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THE MEDICAL SUPPORT OF MANNED SPACE FLIGHT

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After the many distinguished speakers who have been on this program, there is no need to justify spaceflight or to try to provide lists of good engineering spinoffs. In a recent talk, Dr. Teller stated that the greatest benefit from the space program was achieved with the investment of the smallest amount of weight which is as it must be in this program. This benefit was the acquisition of knowledge. At this time no one can say exactly how great this knowledge will be or exactly what tremendous applied benefits may result. There can be little doubt, however, that benefits will accrue to many areas of our life. There are some medical payoffs or spinoffs to this program.

Placing man in a hostile environment has caused us to require that he be monitored to determine the response of his physiology to this environment. We are in effect stretching our stethoscope 100 miles from the Earth's surface instead of using it at the bedside as we did previously. This has required development of bioinstrumentation and telemetering techniques, and these are rapidly reaching into all the areas of the practice of medicine. The impetus of the space program has called for miniaturizing and, if you will, *comfortableizing* such instrumentation in order that we may gain the maximum physiological data on man over long periods of time under very trying situations. Figure 1 shows the array of such instruments used for the Cooper flight. New instruments and methods are constantly being developed, some of which will be of value to us, but many of which will be of value to the practice of medicine on Earth.

Another very interesting outcome of this entire program has been the study of normals. As flight surgeons, we find ourselves concerned principally with the study or care of the normal individual placed in an abnormal environment, whereas the Earthbound physician studies the response of an abnormal individual to a normal environment. In obtaining our many hours of baseline data and then following these normal individuals into a stressful environment, we have found many interesting pulse rates, respiratory rates, and electrocardiographic findings which we be-

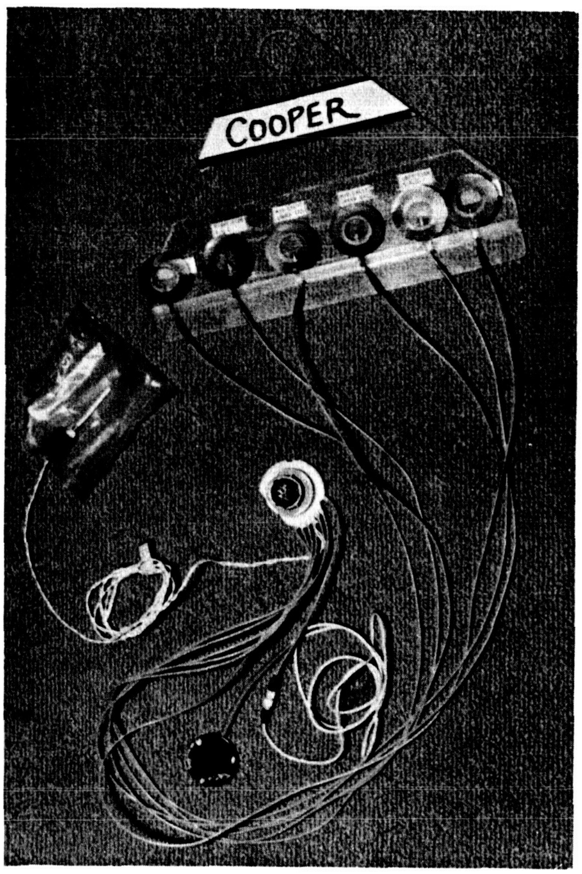

FIGURE 1.—Bioninstrumentation for Cooper flight.

lieve are entirely normal in these situations. As normal man is monitored for prolonged periods, further information will be obtained which will be of value in the study of disease and in establishing new normals. We might look a short distance further and see the uses which bioinstrumentation will be put to in the development of central monitoring stations in hospitals and recovery rooms. This should help in alleviating some of the personnel shortages in hospitals and provide the patient with better all around care at critical times. There are many other areas which I am sure you could think of, but this evening I would like to discuss with you some of the results which we obtained on Project Mercury and then briefly relate these to our future spaceflight programs.

In spite of the vast numbers of people and network assembled to carry out manned spaceflight projects and directed from positions at the Mercury Control Center, now to be the Mission Control Center, we have not come very far from the problems involved in the care of the pilot flying the old World War I Jenny in providing the care for the pilot placed in this precarious position atop the Mercury or Gemini launch vehicle, tied down in a confined space but able to see unbelieveable views of our Earth from his orbiting position. We are still plagued by the basic problems of eating, sleeping, bathing, shaving, handling body waste, and just general habitability.

