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REMARKS

For consideration by the ACHE Committee.

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FROM (Name, office symbol or location)	DATE
E. WELCH, Ph.D. Chief Environmental Sciences Division	17 Sep 71 PHONE

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Addendum to protocol entitled "Correlation of blackout threshold levels in human subjects to $+G_z$ acceleration for sustained periods"

In accordance with the accompanying, approved protocol, 14 human volunteer subjects have been studied during the past year at levels of 7-9 $+G_z$ for sustained periods up to 45 seconds using the standard USAF CSU-12/P anti-G suit and an M-1 maneuver. Following training and weekly exposures on the centrifuge, 9 of these subjects were able to achieve 9G for 45 seconds, one 8.5G for 42 seconds, two 8.5G for 5 seconds, and two 7.5G for 45 seconds. Those unable to reach 9G were stopped at the lower G level because of the occurrence of blackout or excessive fatigue at these lower levels, except for one subject who was terminated at 7.5G because of frequent ventricular premature beats.

An unexpected finding was the occurrence in 2 of the subjects of a marked decrease in heart rate during the latter half of runs above 7.5G (from heart rates of approximately 150-175 early in the run to 75-85 at the end) without any accompanying symptoms or apparent effects on G tolerance. Three other subjects showed slight decreases in rate while the remaining subjects maintained a stable high heart rate throughout the run. It is now of great importance to determine whether this slowing of heart rate during prolonged high $+G_z$ exposures reflects physiological changes indicative of an early presyncopal state or perhaps a compensatory state with an increase in stroke volume, although the mechanism of the latter would be unclear. After extensive discussions between the investigators and the medical consultant, it has been concluded that there is a necessity for investigating the physiological consequences of these sustained high G exposures. It is proposed that the following measurements be obtained in those subjects showing heart rate slowing as well as in those in whom this phenomenon did not occur, these subjects to be exposed as previously to 7-9$+G_z$ for 45 seconds:

(1) direct radial arterial blood pressure referenced to eye level

(2) central venous pressure

(3) peripheral venous pressure in a foot vein

(4) blood oxygen saturation as determined by ear oximetry

Since $+G_z$ tolerance is primarily determined by head level arterial pressure, there is an obvious importance in determining the magnitude of the fall in this pressure in subjects at high G levels and correlating this change with visual symptoms. Changes in arterial pressure should be extremely helpful in evaluating the significance of heart rate changes. Such information will be required before considering any higher G levels or longer periods of exposure. The effects of various types of M-1

straining maneuvers (each subject appears to perform this maneuver somewhat differently) and of positive pressure breathing (PPB) on arterial pressure will also become apparent and provide extremely useful information.

Measurement of central venous pressure will reflect right atrial pressure and provide the necessary determination of right ventricular filling pressure. Whether or not this pressure is maintained by the anti-G suit and M-1 maneuver at these high, sustained G levels must be investigated.

When an anti-G suit is being used, the foot-level venous pressure cannot be calculated by hydrostatic column changes. The occurrence of petechiae on the feet in nearly all subjects at high, sustained G levels suggests that very high venous pressures are reached, and these can be measured only by direct venous pressure monitoring.

In addition to pressure changes, changes in arterial oxygen saturation may also become a limiting factor at very high $+G_z$ levels. A new ear oximeter developed by Mr. Wendell Peters in the Medical Systems Division has recently been tested on the centrifuge up to $+7G_z$ by comparison with direct arterial saturation measurements and has been found to provide reliable data. This then would provide valuable information at the higher G levels by a noninvasive technique.

The measurements described above would be made on the 2 subjects who previously demonstrated heart rate slowing during the high-G runs and on 2 subjects who did not demonstrate this phenomenon and will serve as controls. Studies with pressure measurements will be performed twice only on each subject, once using the M-1 maneuver and once with PPB. These 2 studies will be separated by an interval of 1-2 weeks. Since one subject experienced the slowing at all G levels greater than 6.5G and the other only at levels greater than 8.0G, it is proposed to expose all 4 subjects to 2G levels for 45 seconds during each study, one between 6.0-7.0G and one between 8.0-9.0G. From previous experience, it is known that 2 such exposures can be tolerated on the same day; a greater number of runs would, in most cases, be limited by fatigue. Prior to studies with pressure measurements, each subject would be run as described in the original protocol to again firmly establish his tolerance level and to provide the necessary centrifuge training for achieving these levels. The highest G level at which each subject will be studied with pressure measurements will not exceed the highest level he attained without visual symptoms during the preliminary runs. Such preliminary runs will be performed under the exact conditions as those with pressure measurements except for the presence of the catheters; previous centrifuge experience here has not shown any decrement in tolerance during arterial pressure measurement. Peripheral light loss and central light dimming will be used as an endpoint and the usual centrifuge safety precautions as outlined previously will be observed, with the subject able to terminate a run at any point.

Arterial pressure will be measured with a Teflon catheter sterilely placed and secured in the radial artery and connected to a Statham P-37 strain gage transducer mounted on the subject's helmet at eye level. The transducer will be calibrated prior to being connected to the catheter so that the catheter-transducer system will remain closed throughout the study, thus precluding the possibility of the occurrence of air embolism. All needles will be inserted by Dr. Shubrooks in the usual method and should involve no significant hazard to the subject. Each subject will be observed for an hour after removal of the catheter. This procedure has been used frequently on the centrifuge at levels up to 7G without difficulty or any adverse effects.

Central venous pressure will be monitored by a long, 16 gage radiopaque polyethylene catheter passed through a needle in an antecubital vein and guided fluoroscopically to the distal superior vena cava outside of the heart. As with the arterial catheter, this catheter will be connected to a transducer mounted at right atrial (midthoracic) position so as to reflect right atrial pressure. In some subjects, a short polyethylene catheter will be inserted in an ankle or foot vein and pressure measured at this level also. The catheters will be checked upon removal to ascertain that the entire catheter has been recovered. No hazard other than that of routine venous catheterization is involved in these measurements.

The ear oximeter will be placed on an ear lobe as in previous studies, and no additional risk is involved.

As described in the original protocol, the effects of PPB at breathing pressures of 20-40 mm Hg will again be studied and compared to responses with the M-1 maneuver. Earlier results indicate that these maneuvers are about equally effective in raising G tolerance and that the PPB may require less effort. A British P/Q mask has now been obtained and will maintain breathing pressures up to 40 mm Hg during $+G_z$ without leak. Use of this mask, instead of a mouthpiece and noseclip as used originally, should provide greater ease and comfort for pressure breathing.