British Journal of Anaesthesia 1994; **73**: 836–837

Leg elevation compared with Trendelenburg position: effects on autonomic cardiac control

G. J. McHugh, B. J. Robinson and D. C. Galletly

Summary

We have studied in 12 healthy male volunteers the effects of three different body positions (10° head-down tilt, horizontal supine and supine with 50-cm leg elevation from the hip) on the spectral components of heart rate and finger plethysmographic amplitude variability. We have demonstrated the absence of any statistically significant difference in any measure of variability in the time or frequency domain for both of these measures between the three positions. We conclude that neither leg elevation nor 10° head-down tilt is associated with any significant alteration in the dominant parasympathetic cardiac control in comparison with the resting supine position. (*Br. J. Anaesth.* 1994; **73**: 836–837)

Key words

Position, effects. Position, Trendelenburg. Heart, heart rate.

The possible benefit of the Trendelenburg position has been the subject of considerable debate [1–3] and, for hypotensive states, there is an opinion that simple leg raising, as opposed to whole-body head-down positioning, may be more beneficial [3]. With the possibility that postural changes in autonomic cardiac tone may give clues on the relative merits of the two positions, we have compared simple leg elevation with the Trendelenburg position in their effects on autonomic cardiac control, as seen by changes in heart rate and pulse plethysmograph amplitude variability.

Methods and results

We studied 12 male volunteers (mean age 29.4 yr, range 21–37 yr). None was receiving regular medication or had overt cardiorespiratory or endocrine disease. ECG (lead CM_5, Corometric Neo-Trak 502), infrared digital plethysmography (Hewlett–Packard 78330A) and impedance pneumograph (Corometrics Neo-Trak 502) were recorded for 10-min periods in each of three positions: supine horizontal, Trendelenburg (10° head-down tilt) and leg elevation (heels raised 50 cm vertically with knees extended). The order of the positions was determined according to a Latin square, randomized, crossover pattern. In order to standardize respiratory pattern, subjects were instructed to breathe in time to an audible 0.24-Hz metronome. Monitor outputs were interfaced to a Macintosh IIcx computer, and a purpose-built RR detector was used to co-ordinate plethysmographic data acquisition with each consecutive R wave. Using previously described methods, fast Fourier analysis was used to examine the periodic behaviour of heart rate and plethysmograph amplitude time series [4]. Five-minute, artefact-free segments of data were taken from each study condition. These segments were sampled at 4 Hz to provide an instantaneous heart rate–plethysmograph amplitude series of 1200 values (4 × 5 × 60). A total of 1024 of these values were then high-pass filtered to remove fluctuations less than 0.01 Hz and low-pass filtered to exclude components above the Nyquist frequency (2 Hz). The two series were then subjected to fast Fourier analysis and the power in four frequency bands was determined by integrating the power spectrum (very low frequency = 0.01–0.02 Hz, low frequency = 0.02–0.08 Hz, mid frequency = 0.08–0.15 Hz and high frequency = 0.15–0.45 Hz).

Statistical analysis was performed using ANOVA for parametric data (mean and percentage powers) and Kruskal–Wallis for non-parametric data (absolute powers). $P < 0.05$ was considered significant.

There were no statistically significant differences in heart rate variability and pulse plethysmography amplitude variability in either the time or frequency domain and no change in mean RR interval (i.e. heart rate) or plethysmograph amplitude (table 1).

Comment

At rest, in the horizontal position, the heart is under dominant vagal control, while standing induces orthostatic stress resulting in a shift towards sympathetic control. This shift is seen as a reduction in RR interval, and in HRV, as a reduction in parasympathetically mediated high frequency (ventilatory) beat-to-beat variability in conjunction with an increase in sympathetically mediated low frequency (< 0.15 Hz) heart rate fluctuations [5, 6]. The effects of head-down tilt have been examined less frequently although it might be expected that balance or degree of autonomic control would be

---

G. J. McHugh, MB, CHB, DIPOBST, B. J. Robinson, PHD, D. C. Galletly, MB, CHB, FRCA, FANZCA, Section of Anaesthesia, Wellington School of Medicine, PO Box 7343, Wellington South, Wellington, New Zealand. Accepted for publication: June 14, 1994.

Correspondence to D.C.G.

