40mmHg
- air/fluid separator presaturated
- IV line clamped off at the roller clamp

Inflight observations

- Observable flow did not start until the third parabola(visible by air bubble movement into the air/fluid separator)
- Flow appeared considerably slower than in the previous flight
- By the fifth parabola, flow increased somewhat
- Total flow time 1 minute 52.11 seconds

IV Set #2 - Pre-zero gravity conditions

- 250cc saline bag
- Drip chamber half full
- Air/fluid separator saturated
- IV line clamped off at the pinch roller clamp

Inflight observations

- Set was tested for 4 parabolas only, the remainder of which were lost due to difficulty keeping the blood pressure cuff on the IV bag, however 250cc bag much easier than 500cc bag.
- Air/fluid separator vent port facing north
- Air and fluid flowing into the filter, fluid flowing out.
- Total flow time 1 minute, 41.39 seconds

IV Set # 3 - Pre-zero gravity conditions

- The IV line was clamped off before the air/fluid separator, keeping the filter dry until flow was initiated.
- The line was also clamped off at the roller valve.
- Drip chamber one third full.

Inflight observations

- Flow appeared much greater than in the first two sets.
- Flow rate was consistent throughout the entire set of parabolas.
- Total flow time 35.17 seconds

Chemstrip Protocol

The second set of parabolas was dedicated to analyzing techniques appropriate for urine sample application in zero gravity. Each material was tested for two parabolas. The material with the best results was then tested for the four remaining parabolas in the second set.

Pre-zero gravity conditions

- urine test package taped on testing table which was covered with absorbant material
- 60cc syringe taped to table leg
- Ms. Breeding holding chemstrip
- Ms. Maidlow applying sample

Inflight observations

- The urine test assembly provided extremely easy access to the chemstrips.

Cotton Balls

Controlled Method

- One cotton ball was thoroughly saturated to the point where the fluid was on the verge of escaping from the cotton ball.
- The cotton ball was then passed over the chemstrip and was found to saturated the test strip totally.
- Excess liquid fell out of the cotton ball as it was passed over the chem strip.

- Two cotton balls held the liquid better then the single cotton ball.
- Excess liquid fell out of the balls when passed over the chemstrip.

Free Flowing Method

- One cotton ball became heavily saturated
- When passed over the chem strip, free fluid was released
- The chemstrip was thoroughly saturated
- Two cotton balls became heavily saturated
- When passed over the chemstrip, free fluid was released
- The chemstrip was thoroughly saturated.

Gauze Pads

Controlled Method

- One gauze pad did not hold liquid, the excess was taken up by the absorbant pad.
- The gauze was found to be totally inappropriate for the use intended. Two gauze pads were not tested.

Free Flowing Method

- This was not tested due to the inadequacy of the material.

Calgiswabs

Controlled Method

- One swab was saturated by the syringe, did not hold the entire 5 cc's of liquid
- The single swab wet the chemstrip, however, several passes were

necessary to thoroughly wet the strip. A rubbing motion was necessary.

- Two swabs held the 5 cc's of fluid
- The two swabs thoroughly wet the strip when gently passed over the test area.

Free Flowing Method

- After the syringes were saturated, they were passed over the chemstrips with the same results as in the controlled method.

RESULTS

1. Measuring IV Flow

FLIGHT ONE			
SET UP #	TOTAL FLOW VOLUME (ml)	TOTAL FLOW TIME (sec)	FLOW RATE (cm3/sec)
1	57.95	66.11	.8766
2	46.70	63.94	.7303
3	51.68	71.56	.7220
FLIGHT TWO			
1	60.89	112.11	.5432
2	50.91	101.39	.5021
3	27.76	35.17	.7906

2. Tamper Resistant Seals

Seals did not interfere with Tubex syringe operation.

3. Chemstrip Protocol

Two calgiswabs proved the best material for liquid application on the chemstrips in microgravity.

DISCUSSION AND RECOMMENDATIONS

1. Measuring IV Flow

Results from both flights proved constant operation of the Cutter brand Primary Nonvented IV Administration Set. In all instances, the filter removed all of the air that was visible. The filter removed air regardless of the duration of flow. The pinch roller valve was easy to operate in all portions of the experiment. Injection sites were not tested.

Flow rates varied from .5021 cm^3/sec to .8766 cm^3/sec. Dr. John Schulz concurred this as an acceptable range. The flow did not seem to vary with the blood pressure cuff pressure. In both flights, 86" of tubing length was excessive. Reduction of the tubing length is desired.

From both flights, the following recommendations have been made:

- reduce tubing length
- move one way flow valve to follow the air/fluid separator
- move both injection sites to follow the air/fluid separator
- eliminate the drip chamber

Cutter is unable to custom produce an IV administration set. However, Baxter Travenoll has expressed an interest in accommodating the needs of Medical Operations. A new set is currently in design, this set will include(in order):

- IV bag spike
- approximately 36" IV tubing
- air/fluid separator
- oneway flow valve
- pinch roller clamp
- two medicinal entry sites
- luer adapter

See appendix D for the proposed design. When the prototype is obtained,testing will occur on the KC-135.