The nature of the challenge posed by the development of a medical support program called for ground rules applicable to these aspects, and not unlike those outlined for the overall project by Dr. Williams:

1. Man is being thrust into a truly unknown environment and his reactions to this environment are relatively unknown.
2. The simplest and most reliable approach should be used.
3. Off-the-shelf items and existing technology should be used wherever possible.
4. Attempts would be made to provide the best protection and monitoring capable within the operational constraints of the mission.

Many lessons have been learned from this first experience of the free world with manned space-flight operations. The responsible medical community had very honestly attempted to evaluate potential problems based upon knowledge at that time. In doing this, several possible ogres were raised which, it appears, this program has killed or at least wounded. Weightlessness is a good example of the many barriers to man's entry into space which were raised prior to this program. Some of the dire physiological effects predicted as a result from exposure to this condition and, therefore, thought to be limiting to space flight were anorexia, nausea, sleepiness, sleeplessness, fatigue, restlessness, euphoria, hallucinations, disorientation, decreased G tolerance, urinary retention, diuresis, muscular incoordination, muscle atrophy, gastrointestinal disturbance, and demineralization of bones. As a result of our flights to date, few of these remain of concern, although our total experience in the free world is limited to 34 hours.

Another area in which there were dire predictions is in the psychological response to the isolation of space. Our astronauts have certainly not been isolated in space but have generally commented on too much Earth contact. There has been no evidence of any breakoff phenomenon or any aberrant psychological reaction of any sort. Thus, while we had no serious problems in space, the present conclusions can only be based upon the duration of flights thus far flown—34 hours. Each mission has been used as a means of evaluating the next step into space, and it is believed that the six manned missions in this program have laid the groundwork for future programs.

CREW SELECTION AND TRAINING

The medical portion of the selection program had as its objectives the provision of crewmembers who (1) would be free of intrinsic medical defects at the time of selection, (2) would have a reasonable assurance of freedom from such defects for the predicted duration of the flight program, (3) would be capable of accepting the predictable psychophysiologic stress of the missions, and (4) would be able to perform those tasks critical to the safety of the mission and the crew. The selection board found themselves viewing already trained test pilots somewhat in the same manner as cadets entering a training program are viewed. Small numbers were selected, leaving little excess for attrition. In view of these objectives, the group was culled by records review, interview, and testing until a final group was given a rigorous medical examination at the Lovelace Clinic in Albuquerque, N. M. This examination was followed by a stress-testing program at Wright-Patterson Air Force Base, Ohio (fig. 2). The results of these examinations were reviewed by the participating physicians, and the candidates were given a medical rank order. This

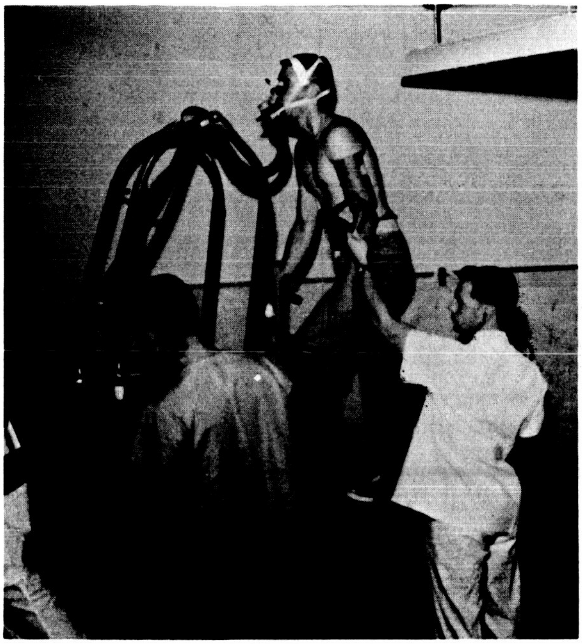

FIGURE 2.—Stress testing on treadmill.

rank order was then presented to a board which selected the original seven astronauts.

In retrospect, it can be said that the results of this program were adequate in view of the fact that the assigned astronauts have successfully completed their flight missions. This early program has been of assistance in the development of current selection programs with the USAF School of Aerospace Medicine. The stress testing in the initial selection efforts has been deleted since it was found to be of little value in a group who had already been very thoroughly stress tested by virtue of their test-pilot background. Stress testing has become a part of the training program with a selection in depth carried on during the training.