Table 1 Effects of position on time and frequency domain fluctuations in RR interval and plethysmographic amplitude (PA). Parametric measures are given as mean (SEM) and non-parametric as median (range). MCD = Mean consecutive difference. Power is expressed in arbitrary units. Overall between-position differences were not significant (ANOVA or Kruskal–Wallis)

	Position		
	Lying	Legs elevated	Trendelenburg
RR interval			
Mean (ms)	1065.5 (38.3)	1021.8 (33.6)	1031.8 (38.4)
MCD (ms)	44.7 (9.1)	47.0 (9.0)	42.7 (8.9)
Total power	1.2 (0.3–11.3)	1.4 (0.5–8.4)	1.2 (0.2–8.8)
% High	31.2 (5.1)	39.8 (4.0)	33.6 (4.7)
% Mid	27.8 (4.9)	25.3 (4.1)	26.1 (5.1)
% Low	28.0 (3.1)	25.2 (2.8)	27.8 (4.3)
% Very low	13.0 (2.3)	9.7 (1.8)	12.5 (2.8)
PA			
Mean (mV)	2722 (433)	2509 (404)	2520 (338)
SD (mV)	469.5 (73)	423.3 (62)	382.3 (76)
Total power	57.3 (1.2–592)	44.5 (3.0–259)	56.3 (1.8–239)
% High	6.3 (1.9)	11.7 (4.0)	11.9 (5.5)
% Mid	7.5 (1.3)	5.6 (1.0)	6.2 (1.2)
% Low	58.8 (3.8)	50.2 (4.1)	49.4 (5.5)
% Very low	27.4 (3.7)	32.5 (5.0)	32.5 (5.3)

altered by any positional alteration in venous return. In this study we were unable to demonstrate any posturally influenced alteration in cardiac autonomic control when comparing head-down tilt, leg elevation and lying supine. There were no statistically significant differences in any measure of heart rate or pulse plethysmograph amplitude variability in either the time or frequency domains.

Previous work has concentrated on the haemodynamic effects of postural changes, with emphasis on fluid shifts and alterations in filling pressures and flow indices (cardiac output and venous return) [1, 2]. The most consistent findings of the effect of the Trendelenburg position are those of no significant alteration in heart rate with little change in mean systemic arterial pressure [1–3]. Cardiac output and cardiac index, together with measures of central venous pressures, were unchanged or increased [2]. Our results indicated that the changes in haemodynamic state associated with the Trendelenburg position did not cause any shift in the balance of autonomic cardiac control from that of the supine position, and that with regard to such control, leg elevation was not significantly different. Haemodynamic studies also indicate that systemic vascular resistance (SVR) is unchanged or decreased with head-down tilt. In keeping with this, a comparison of the Trendelenburg position with both the lying and leg-elevated positions did not show any significant alterations in plethysmographic amplitude or spectral components. Because under normal resting supine conditions dominant cardiac control is parasympathetic (while head-up positioning reflexly augments sympathetic control in response to reduced venous return), our results suggest that the dominance of parasympathetic control is not influenced by leg-up or Trendelenburg positioning, as might be expected with maintained or modestly increased venous return. It should be stressed that these results apply only to subjects who are normovolaemic; changes might be expected in hypovolaemic subjects where the control condition is one of sympathetic excitation. We conclude that in healthy normovolaemic subjects, leg elevation and 10° head-down tilt are not associated with any significant alteration in cardiac autonomic control compared with the resting supine position.

Acknowledgements

This study was supported by the New Zealand Guardian Trust, the Wellington Anaesthesia Trust and the Kelvin Day Trust.

References

1. Sibbald WJ, Paterson NAM, Holliday RL, Baskerville J. The Trendelenberg position: hemodynamic effects in hypotensive and normotensive patients. *Critical Care Medicine* 1979; 7: 218–224.
2. Pricolo VE, Burchard KW, Singh AK, Moran JM, Gann DS. Trendelenberg versus PASG application—hemodynamic response in man. *Journal of Trauma* 1986; **26**: 718–726.
3. Wilcox S, Vandam LD. Alas, poor Trendelenburg and his position! *Anesthesia and Analgesia* 1988; **67**: 574–578.
4. Galletly DC, Tobin PD, Robinson BJ, Cofiatis T. Effect of inhalation of 30% nitrous oxide on spectral components of heart rate variability in conscious man. *Clinical Science* 1993; **85**: 389–392.
5. Akselrod S, Gordon D, Ubel FA, Shannon DC, Barger AC, Cohen RJ. Power spectrum analysis of heart rate fluctuations: a quantitative probe of beat-to-beat cardiovascular control. *Science* 1981; **213**: 220–222.
6. Pomeranz B, Macaulay R, Caudill M, Kutz I, Adam D, Gordon D, Kilborn KM, Barger AC, Shannon DC, Cohen RJ, Benson H. Assessment of autonomic function in humans by heart rate spectral analysis. *American Journal of Physiology* 1985; **248**: H151–H153.