N95- 15094

108680

TRANSESOPHAGEAL ECHOCARDIOGRAPHIC EVALUATION OF BABOONS DURING MICROGRAVITY INDUCED BY PARABOLIC FLIGHT

Marina N. Vernalis, Ricky D. Latham, John W. Fanton, F. Andrew Gaffney

Laboratory for Aerospace Cardiovascular Research (LACR) Armstrong Laboratory, AL/AOCIY Brooke AFB, Texas 78234-5301, USA

BACKGROUND

The central cardiovascular responses to transient microgravity are not well understood. Theoretically, entrance into microgravity results in the loss of the hydrostatic pressure head and an increase in central venous pressure (CVP) as a consequence of augmented venous return. However, controversy exists regarding the time course and magnitude of cephalad blood volume shifts and its relationship to central atrial filling pressures. On the June 1991 STS 40 shuttle mission, pre-launch echocardiograms suggested changes in cardiac dimensions occurred while the astronauts were in the supine, feet-up position. Furthermore, a CVP line in an astronaut (n=1) demonstrated an unexpected abrupt decrease in CVP during orbital insertion. In April 1991, our laboratory performed Doppler echocardiography in 6 normal human volunteers during parabolic flight. Increases in right ventricular velocities reflecting a central shift of blood volume was demonstrated in subjects in the sitting position. However, test subjects examined in the horizontal positions had no significant rise in Doppler velocities. In addition, Latham et al noted variable central cardiovascular responses in chronically instrumented baboons during early microgravity.[1]

Transthoracic echocardiography (TTE) is a feasible method to noninvasively examine cardiac anatomy during parabolic flight.[3] However, transducer placement on the chest wall is very difficult to maintain during transition to microgravity. In addition, TTE requires the use of low frequency transducers (2.5 MHz) which limits resolution. Transesophageal echocardiography (TEE) is an established imaging technique which obtains echocardiographicc information from the esophagus. It is a safe procedure and provides higher quality images of cardiac structures than obtained with TTE.[4] Since there are no interposed structures between the esophagus and the heart, higher frequency transducers can be used and resolution is enhanced. With TEE, a flexible transducer tip permits contact with the esophageal mucosa, allowing for consistent imaging.

This study was designed to determine whether TEE was feasible to perform during parabolic flight and to determine whether acute central volume responses occur in acute transiton to zero gravity (OG) by direct visualization of the cardiac chambers.

METHODS

In flight TEE was performed in five mature male baboons weighing between 20-25 kg. These test animals were chronically instrumented in order to simultaneously evaluate central hemodynamics. Echocardiographic examinations were performed by utilizing the Hewlett-Packard (HP) Sonos 1500 ultrasound system with Acoustic Quantification interfaced with a 7.5 MHz biplane transducer tipped endoscope.

The study animals were in a fasting state and placed in a custom designed confinement chair. The study animals were intubated and anesthesia was maintained. An experienced echocardiographer inserted the TEE probe into the esophagus of the baboon.

After introduction of the probe, baseline TEE images of the heart were obtained. Three standard esophageal views were obtained using the transverse sectioning plane transducer.[2] Each study began by imaging the transgastric short axis views of the heart at the level of the papillary muscles. The echoscope was withdrawn to the midesophageal position to obtain the four chamber tomographic views of the heart. This was followed by slight withdrawal of the scope to the upper esophagus to obtain the various basal short axis views. The best images were identified for measurement of the cardiac chamber dimensions. The right atrial (RA), left atrial (LA), right ventricle (RV), and left ventricle (LV) chamber cavities were outlined as the "region of interest" with the use of the HP Acoustic Quantification software. End-diastolic and end-systolic fractional area changes were measured at baseline (1G) and during three phases of flight: pull-up (2G), early OG and late OG. Images were recorded on .5 inch videotape for real time and frame by frame analysis. ECG and accelerative signals were simultaneously displayed and recorded.

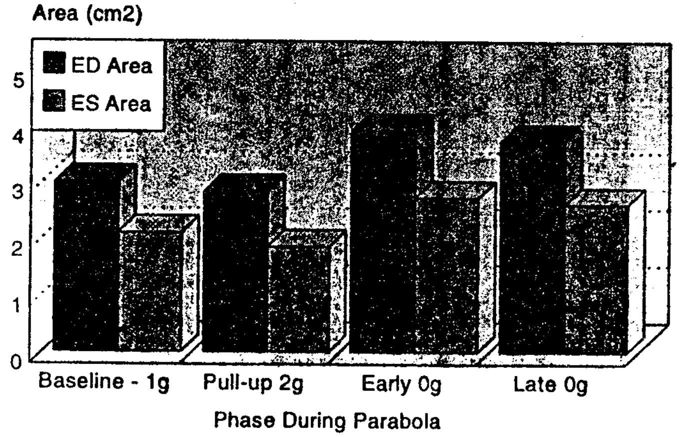
NASA's KC - 135 aircraft was used to perform parabolic flight profiles. Five daily flights occurred with 40 parabola per flight in 4 sets of 10. Each parabola provided 25-30 seconds of near zero gravity after a brief 2G period during the ascent. TEE was performed on one baboon per flight and imaging continued throughout the parabolic phases. The test animals were controlled for volume status. On flight days 1-4, the animals were euvolemic. These animals were examined in the upright position. On flight day 5, the test animal was pretreated with furosemide the night prior to flight to result in a volume depleted (VD) state. The VD baboon was examined in the upright and supine, feet up positon.