The training program has included a series of lectures on the anatomy and function of the human body, and the series has proven to be of great value during inflight monitoring and discussion of potential medical problems. Every attempt has been made to use engineering analogies where possible and to impress the flight crews with the fact that the human organism and its many systems must be monitored as thoroughly as the engineering systems if mission success is to be assured.

There has been no formal physical-training program, but each astronaut has been charged with maintaining his fitness through programed exercise of his choice. A wide variety has been used by the group. Medical advice was offered and the importance of regular training periods was stressed during the preflight preparation period. A plateau should be reached, and, although no specific level is specified, it is believed the astronaut is better prepared to withstand the flight stresses if he maintains a state of physical fitness.

MEDICAL MAINTENANCE AND PREFLIGHT PREPARATION

The medical maintenance during this program consisted of the routine medical care, similar to that provided specialized groups of aircraft pilots, annual physical examinations and special physical examinations performed before procedures such as altitude-chamber runs, pressure-suit indoctrinations, and centrifuge runs. The flight schedule with its necessary preflight spacecraft checkout procedures, simulated flights, and launches, frequently exposed each flight crewmember to severe physical examinations within a given year. An attempt was made to make these physical examinations serve several purposes such as qualifying the individual for his annual physical, being ready to participate in a given procedure, and collecting baseline data. Having flight surgeons monitor astronauts participating in all stress exposures and training exercises proved to be extremely valuable preparation for the flight mission. Preflight physical examinations added to the necessary medical status evaluations; and, throughout these activities, a close and frequent contact was maintained between flight crews and flight surgeons. This close association also provided excellent preventive medicine practice among the flight crews.

The preflight physical examinations were to serve two basic purposes. First, they should allow the flight surgeon to state that the astronaut was qualified and ready for flight. Second, they should provide a baseline for any possible changes resulting from exposure to the space-flight environment. The flight surgeon appears best qualified to determine whether the astronaut is medically ready for flight. Early in the program, the search for unexpected changes in body systems as a result of exposure to space flight dictated specialty examinations of various body systems. A team, assembled from the Department of Defense, included specialists in internal medicine, ophthalmology, neurology, psychiatry, and laboratory medicine.

The same specialties have continued to be represented, but certain items of the examinations have been modified as knowledge of the lack of serious effects of flight on the astronaut was gained. Prior to the selection of a flight astronaut for a given mission, the medical records of those being considered are reviewed in detail and a medical recommendation given to the operations director. In addition to the annual and pretraining examination, it was determined that a thorough evaluation of the flight astronaut would be made 10 days prior to the scheduled mission to assure management and the flight director that the astronaut was indeed ready for the mission. This examination included a medical evaluation of both the flight astronaut and his backup. Two days prior to the mission, the detailed physical examination was completed by the various medical specialists and the necessary laboratory work was accomplished. On flight morning, following a brief medical examination, a final determination was made as to the readiness of the astronaut for flight. This examination was principally concerned with noting any recent contraindications to flight which may have developed. While early in the program other specialists participated in this examination, on the last two missions, the participation was reduced to that by the flight-crew surgeon.

The postflight medical examinations were initially made by the Department of Defense recovery physicians stationed aboard the recovery vessel. On the early missions, the astronaut was then flown to Grand Turk Island and was joined there by the team of medical specialists who had made the preflight examination and by the flight-crew surgeon. As the flights became longer and recovery was accomplished in the Pacific Ocean, the plan was changed and one of the NASA flight surgeons was predeployed aboard the recovery carrier to do the initial postflight examination and debriefing. On the MA–8 mission, Walter Schirra's flight, the Director of Medical Operations and the medical evaluation team deployed to the Pacific recovery site several hours after recovery, and this was not only a tiring experience, but necessitated that a great deal of the examination and debriefing be done prior to their arrival. The MA–9 detailed postflight specialty examination was then conducted at Cape Canaveral when the astronaut returned from the recovery site. In our experience, the retention of the specialty examination team at a mainland launching or debriefing site is the preferable plan of action.

