COUNTERMEASURE FOR REDUCING POST-FLIGHT ORTHOSTATIC INTOLERANCE

LOWER BODY NEGATIVE PRESSURE (LBNP) EXPERIMENT E140

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Investigators have shown that after 1-2 weeks of bed rest ingestion of 1000 ml of a salt water solution during 4 hours of continuous exposure to 30 mm Hg of lower body negative pressure will protect plasma volume and orthostatic function for up to 24 hours. We hypothesize that a similar countermeasure will reduce the effects of fluid loss induced by headward fluid shift during space flight. The objective of this flight experiment is to evaluate the efficacy of the proposed countermeasure in reversing these effects on the cardiovascular system.

Experimental Procedures

Lower Body Negative Pressure (LBNP) involves exposing the legs and lower abdomen to reduced air pressure. The LBNP device is an air-tight chamber that seals the subject's waist to enclose the lower body. As used in this experiment, LBNP provides both the candidate treatment as well as the means of assessing the effectiveness of the treatment.

1. LBNP Response Tests ("RAMPS")

LBNP response tests ("ramps," Figure 1) will be conducted to measure orthostatic responses three times inflight for each participating crewmember. During this LBNP test, after 6 minutes of control data collection, the pressure will be decreased in 10 mm Hg steps every 3 minutes until a pressure of 50 mm Hg below ambient is attained. After 3 minutes at -50 mm Hg, the vacuum will be released and 3 minutes of recovery data will be collected. ECG, echocardiographic parameters, and calf dimensions will be monitored continuously; blood pressure measurements will be made at every minute of the "ramp"; leg volume measurements will be made immediately before and after each LBNP "ramp" test. Real-time medical monitoring of ECG, blood pressure, and LBNPD pressure is required throughout the ramp test.

Each LBNP "ramp" test is a 2-crew member operation. One crew member serves as the LBNP subject and will also operate the LBNP device. The other crew member is the prime hardware operator for the echocardiograph (AFE) and automatic blood pressure system (ABPS), both of which are described in detail below.

2. LBNP Treatment ("SOAK")

The treatment protocol ("soak," Figure 2) will be conducted inflight once for each participating crewmember. After 6 minutes of baseline data collection, the pressure in the LBNP device is decreased in 10 mm Hg steps every 3 minutes until a pressure of 50 mm Hg below ambient is attained. After 3 minutes at -50 mm Hg, the vacuum will be partially released to 30 mm Hg below ambient for the "soak" period. During the first hour of the soak period, the crew

member will ingest 8 salt tablets and 4 beverage containers of water (128 oz, total). This pressure level (-30 mm Hg) will be maintained for 225 minutes. Then, the pressure will be reduced in 10 mm Hg steps every 3 minutes until a pressure of 50 mm Hg below ambient is attained. After 3 minutes at this pressure step, the vacuum will be released and 6 minutes of recovery data will be collected.

During the ramp-like portions of the protocol, measurements will be made and described above. During the soak portion (e.g., the 225 minutes at 30 mm Hg), echo and blood pressure measurements will be continuously made for 10 minutes at scheduled times (one 10-min session occurs every 50-60 minutes). In addition, one blood pressure measurement will be taken every 15 minutes throughout the soak. ECG will be monitored continuously and will be available onboard for crew member reference. Leg volume measurements will be made immediately before the pre-soak ramp and after the post-soak ramp. Real-time medical monitoring of ECG, blood pressure, and LBNPD pressure is required during the soak period.

The LBNP "soak" is a 2-crew member operation. One crew member serves as the LBNP subject and will also operate the LBNP device. The other crew member serves as the prime hardware operator for the AFE and ABPS. During periods of the soak when no measurements are being made on the LBNP subject, the second crew member can perform other tasks but must continue to monitor the subject.

For an overview of all LBNP experiment operations on SL-J, please refer to Figure 3.

