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Blood Pressure Variability in Tetraplegic Patients with Autonomic Hyperreflexia

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Summary

Autonomic hyperreflexia (AH) is a syndrome characterised by profound pressor responses, sweating and headache which occurs in tetraplegic patients in response to a variety of stimuli below the level of cord injury. The pathogenesis of this syndrome is unclear but may be associated with increased blood pressure (BP) variability in these patients. To investigate this possibility, 24 hour ambulatory BP monitoring was performed utilising the Spacelabs 5300 Ambulatory BP system in 30 patients: 10 normal subjects, 10 spinal cord injury (SCI) patients who had never experienced AH and 10 SCI patients who had experienced recent episodes of AH (but with no *symptoms during the study period). There were no statistically significant differences in systolic BP (SBP), diastolic BP (DBP) or heart rate (HR) between the three groups. The average of the coefficients of variation of SBP, DBP and HR within each subject over the study period were calculated. Tetraplegic patients who had recently experienced episodes of AH had greater SBP, DBP and HR variability than normal persons ($p < 0{\cdot}01$, $p < 0{\cdot}005$, $p < 0.005$) and greater DBP and HR variability than SCI patients who had never experienced AH ($p < 0{\cdot}01$. $p < 0{\cdot}05$). AH may represent the symptoms associated with the upper extremes of this BP variability. The increased variability may be the result of enhanced cardiovascular responsiveness to noradrenaline and arginine vasopressin or because of the absence of descending inhibitory pathways in the decentralised cord that would normally suppress spinal sympathetic reflexes.*

Key words: *Tetraplegia; Blood pressure; Autonomic hyperreflexia.*

Autonomic hyperreflexia (AH) is a syndrome characterised by profound pressor responses, sweating and headache which occurs in tetraplegic patients in response to a variety of stimuli below the level of cord injury (Head and Riddoch, 1917; Guttmann and Whitteridge, 1947). The pathogenesis of this syndrome is unclear. It is possible that blood pressure (BP) variability increases in some patients with spinal cord injury (SCI) compared to normal persons and that episodes of AH represent symptoms associated with the upper extremes of this

variability. To test this hypothesis, blood pressure variability was assessed utilising 24 hour ambulatory BP monitoring in patients with spinal cord injury who were currently experiencing episodes of hyperreflexia, patients with spinal cord injury who had never experienced episodes of hyperreflexia and in normal volunteers.

Methods

Patients and normal subjects

BP monitoring was performed in 30 patients: 10 normal persons consisting of medical students and Clinical Pharmacology Unit staff members with no medical problems and on no medications, 10 SCI patients never having experienced episodes of AH, and 10 SCI patients currently experiencing episodes of hyperreflexia. The spinal patients were on no cardiovascular medications apart from anticholinergics which were not altered during the study period. Groups were matched as closely as possible for age, sex, duration of injury and level of transection.

The tetraplegic patients with recent episodes of AH were required to have 2 documented episodes of AH in the prior 7 days, consisting of a rise in systolic BP (SBP) of >30 mm Hg or diastolic BP (DBP) of >20 mm Hg, as well as at least one associated symptom consisting of either sweating, flushing or headache. In addition, if symptoms occurred during the period of ambulatory monitoring, that data was excluded and the monitoring repeated. There were no restrictions on physical activity undertaken during the study period in any group.

BP monitoring

Twenty four hour ambulatory BP monitoring was performed using the Spacelabs 5300 Ambulatory Blood Pressure System (Spacelabs, Hillsboro, Oregon, USA) SBP, DBP and heart rate (HR) were recorded automatically half hourly from 06:00 to midnight, then hourly overnight. The device was calibrated against mercury sphygmomanometer recordings prior to commencement of recordings in each patient. Artefactual recordings (pulse pressure <10 mm Hg, heart rate less than 30 bpm or greater than 160 bpm) were excluded. At least 25 nonartefactual BP and HR recordings were required within the 24 hour period to be included in the study.

Statistical analysis

The mean and standard deviation for SBP, DBP and HR over 24 hours were obtained for each individual and the average value for the group determined. A coefficient of variation (CV) for SBP, DBP and HR was obtained for each of the subjects and used as a measure of blood pressure and heart rate variability over the study period. One way analysis of variance was used to compare mean 24 hour blood pressure and heart rate variability between the three groups.