Early in the preflight preparations, it was determined that there was a need for many practice runs of various procedures. These runs were accomplished by doing the actual flight-type preparation for each of various preflight procedures. A medical countdown (table I) was developed with specific timing of the various events and coordination with the blockhouse and range countdown. In order to have no delay

TABLE I.—*Aeromedical Countdown*

Activity	Countdown time		Planned time			Actual time		
	Pad (T)	Aeromedical (A)	A.M. E.S.T.	Minutes: Duration	Minutes: Total	A.M. E.S.T.	Minutes: Duration	Minutes: Total
Awaken	T–220	A–170	2:50	35	35	2:51	31	31
Breakfast	T–185	A–135	3:25	30	65	3:32	33	64
Medical examination	T–155	A–105	3:55	15	80	3:55	16	80
Partial dressing	T–140	A–90	4:10	5	85	4:11	4	84
Sensor placement		A–85	4:15	10	95	4:15	9	93
Suiting		A–75	4:25	20	115	4:24	18	111
Suit/sensor checkout		A–55	4:45	15	130	4:42	12	123
Hangar S to transfer van		A–40	5:00	10	140	4:54	6	129
Transfer van to launch pad		A–30	5:10	20	160	5:00	*27	156
Ascend gantry		A–10	5:30	10	170	5:27	6	162
Insertion	T–140	A–0	5:40	140		5:33	151	
Launch	T–0		8:00		310	8:04		313

*9 minutes spent at the bottom of gantry for weather briefing, mission briefing, etc., by backup astronaut.

in the scheduled launch, a great deal of practice in this countdown was necessary. It has continued to pay dividends in the later missions.

Prior to the first Mercury launch, consideration was given to the necessity for isolating the flight crew in order to prevent the development of some communicable disease immediately prior to or during flight. It soon became evident, however, that such isolation was impractical in view of the numerous requirements upon the flight crew during the 2 weeks prior to launch. Many activities required the presence and participation of the astronaut, and the isolation was reduced to attempts to curtail the number of contacts with strangers. As the missions get longer and longer, the situation may have to be reevaluated since the mission could last longer than the incubation period of some diseases. No difficulty was encountered during the Mercury program with the use of only a very modified isolation plan.

One of the basic concepts developed stated that there would be no drugs used as routine measures, but that drugs would be made available for emergency use. Injectors were made available which could deliver their contents through the pressure suit into the astronaut's thigh. During the first four missions, the drugs available in the injectors included an anodyne (a drug for pain), an anti-motion-sickness drug, a stimulant, and a vasoconstrictor for treatment of shock. In the later missions, the injectable drugs were reduced to the anti-motion-sickness drug, a stimulant, and a vasoconstrictor for treatment of shock. For the MA–9 flight medication was reduced to the anti-motion-sickness drug and an anodyne, available both on the suit and in the survival kit (fig. 3). Anti-motion sickness and antihistamine tablets were also made available.

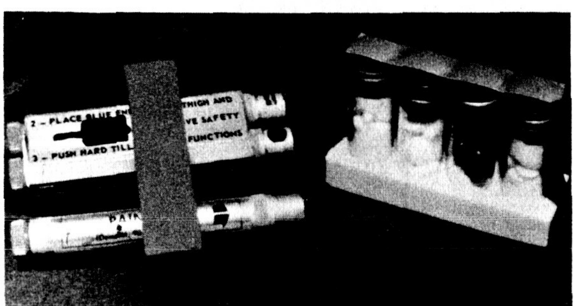

FIGURE 3.—Injectors and pill case used for MA–9 flight.

The astronauts' mental and physical integrity were never in doubt during the mission. As the time for retrofire approached on Major Cooper's mission, a review of the mission tasks made it evident that the astronaut had undergone a long and rigourous work schedule from which he might be expected to experience considerable fatigue, even assuming ideal environmental conditions and full benefit from restful sleep. As has been reported, medication was used for the first time during flight when the dextro-amphetamine sulfate was taken prior to the initiation of retrosequence. Such drugs should be available and plans must be made for their availability both during flight and postflight in the survival kit. The astronaut must always be pretested for effect of the drugs which may be used.

Experience has shown that care must be taken to prevent astronaut fatigue during the final preflight preparations as well as postflight. As launch day grows closer, the demands on the astronaut's time increase. Careful scheduling of rest, activities, and exercise periods are needed. Experience has shown that 48 to 72 hours is a minimum time for postflight debriefing, rest and relaxation following a 34-hour mission. Seventy-two hours should be a minimum for future missions. As missions get longer, this time should be increased.