In-flight Hardware Description

1. Lower Body Negative Pressure Device

The components of the Lower Body Negative Pressure Device (LBNPD) are an inflatable cylinder assembly, a control console assembly, and a cover/stowage container (Figure 4). During launch and landing, the LBNPD collapses into a compact unit and stows in its Nomex cloth container attached to a floor section of the Spacelab. The stowage container has flaps with zippers to enclose and stow the control console and the compressed cylinder assembly.

The control console assembly contains a pressure/vacuum pump, switches, digital logic, pressure/vacuum and pressure relief valves, pressure/vacuum hoses, and a pressure gauge. The pressure/vacuum pump operates on 28 volts dc and pressurizes the walls of the cylinder to inflate it to its full height. After inflation, a negative pressure is created within the cylinder by operation of the pump in the vacuum mode.

2. American Flight Echocardiograph

The American Flight Echocardiograph (AFE) is an off-the-shelf medical ultrasonic imaging system modified for space shuttle compatibility. The AFE has flown on STS 51-D (April 1985) and STS-32 (January 1990) and SLS-1 (June 1991). It is an ultrasound instrument designed to acquire real time (30 frames per second) two-dimensional images of the heart. The non-invasive scan procedure provides data on cardiac structure and dynamic function. The power supply is optimized for use with three-phase, 400 Hz, 100-volt ac shuttle power.

Structural-packaging modification allows for operation from within a middeck locker.

3. Automatic Blood Pressure System

The Automatic Blood Pressure System (ABPS) is an electronic sphygmomanometer which, when used with cuff and transducer, comprises a system for measuring both systolic and diastolic arterial blood pressures using a patented infrasonic pulse-detection method. The ABPS incorporates a digital printer, an RS-232 communications interface, an ECG input connector, a heart rate monitor, and a series of buffer amplifiers to provide data outputs. The main unit controls inflation and deflation of the cuff while calculating and displaying blood pressure. It contains a microprocessor and other electronics, a dc air pump to inflate the cuff, a cuff-pressure transducer, and a keyboard and various other controls. Results appear on three liquid crystal displays (LCDs). The ABPS also incorporates an ECG medical isolation amplifier/signal conditioner to provide ECG in conjunction with blood pressure information.

4. Central Venous Pressure Device and Data Recorder

The Central Venous Pressure Device (CVPD) consists of a non-invasive Doppler blood flow probe (8 MHz continuous wave) mounted in an aluminum enclosure along with an electronic pressure meter, hardware circuitry, and LCD display. A mouthpiece/pressure transducer plugs into the pressure meter. The probe is placed over the jugular vein in the neck. The subject expires into the restricted mouthpiece while listening through stereo headphones to the flow sounds and watching the pressure meter to generate various target pressures. The mouthpiece

pressure which transiently interrrupts jugular flow is taken as an estimate of central venous pressure. Flow and pressure data are recorded onto a TEAC 7-channel cassette data recorder.

5. Ultrasonic Limb Plethysmograph

The Ultrasonic Limb Plethysmograph (ULP) is a self-contained device which uses pulses of ultrasound to determine chord lengths through the calf at two levels. Ultrasound transducers are attached to the skin over the calf muscle. An ultrasonic pulse (2.5 MHz frequency) propagates through the tissue from the transmitter crystals to the receiver crystal. The transit time is converted to distance representing chord length, displayed in millimeters on a numeric indicator, and stored on a microcassette recorder integral to the ULP.

6. Stocking (Leg) Plethysmograph

The leg plethysmograph is a stocking-like device pulled over the lower portion of the leg. The material is slightly elastic to maintain contour and grip on the leg. Integral circumferential tapes are pulled snug and marked with a colored pen for post-flight analysis. Longitudinal tapes aid in donning and insure the location of the circumferential tapes.