2. Chemstrip Protocol

The two calgiswab method of wetting the chemstrip appears to be the

best technique for on orbit urine analysis. Although the cotton balls held sufficient liquid and saturated the chemstrip, surgical gloves would be necessary with this technique. With the calgiswabs, the 7" wooden handle would allow the flight crew member to hold the hand clear of the urine stream. The technique is appropriate for males and females alike .

The swabs can be placed in the wet trash when the urine analysis is been complete. This technique has been incorporated into the Medical Checklist.

To facilitate urine sample collection, we recommend the placement of a velcro square on the back of the urine test assembly. The velcro could then be mounted to the velcro in the WCS compartment. Currently, the crew member has to hold on to the assembly which understandably could be quite cumbersome when gathering a sample.

3. Tamper Resistant Seals

Results from the hypobaric chamber proved the tamper resistant seals inappropriate for partially filled Tubex syringes. Results from microgravity testing were satisfactory. The surface tension of the seals did not pose a problem for actual Tubex operation. The benefit of using tamper resistant seals is substantial. A request has been made to the pharmaceutical company that manufactures the medications in the partially filled Tubex to produce 1ml syringes. The company has not given an answer to this request at this time.

SUMMARY OF PHOTOS AND VIDEO

NASA Photo Description

S90-36902 *IV flow analysis set up, flight one*

- blood pressure cuff inflated around set numbers 3&4
- flow just started in set #4
- Ms. Maidlow holding air/fluid separator in N/S orientation in relation

to the table

- flow had been initiated in all 4 sets

S90-36904 ***Air/fluid separator, flight one***

- IV set up #4
- drip chamber totally full, air/fluid mixture flowing into the air/fluid separator, fluid flowing out
- air/fluid separator containing a great deal of air

S90-36905 ***Air/fluid separator, flight one***

- IV set up #4
- air/fluid separator in N/S plane of orientation
- drip chamber filled with air and fluid
- air/fluid separator filled primarily with fluid
- pinch roller clamp open

S90-36912 ***SOMS Kit evaluation***

- Ms. Maidlow holding MBK
- Dr. Lloyd holding Tubex syringe with tamper resistant seal
- Dr. Schulz holding IV set with inflated blood pressure cuff getting ready for the swinging air removal method

S90-36913 ***SOMS Kit evaluation***

- Ms. Maidlow holding the MBK
- Dr. Lloyd holding Tubex syringe
- Dr. Schulz holding IV set prior to swing method modification

S90-36894 *SOMS Kit evaluation*

S90-36914

- Ms. Maidlow holding Norgestrel/ethinyl/estradiol pills
- Dr. Lloyd holding Tubex syringe and receiving bag
- Dr. Schulz holding IV administration set

S90-39743

- Chemstrip protocol for urine analysis, flight two
- Ms. Breeding holding chemstrip
- Ms. Maidlow holding 60cc syringe and applying sample to the chemstrip with calgiswab

NASA Video Reference Master 117583

Title: STS-32 Onboard ID#18
Work Order: 01060
Date: 3/21/90

On board video of mission specialist Bonnie Dunbar operating the Cutter brand IV Administration Set.

APPENDIX A

HYPOBARIC ANALYSIS OF USCP TAMPER RESISTANT SEALS

Partially filled Tubex syringes pose a problem during Shuttle missions when the cabin is depressed to 10.2 psia during EVA preparation. Gasses trapped within the syringe expand which causes plunger movement. If the movement is prohibited, a pressure chamber within the syringe results. When the protective covering is removed from the needle, it is projected that the medication would shoot out of the needle.

To simulate 10.2 psia cabin operations preflight testing protocol included a hypobaric chamber run using partially and prefilled Tubex syringes. To examine the force exerted on the syringe stopper by the seals, 10 syringes were observed. Morphine and meperidine are the only partially filled Tubex syringes flown in the SOMS medical kits. Three of each were taken into the chamber along with 4 prefilled sodium chloride syringes for generic observation.

10.2 psia is equivalent to 9700 ft. on an altimeter.

The following results were obtained:

Morphine Sulfate

syringe #1

- at 8,8000 ft., stopper began moving toward the end of the syringe
- 15,000 ft could not move any further, it had hit the seal

syringe #2

- began moving at 10,10,000 ft.

syringe #3

- began moving at 6,6000 ft.

Stoppers on all syringes stopped moving at 15,15,000 ft., they had reached the limit of the tamper resistant seal. When the protective covering was removed from one of the syringes, the medication shot out in a projectile motion. During descent, all stoppers retracted slightly. but not enough to overcome the pressure built up in the syringe.

Meperidine

syringe #4

- stopper began moving around 9,9000 ft.
- stopper hit tamper resistant seal at 9700 ft.

syringe #5&6

- stopper hit tamper resistant seal at 9700 ft.