Early missions required only simple provisions for the collection of urine and blood samples. As the mission duration increased, this became an unworkable procedure; and further, there was a desire to obtain separate urine samples for analysis. The last mission utilized a system for collecting five separate and complete urine samples for later evaluation. This system worked properly but will require modification for future missions. No blood samples have been obtained during flight. Every attempt has been made to combine the various preflight blood requirements in order to require as few vena punctures as possible, both preflight and postflight.

Dietary control has been utilized for approximately 1 week prior to each mission. The first several days were used to assure a normal balanced diet during the rather hectic preflight preparations. In order to prevent defecation during the mission, the low-residue diet was programed for 3 days prior to launch; and the time extended if the launch was delayed. This diet performed its task very satisfactorily during the entire Mercury program; still, indications are that any more prolonged period without provision for defecation would seem unwise. The in-flight food consisted of tablets, bite-sized and semiliquid tube food on the early missions. On the last mission, the freeze-dehydrated food was added. Problems with crumbling have been encountered with the bite-size food, and difficulty in getting and keeping water in the containers of the freeze-dehydrated food was encountered on the last mission. The assurance of palatable food is necessary, and proper containers and practice in their use appear indicated. It also appears necessary to schedule food and water intake on the flight plan.

MEDICAL MONITORING

The Mercury program provided the free world with the first opportunity for full-time monitoring of man in the space-flight environment. At the start of this program, the continuous monitoring of physiological data from a pilot conducting a mission was a very recent concept. At the time, there were no off-the-shelf items available to allow continuous and reliable physiological monitoring. It was decided to attempt to monitor body temperature, chest movement, and heart action. Standards required that the sensors and equipment be comfortable, reliable, and compatible with other spacecraft systems, and would not interfere with the pilot's primary mission.

It should be realized that the biomedical sensors are used as a means of flight-safety monitoring. The primary purpose is to assist the monitoring flight surgeon in determining whether the astronaut is capable of continuing the mission from a physiological point of view. This information is used as a basis for making go/no-go decisions in the control center. No attempt has been made under the current operational conditions to perform detailed system evaluation or analysis.

A great deal of experience in medical flight control of an orbiting astronaut was obtained through the use of the many range simulations and the several actual flights. The participation in simulations and in flights prior to those which were manned proved to be extremely valuable training exercises for the actual missions. The development of mission rules to aid in flight control was necessary in the medical area just as in the many engineering areas. Gradually, these rules were made less specific so that the evaluation and judgment of the medical flight controller were the prime determinants in making a decision. The condition of the astronaut as determined by voice and interrogation, rather than physical parameters, alone became a key factor in the aeromedical advice to continue or terminate the mission. This is as it should be and follows the lessons which were learned in general medicine wherein numerical laboratory values are not necessarily the final answer. Trend information as shown by at least three stations was shown more reliable than single values.

In developing the flight-control philosophy prior to the first manned flight, it was thought that it would be necessary for the flight surgeon to talk directly to the astronaut very frequently in order to evaluate his physiological state. As operational experience was gained, it became obvious that this was not the case. Information inquiries were passed easily and smoothly through the Cap Com (capsule communication) with the privilege of talking directly remaining should the need arise. It was also thought early in the program that the occurrence of most any medical emergency in flight would require an early or even a contingency landing. Again, as operational experience was gained with the range and with the planned recovery operation, it was determined that the best philosophy was one which held that the astronaut was in a very fast, air-conditioned ambulance on 100 percent oxygen and in most instances it would be better to return him in the spacecraft to a planned recovery area rather than to abort the flight in a contingency area where it might take hours or days to recover him. The physiological parameters monitored are shown in figure 4. Electrocardiographic electrodes were low impedance to match the spacecraft amplifier. They were required to record during body movements and to stay effective during flight durations of over 30 hours. These electrodes functioned well and gave very good information on cardiac rate and rhythm. The value

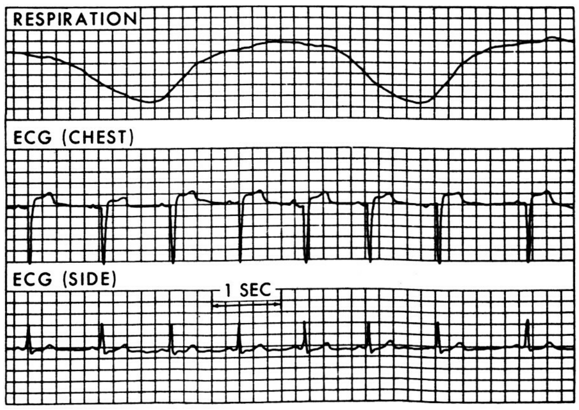

FIGURE 4.—MA–9 biotelemetry sample.

of having two leads of electrocardiograph, even though they differed from the standard clinical leads, was repeatedly shown.