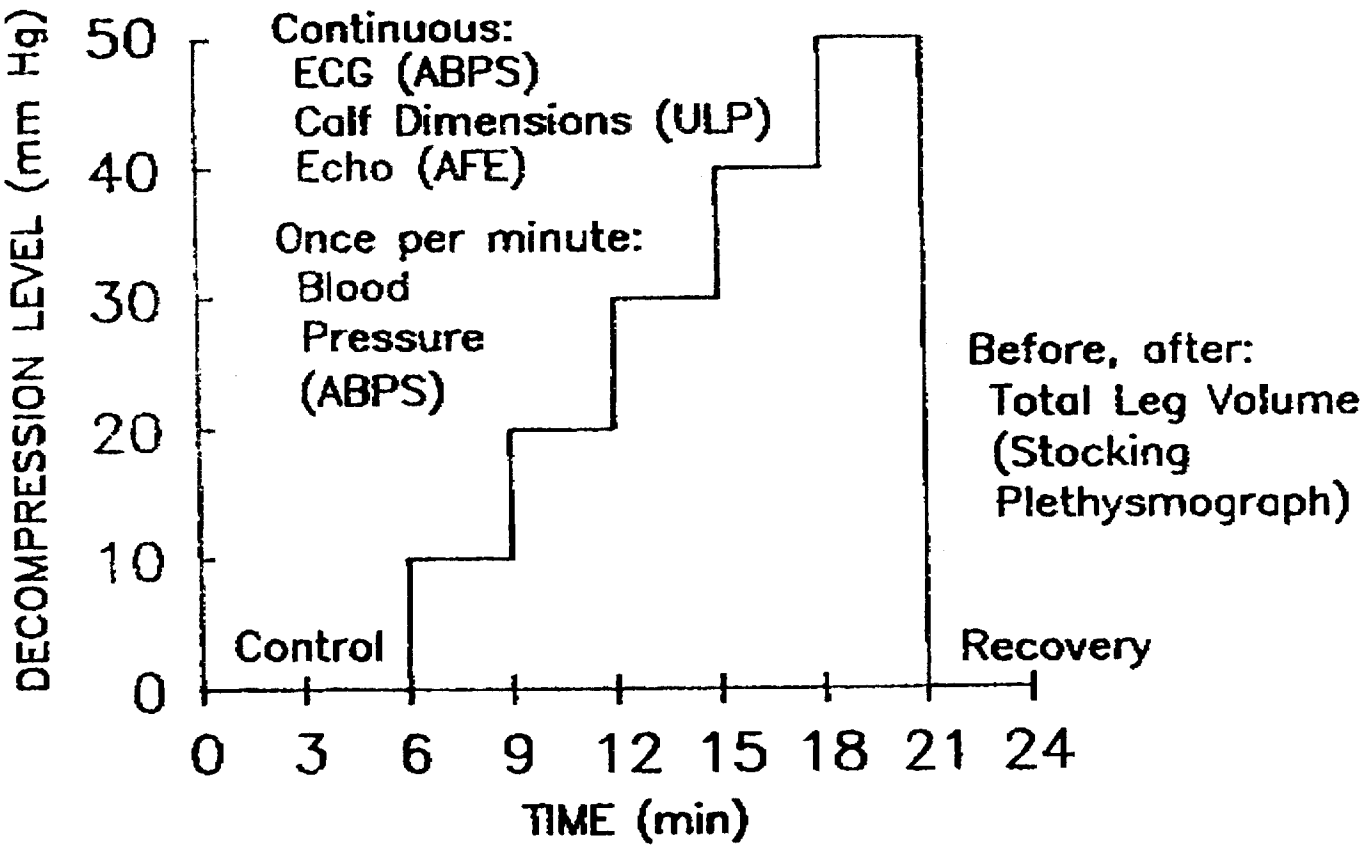

Figure 1. LBNP test protocol ("RAMP").