Results

Demographic data is summarised in Table I. Although the patients having experienced recent AH were generally younger than the other groups, this difference did not reach statistical significance. Mean SBP, DBP and HR values for the three groups are displayed in Table II. There was no significant difference in mean SBP, DBP or HR between the three groups. The average of the coefficients of variation for SBP, DBP and HR within individuals are displayed in the Figure. Spinal patients who had recently experienced AH had significantly greater CV's for SBP, DBP and HR than normal persons and significantly greater coefficients of variation for DBP and HR than patients who had never experienced AH. Although the CV's for all 3 parameters were higher in the SCI without AH group than in normal persons, the difference did not reach statistical significance. In order to investigate whether the difference in BP and HR variability between SCI patients with AH and SCI patients without AH could have been due to differences in the level of spinal transection, SCI patients without AH were further divided into those with SCI levels above and below T6—the level below which SC injury is rarely complicated by AH (Guttmann and Whitteridge, 1947) (Table III). There was no significant difference in BP or HR levels, nor in variability of these parameters when the group was subdivided in this way. However, it should be emphasised that in view of the small number of SCI patients looked at in this subgroup comparison, the statistical power to detect differences between them would be small.

Table I Demographic data of Spinal Cord Injury patients and normal persons used for studies of 24 hour blood pressure and heart rate variability. Although the spinal cord injury patients who had recently experienced autonomic hyperreflexia (AH) were on average younger than the other two groups, the difference was not statistically significant (one way analysis of variance). Age values are the mean ± standard error of mean.

				Level of lesion (no. patients)		Time from injury (no. patients)	
	Age	Sex M	F	Above T6	T6 or below	<6/12	>6/12
Normal persons (n = 10)	33·4 ±3·2	6	4	—	—	—	—
SCI patients without AH (n = 10)	36·2 ±4·5	8	2	6	4	5	5
Recent AH patients (n = 10)	23·3 ±2·0	9	1	10	0	5	5

Table II Mean (± standard error of the mean (SEM)) of average 24 hour blood pressures (BP) and heart rates in normal volunteers, spinal cord injury (SCI) patients who had never experienced autonomic hyperreflexia (AH) and SCI patients who had recently experienced AH. There was no significant difference in any of the parameters between the three groups (one way analysis of variance).

Mean ± SD	Systolic BP mean ± SEM	Diastolic BP mean ± SEM	Heart rate mean ± SEM
Normal persons (n = 10)	118·41 ± 4·30	78·83 ± 2·79	77·06 ± 2·24
SCI patients without AH (n = 10)	116·24 ± 4·80	69·72 ± 4·41	79·13 ± 2·91
Recent AH patients (n = 10)	118·24 ± 4·91	74·54 ± 3·48	88·24 ± 3·82