Respiration was at first measured by an indirect method by using a linear potentiometer and carbon-impregnated rubber. This method was changed early in the program to a thermistor kept at 200° F and placed on the microphone pedestal in the helmet. Neither of these methods gave reliable respiration traces during flight, and a change was made to the impedance pneumograph for the last two missions. This device gave very accurate respiration information during most of the flight.

Body temperature was monitored in all missions. Rectal temperature was found to be the most reliable measurement and was used through MA–8. The long duration of the last flight and a desire for more comfort resulted in this thermistor being modified for oral use.

In 1958, the obtaining of blood pressures in flight was considered and then delayed as no satisfactory system was available. Definitive work began about the time of the Mercury-Redstone 3 (MR–3) flight, and the automatic system which used the unidirectional microphone and cuff was developed for use in the orbital flights. This system without the automatic feature was used on the MA–6 mission of Astronaut Cooper. During the MA–7 mission, all of the in-flight blood pressures obtained were elevated, and an extensive postflight evaluation program was undertaken. It was determined that the cause of these elevations was most likely instrumentation error resulting from the necessity for very careful gain settings matched to the individual astronaut along with the cuff and microphone. A great deal of preflight calibration and matchings of these settings was done prior to the MA–8 flight; and on both the MA–8 and the last mission, MA–9, very excellent blood-pressure tracings were obtained.

Voice transmissions have been a very valuable source of monitoring information. The normal flight reports and answers to queries have been used for evaluation of the pilot. In order to insure that the monitors were familiar with the astronaut's voice, tapes of mission simulations with the flight astronaut as a pilot were dispatched to all of the range stations for use in preflight simulations. Inflight photography and, on the last mission, television views of the astronaut had been planned as additional data sources. In Mercury experience, both of these sources have proved to be of very little value in the medical monitoring of the astronaut because of poor positioning of cameras and varying lighting conditions resulting from the operational situation.

The value of the comparison of multiple physiological parameters and their correlation with environmental data has been repeatedly proven. It has been interesting to note that a satisfactory amount of information on current astronaut status can be obtained with the use of such basic vital signs or viability measures.

PHYSIOLOGICAL RESPONSES TO SPACE FLIGHT

One of the basic objectives of the Mercury flights was the evaluation of man's physiological responses to exposure to this space-flight environment. These responses also had implications as to his performance capability in this environment. The stresses of this environment to which physiological responses are elicited include the wearing of the full-pressure suit although not pressurized in flight, confinement and restraint in the Mercury spacecraft with the legs at a 90° elevated position, the 100 percent oxygen 5-psi atmosphere, the changing cabin pressure through powered flight and reentry, variation in cabin and suit temperature, the acceleration force (G force) of launch and reentry, varying periods of weightless flight, vibration, dehydration, the performance required by the flight plan, the need for sleep and for alertness, changes in illumination inside the spacecraft, and diminished food intake.

Sources of data used in evaluating these responses have included the control baseline data previously referred to, data from the biomedical sensors received at both the Mercury Control Center and the range stations, voice responses at these stations and the detailed onboard tape, the onboard film record and television, answers to debriefing questions, and the detailed postflight examination.

In considering these physiological responses, it was found necessary to have a detailed in-flight event history since the peak physiological responses are closely related to critical inflight events. This meaningful relationship is very well demonstrated in considering the pulse responses to the Mercury flights (table II). The peak pulse rates during the launch phase have usually occurred at sustainer engine cutoff. This peak value has ranged from 96 to 162 beats per minute. The peak rates obtained on reentry have ranged from

104 to 184 beats per minute. This peak usually occurred immediately after obtaining peak reentry acceleration, or on drogue parachute deployment. Pulse rates obtained during weightless flight have varied from 50 to 60 beats per minute during the sleep periods to 80 to 160 beats per minute during the normal wakeful periods. Elevated rates during weightless flight can usually be related to flight plan activity, and it is not possible to compare pilots by these data.