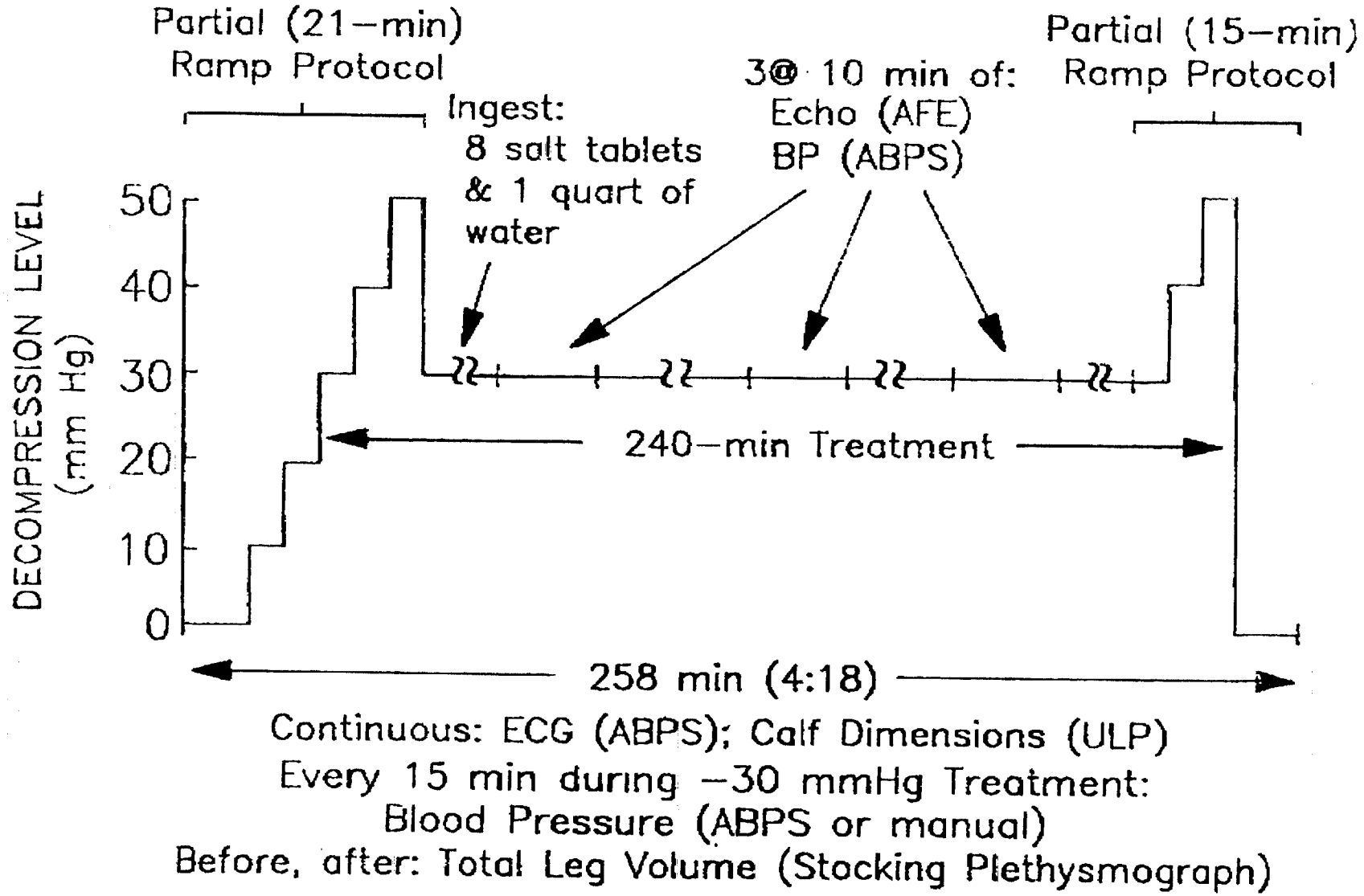

Figure 2. LBNP treatment protocol ("SOAK").