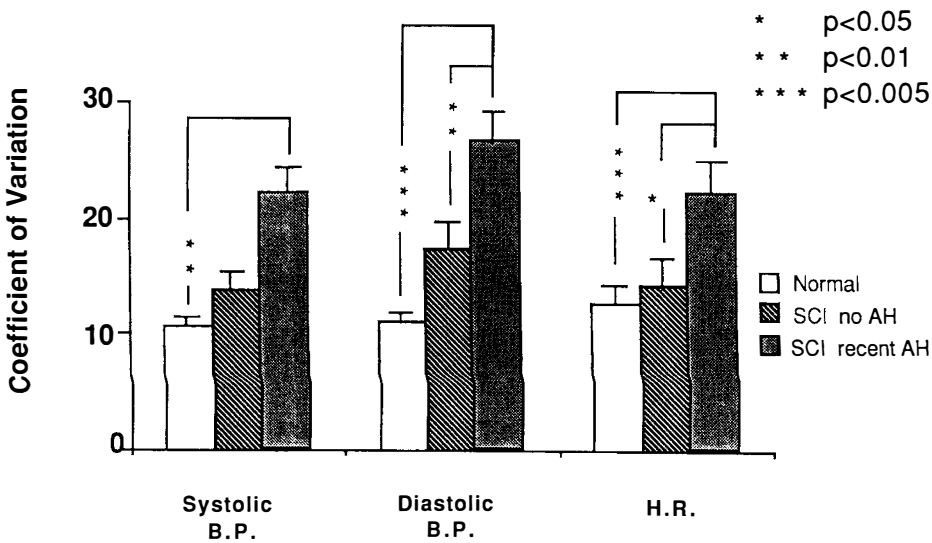

Figure Average values (± standard error of mean) for the coefficients of variation of blood pressure (BP) and heart rates (HR) over a 24 hour period in normal persons, spinal cord injury (SCI) patients who had never experienced autonomic hyperreflexia (AH) and SCI patients who had recently experienced AH. SCI patients with recent AH had significantly greater variability of diastolic BP and HR than both normal subjects and SCI patients without AH, and significantly greater variability of systolic BP than normal persons. (One way analysis of variance, pairwise comparisons by Student's t-test with Bonferonni correction).

Table III Blood pressure variability in spinal cord injury (SCI) patients who had never experienced autonomic hyperreflexia (AH) analysed according to SCI level' Patients with SCI above T6 did not differ in their blood pressure or heart rate variability to those with SCI below T6 (Student's unpaired t-test). Values are mean ± standard error of mean (SEM).

SCI level	Number of patients	Systolic BP (mm Hg) Mean	CV	Diastolic BP (mm Hg) Mean	CV	HR (beats/min) Mean	CV
Above T6	6	109·48 ± 4·33	12·9 ± 2·74	70·11 ± 4·35	17·72 ± 6·63	78·07 ± 3·28	15·25 ± 3·01
T6 or below	4	126·36 ± 8·29	14·5 ± 1·50	68·14 ± 9·88	16·65 ± 1·86	80·71 ± 5·90	12·64 ± 2·34

Discussion

Blood pressure variability has been previously described in normotensive and hypertensive non-SCI subjects using 24 hour ambulatory BP recordings (Reeves *et al.*, 1983). Age, sex, level of blood pressure and antihypertensive treatment did not appear to alter BP variability when assessed using this method. Our results demonstrate significantly greater BP variability in SCI patients having recently experienced AH. These patients did not experience AH during the study period, therefore the increased BP variability in these patients could not be attributed simply to further episodes of AH during the course of the study.

The pathogenesis of the increased BP variability in AH patients is unclear. Chronic SCI patients have enhanced blood pressure rises during noradrenaline infusions (Christensen, Frankel, Mathias, Spalding, 1975; Mathias, Frankel,

Christensen, Spalding, 1976). This may indicate an increased sensitivity of adrenoceptor mediated responses resulting from reduced sympathetic nerve activity below the level of cord injury, or merely occur because of an impaired baroreceptor reflex arc which would normally tend to suppress rises in BP during infusions of pressor substances. Similarly, an enhanced pressor response to arginine vasopressin (AVP) at plasma levels within the physiological range has recently been demonstrated (Poole, Williams, Lightman, Frankel, 1987). A greater than normal rise in plasma levels of both hormones in SCI patients is seen with physiological stimuli such as orthostasis (Mathias, Christensen, Corbett, Frankel, Goodwin, Peart, 1975; Sved, McDowell, Blessing, 1985; Poole, 1987). Thus minor alterations in posture or physical activity may trigger an exaggerated cardiovascular homeostatic response with a resultant increase in BP variability.

Relatively minor stimuli associated with the development of AH, such as bladder or bowel distension, may initiate enhanced blood pressure responses because of an absence of descending spinal inhibitory pathways which normally suppress spinal sympathetic reflexes. These reflexes can therefore become amplified and generalised in the isolated cord and lead to both rises in BP and associated autonomic symptoms. Although not statistically significant, the somewhat higher than normal BP variability in spinal patients never having experienced AH is in keeping with this postulate of an enhanced hemodynamic response to minor stimuli in SCI patients.

In conclusion, tetraplegic patients who have recently experienced episodes of AH have greater BP variability than normal persons and patients with spinal cord injury who have never experienced AH. AH may represent the symptoms associated with the upper extremes of this BP variability. The measurement of 24 hour BP variability may provide a useful index of cardiovascular instability in spinal patients, and of the potential efficacy of therapies for the prophylaxis of AH.

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