TABLE II.—*Pulse Rates*

Mission	Peak at SECO*	Range during weightlessness	Peak during reentry
MR-3	138	108–125	132
MR-4	162	150–160	171
MA-6	114	88–114	134
MA-7	96	60–94	104
MA-8	112	56–121	104
MA-9	144	50–60 asleep 80–100 awake	184

*Sustainer engine cutoff.

Further evidence of normal pulse lability is shown by the response to transferring urine early in the flight and to the observation of the 0.5-g light being on late in the mission. Changes noted in the electrocardiograms have included alterations in the pacemaker activity with wandering pacemakers and aberrant rhythms. All of these *abnormalities* are considered normal physiological responses when related to the dynamic situation in which they were encountered. In-flight blood-pressure values and body-temperature readings have all been within the physiologically normal range.

The six astronauts who have flown have shown themselves capable of normal physiological function and performance during the acceleration of launch and reentry. The vibration produced by launch or reentry has been well tolerated in all cases. There has been no conclusive evidence of disorientation during flight.

The heat loads imposed by the environmental control system have on occasion caused discomfort but have not been limiting factors in the missions to date. The heat loads and decreased water intake have resulted in postflight dehydration. It has been learned that thermal control in the environmental system is of critical importance.

The results obtained from radiation dosimetry on the last two flights revealed that the astronauts have received no more radiation dose than they would have received had they been here on Earth and certainly less than that received during a chest X-ray.

The Mercury program has provided incremental exposures to weightless flight in order to obtain information on which to base predictions of reactions to more prolonged exposures. The crews have uniformly reported that weightlessness is extremely pleasant and restful. In fact, most of the crews think that it is the only time they have been comfortable in a pressure suit. They have conducted complex visual motor coordination tasks proficiently in the weightless environment.

No evidence of body-system disfunction has been noted during the period of weightless flight through any of the means of monitoring at our disposal. Food has been eaten normally. Urination has occurred quite normally in timing and amount, and there is no evidence of difficulty in intestinal absorption in the weightless state. Our one experience with sleep periods (during the Cooper flight) has raised the question as to whether brief periods of sleep in the weightless condition are more restful than the same periods in a 1-G atmosphere. The MA-9 astronaut feels that they are. This question will require further investigation on other flights. In the missions to date, there has been no evidence of the mobilization of calcium.

On the last two missions some postflight orthostatic hypotension, or changes in blood pressure and pulse rate with change in body position, has been noted. This postflight condition has been investigated by the use of the tilt table during the last mission and these results confirm what was only a suspicion on the previous mission. Symptoms of faintness occurred following egress from the spacecraft on MA-9 (Cooper), and on both MA-8 (Schirra) and MA-9 the changes in blood pressure and pulse rate were present for some 7 to 19 hours after landing. In both instances, these changes have been present up until the astronaut retired for the night, a time period of approximately 7 hours; and they have always disappeared by the time of the first check after the astronaut was awakened.

Thus, the orthostatic changes have lasted no longer following the more prolonged flight in the MA–9 position than for the shorter flight; and, in both instances, blood pressure and pulse rate have returned to normal while the astronaut was at bed rest. These findings do cause concern about prolonged exposure without some interim steps for further evaluation of this condition. The Gemini flights will take these findings into consideration.

RECOVERY

The medical support of the overall Project Mercury recovery operation had to meet two basic requirements:

1. The capability of providing prompt, optimum medical care for the astronaut, if necessary, upon his retrieval from the spacecraft
2. The provision for early medical evaluation to be made of the astronaut's postflight condition.

It was considered essential to establish a medical capability for any circumstance under which recovery could occur. The general concept was to provide the best care in the fastest manner possible. The extent of medical care which could be effectively administered to the astronaut during the recovery operation is governed to a large degree by the physical circumstances under which recovery occurs. Consequently, the level of medical support necessary at the different recovery areas varies according to the potential extent to which competent medical treatment can be administered in that area, and the most extensive medical support is properly concentrated in those areas where descent to Earth by the astronaut is most probable.

Since the recovery forces are routine operational units diverted to this operation by the Department of Defense, it also became obvious that the medical support must be obtained through the cooperation of the Department of Defense. Civilian physicians are not available for deployment for the necessary time periods. It will be noted that one of the basic philosophy changes during the program involved a change in emphasis from taking medical care to the astronaut in the early mission to provisions for returning the astronaut to definitive medical care in the later missions.