RESULTS

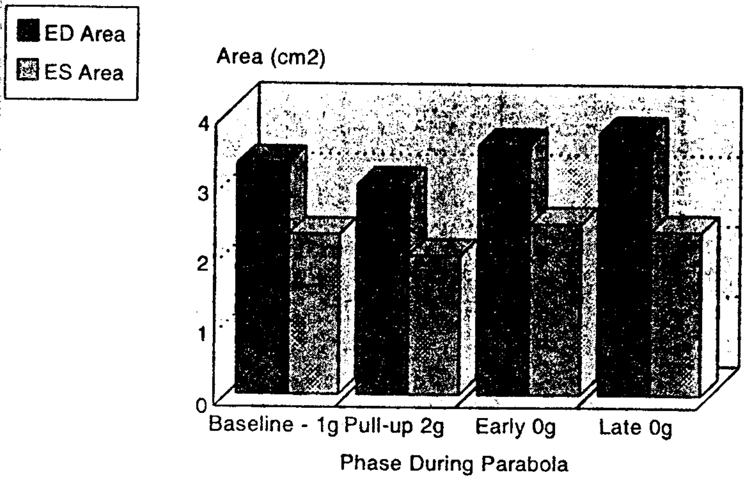
TEE probe insertion was easily accomplished in flight and the echocardiographic examinations were conducted without major complications. One baboon required treatment for esophagitis post-flight. The resolution of the baseline images obtained by TEE was excellent. Good visualization of the RA, LA, and LV chambers was maintained even during the roller coaster like parabolic profiles. The RV chamber was unable to be consistently viewed for accurate area measurements.

Early and late OG area changes were compared to values during the ascent phase and at baseline in the euvolemic animals (n=4). There was no statistical area change between baseline and the pull-up phase. During early OG, RA end-diastolic area significantly ($p<.01$) increased. A significant ($p<.05$) increase in RA end-systolic area during early and late OG compared to the ascent phase was recorded as well as an area change between OG and late OG. A trend toward end-systolic area expansion occurred during early OG compared to baseline.

These results are shown in Figure 1.



Less dramatic but similar changes were seen in the LA. There was a significant ($p<.05$) increase in the LA chamber area in late OG compared to early OG. (Figure 2)



There was no statistically significant area changes noted in the LV. However, on visual inspection all chamber areas appeared to dilate during transition to microgravity.

DISCUSSION

We successfully performed TEE in baboons during parabolic flight. Not unexpectedly, TEE provided superior images of the cardiac structures as well as consistent imaging during the parabolic profiles.

During the acute transition to zero gravity LA and RA chamber areas increased in the EV and VD animals when upright. Furthermore, the echocardiographic area changes paralleled the changes in pressures from the respective chamber when hydrostatic forces were absent. We believe these results verified the hypothesis that sudden microgravity results in an increase in atrial filling pressures as a consequence of a central shift of volume.

However, these findings were not observed in the dehydrated test animal when examined in the supine feet up position. In fact, the reverse was evident, that is, the RA chamber appeared smaller and the RA pressure declined. The latter suggested that central atrial filling pressure responses to microgravity are dependent upon initial circulatory volume status. and position

Early to late changes in the LA chamber suggested initial right heart preload increases were delayed representing transit through the lungs.

There were limitations in our parabolic flight study. The study sample was small and only one primate could be studied per flight. TEE was performed in the upright posture except for one VD animal subject, thus no supine EU data was available for comparison. Furthermore, only one VD animal was studied and therefore results were not reproduced.

In summary, changes in chamber area by TEE with a concomitant parallel change in pressure appear to be a consequence of volume rather than primary changes in cardiac chamber compliance. In addition, venous capacitance effects play an important role in the acute central response to microgravity.

REFERENCES

1. Blomqrist, C.G. and Stone, H.L. Cardiovascular adjustments to gravitational stress. Handbook of Physiology, The Cardiovascular System, Peripheral Circulation and Organ Blood Flow. Bethesda, MD: Am Physiol Soc., Sect 2, Vol 3, part 2: 1025-1063, 1983

2. Latham RD, Rubal BJ, Sipkema P, Westerhof N, Virmain R, Robinowitz M, Walsh RA. Ventricular/vascular Coupling and Regional Arterial Dynamics in the Chronically hypertensive Baboon: Correlation with Cardiovascular Structural Adaptation. Circulation Research 63:798-811, 1988.

3. MN Vernalis, JP Johns, JM Karemaker, RD Latham. Echo-Doppler Determined Blood Flow in the Right Heart of Man During Microgravity Induced by Parabolic Flight. Aerospace Medical Association Meeting, Miami Florida, May 1992.

4. JB Seward,, BK Khandheria, JK Oh, MD Abel, RW Hughes, WD Edwards, BA Nichols, WK Freeman, AJ Tajik. Transesophageal Echocardiography: Technique, Anatomic Correlations, Implementation, and Clinical Applications. Mayo clinic Proceedings 63:649-680, 1988.

ACKNOWLEDGEMENTS

The views expressed herein are solely those of the authors and are not to be construed as representing those of the Department of Defense or Departments of the Air Force or Army. The animals in these studies were procured, maintained and used in accordance with the Animal Welfare Act and the"Guide for the Care and use of Laboratory Animals" prepared by the Institute of Laboratory Animal Resources, National Research Council. This study was reviewed and approved by the Institutional Animal Use and Care Committee for Armstrong Laboratory, Brooks AFB, Texas. Armstrong Laboratory has been fully accredited by the America Association for Accreditation of Laboratory Animal Care (AAALAC) since 1967. The authors express gratitude for the editorial assitance of Mrs. Vivian Simpson in the preparation of this manuscript. Supported in part by AFOSR Grant 2312W7 and NASA RTOP A2401D(SLS).