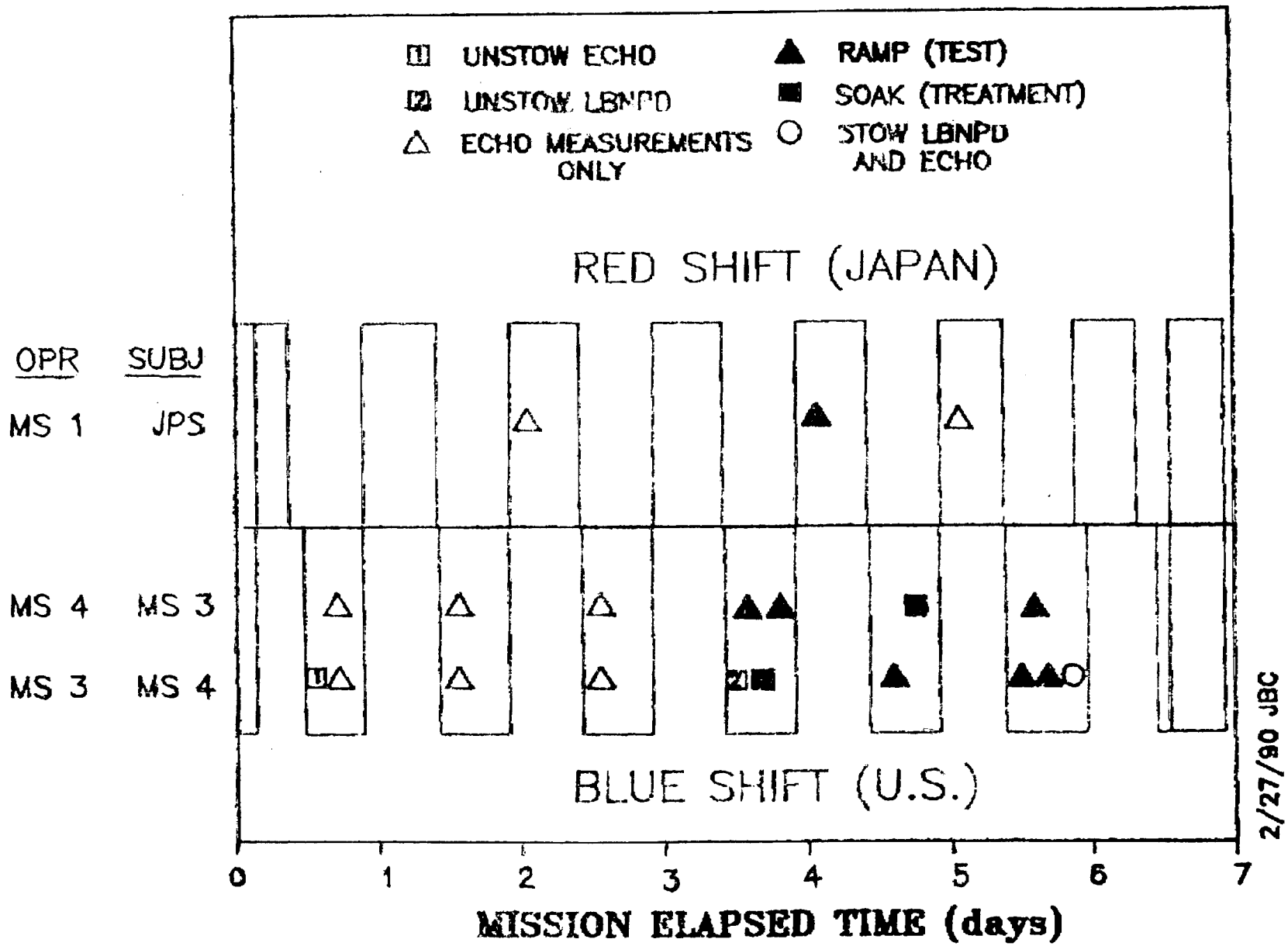

Figure 3. Spacelab-J Experiment E06 ("LBNP").