In the launch-site area, this support included a medical team consisting of representatives of many of the medical specialties. In the early missions, these individuals were deployed to Cape Canaveral (now Cape Kennedy) and were available should the need arise for their use either at Cape Canaveral or, in the event of a requirement for their services in the recovery area, they could be dispatched by aircraft. On the last two missions, it became necessary to develop a team at Tripler Army Hospital, Hawaii, to cover the Pacific area. It became obvious that there were large numbers of highly trained physicians who were merely waiting out the mission in a deployed state with an unlikely probability that they would be utilized.

Careful evaluation of the experience and of sound medical principles involving emergency medical care led to the conclusion that the specialty team could be maintained on standby at a stateside hospital and easily flown either to Cape Canaveral or a recovery site if their services were needed. Other launch-site support was provided by a point team consisting of a flight surgeon and scuba-equipped pararescue personnel airborne in a helicopter. Medical technicians capable of rendering first-aid care were also available in LARC vehicles and in a small boat stationed on the Banana River. A surgeon and an anesthesiologist with their supporting personnel were stationed in a blockhouse at Cape Canaveral to serve as the first echelon of resuscitative medical care in the event of an emergency. Physicians were stationed throughout the recovery areas aboard destroyers and aboard one aircraft carrier in the Atlantic and one in the Pacific. In the early missions each vessel was assigned a surgeon, anesthesiologist, and a medical technician team with the supporting medical equipment chest necessary for evaluation and medical or surgical care.

As confidence was gained in the operations, this distribution was modified to assigning only a single physician, either surgeon or anesthesiologist, to the destroyer. Attempts were made to place a surgeon on one and an anesthesiologist on another vessel nearby. This would allow their teaming up if necessary. The general concept was, however, that they would provide resuscitative care only and then evacuate the astronaut to the carrier in their particular area, where there was a full surgical team. Hospitals along the orbital track were alerted for their possible use, and some near planned landing areas were briefed by NASA–DOD teams. Early in the missions, blood was drawn from donors and made available for transfusion at Cape Canaveral and in the recovery area. As the operation grew wider in scope involving the Pacific, and as more confidence was gained, dependence was placed upon walking blood-bank donors who were typed, and drawn blood was available only in the launch-site area.

In conclusion, Project Mercury gave the opportunity to define more closely the medical problem areas, and we anticipate the future with great expectations and confidence in man's ability to adapt to and conquer this new frontier.

FUTURE PLANS

As we look at future missions in two-man Gemini and three-man Apollo vehicles, there are some changes aside from crew size which pose potential problems. The maximum mission durations planned for both these projects is 14 days. This is a considerable increase over the 34-hour duration thus far flown. We hope to reach this duration by incremental steps to learn more about man's response to the weightless environment. We are particularly anxious, of course, to gain further information concerning the responses of his cardiovascular system as well as those of the musculoskeletal system, particularly as regard calcium balance.

In the lunar program for the first time, there will be an operational demand to have the suit, which has traditionally served as a backup pressurization system, serve as a primary system while the astronaut explores the lunar surface. This has caused some special attention to be paid to the development of various aspects of this suit in consideration for additional thermal protection and micrometric protection.

Mobility in a pressurized suit in the 1/6-g lunar gravity is also a problem undergoing careful evaluation at the present time. We will first try exposures to the actual space environment in a suit in the Gemini program, by having an astronaut open a hatch and stand up and finally, actually depart the Gemini spacecraft on a tether and spend varying periods of time in free space.

Waste disposal and personal hygiene become problems of concern on these prolonged missions; they have not been of concern on our short-duration missions. We have decided that provisions must be made for defecation, and the Gemini suit has been so designed. The system to be utilized, however, has some psychologically less acceptable features than in the Apollo program where we can use the more conventional bathroom approach due to the space and weight limitations available. Body cleansing will be provided by the use of bactericidal agent present in small pads. A special vacuum-cleaner-type shaver is being designed in order that the loose whiskers will not be free in the weightless environment. A special ingestable dentifrice-type tablet has also been designed to provide proper oral hygiene.

The proper establishment of work-rest cycles is of importance on these long missions and particularly so in a lunar mission where the lunar excursion phase alone could last for a period of 48 hours. The multicrew operations will require modifications of our preparation in recovery procedures, and our countdowns will either have to be lengthened, or we will have to provide multiple examination and preparation teams.

We look forward to these programs in the future manned orbiting laboratories and Mars missions with a great deal of anticipation and with still a firm feeling that man will be able to adapt to and conquer this new environment.