Sodium chloride

syringe #6-10

- stopper movement was not apparent

APPENDIX B

IV ADMINISTRATION TECHNIQUE LISTED IN THE MEDICAL CHECKLIST

p. 4-8 Medical Checklist

Intravenous Fluid Infusion

1. Unstow:
   - IV fluid bag (D1-8)
   - IV administration set (D1-8)
   - Tape, Dermacil (F1-4)
   - Blood Pressure Cuff (C1-1)

2. Tear off four 4-in. strips Dermicil tape

3. Assemble IV setup:
   - Remove IV bag from package
   - Remove caps and plug IV tubing spike into IV bag

NOTE: Make sure IV line roller clamp in CLOSED

4. Remove cap from patient end of tubing save finial cap

5. Open roller clamp and squeeze bag to prime IV line and purge air: close clamp

6. Re-cap patient end of line

7. Wrap blood pressure cuff tightly around bag and inflate to 300mmHg

DEPLOYMENT AND TESTING OF A SECOND PROTOTYPE EXPANDABLE SURGICAL CHAMBER IN MICROGRAVITY

PRINCIPAL INVESTIGATORS:	Sanford M. Markham, Colonel USAF, MC, SFS
	John A. Rock, M.D.
GROUP/ORGANIZATIONS:	Department of Obstetrics and Gynecology, David Grant USAF Medical Center, Travis AFB, CA, Section of Reproductive Surgery
	Department of Gynecology and Obstetrics, The Johns Hopkins Hospital, Baltimore, MD
FLIGHT DATE:	May 25, 1990

OBJECTIVE:

To test the functional usefulness and adaptability of a second prototype of an expandable surgical chamber for use in microgravity environments.

In-Flight Test Procedures:

1. During the microgravity exposure, two separate expandable surgical chambers were tested. The first chamber was fitted with prepositioned surgical gloves attached to the arm port cuffs. The second chamber was fitted only with elastic cuffs through which the gloved surgeon's hands were passed into the port.

2. Both chambers had been modified to fit the microgravity work station without extending over the sides of the table.

3. Both chambers were attached to a portable laminar flow generator which served two purposes: (a) to keep the chambers expanded during

use and (b) to provide an operative area environment free of contamination.

4. During the tests, the chambers were placed on various parts of a total body moulage (which was attached to the microgravity surgical work station) to simulate management of several types of trauma.

5. The tests consisted of (a) cleansing contusions, (b) debridement of burns, and (c) suturing of lacerations. The injuries were created on plastic and foam rubber sheets attached to the abdomen and leg of the total body moulage.

6. Additionally, indigo carmine dye was deliberately injected into the chamber during the tests to determine the ease of cleansing the chamber walls after contamination by escaping fluids.

7. Upon completion of the tests, the expandable surgical chambers were deflated, folded, and placed in a flattened state back into their original containers for storage and later disposal.

Results of Test Procedures:

1. The chambers could be fitted with ease to any part of the moulage body because of the adhesive surface which allowed attachment to flat as well as rounded surfaces.

2. Visualization into the chamber was excellent because of the new Texan top which provided an unobstructed view of the surgical field,

3. The arm port sleeves were of sufficient size as to allow complete freedom of motion to all portions of the chamber.

4. The laminar flow generator adequately expanded the chamber during the microgravity exposures, allowing for considerable space in the area of surgical repair. Back-up plastic rods were available to keep the chambers expanded but were not needed.

5. The indigo carmine dye injected into the chamber during microgravity exposures formed small spheres that did not adhere to the lexan top, but migrated to the chamber side walls and were easily absorbed by loose weave gauze prepositioned within the chamber for that purpose. The

dye did not smear on the surface and did not obstruct vision into the chamber.

6. All of the dye (60 cc) was contained within the chamber and did not pass through the exit filter port on one side of the chamber.

7. Comparison of the two models indicated a greater ease of entry and exit utilizing the model where the gloved hand was passed through the opened arm port. Comparison of models:

	Glove inserts	**Sleeves only**
Ease of entry	difficult	easy
Ease of removal	difficult	easy
Range of motion	good	excellent
Sterility	excellent	good

8. Surgical instruments were passed into and out of the exit port with ease and without collapse of the chamber.

9. Surgical instruments were not affixed to the chamber walls and, when not in use, floated about the chamber during microgravity exposure. Future chambers should not contain pockets or a magnetized panel to restrain unused instruments and needles.

10. After testing, the chambers could be deflated, folded, and replaced into their original container for storage until disposal.

NASA PHOTO REFERENCE

S90-39742
Fluid behavior in 0-g in enclosed chamber

S90-39746
Demonstration of microgravity

S90-39748
Demonstration of microgravity

S90-39750
Surgical technique in 0-g in an enclosed chamber

S90-39755
Surgical technique in an enclosed chamber

S90-39756
Surgical technique in an enclosed chamber

S90-39769
Surgical technique in an enclosed chamber

S90-39770
Surgical technique in an enclosed chamber

S90-39772
Surgical technique in an enclosed chamber

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