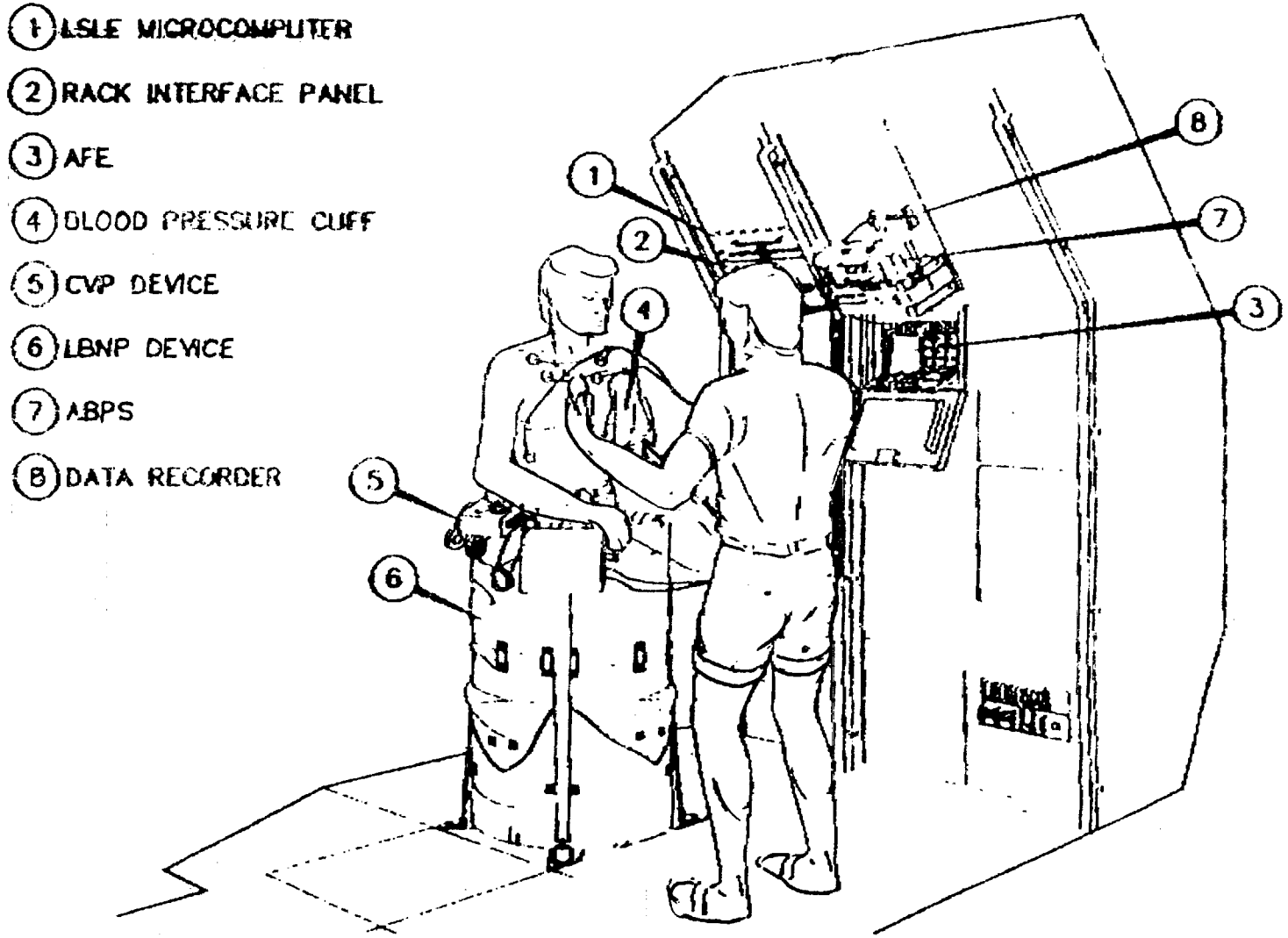

Figure 4. Lower Body Negative Pressure Experiment.