

Twenty-four-hour blood pressure in junior medical staff

ABSTRACT—Circadian variations in blood pressure in junior medical staff were compared during routine working days and days receiving medical emergencies. The overnight work commitment of junior medical staff when receiving medical emergencies causes a loss in the normal circadian blood pressure rhythm, with overnight blood pressure falling 10/11 mmHg less than on routine working days. This supports the hypothesis that circadian blood-pressure changes are activity related rather than dependent upon hormonal variation. Long-term health effects of abolishing such normal circadian rhythms are not known.

There is at present considerable interest in the workload and rotas of junior medical staff [1,2]. Medical staff receiving little or disturbed sleep in a 24-hour period might be expected to lose the usual circadian changes in blood pressure.

Ambulatory 24-hour blood-pressure monitoring demonstrates a circadian rhythm, with higher blood-pressure measurements during waking hours [3]. Although a number of hormones with pressor activity also exhibit circadian rhythms [4,5], studies in industrial shift-workers show complete adaptation of blood-pressure curves to waking and sleeping phases within the first 24 hours of changing shifts [6]. This suggests that blood pressure is largely independent of internal circadian rhythms.

The aim of this study was to compare blood pressure in healthy junior medical staff during a 24-hour period admitting emergencies with that during a routine 24-hour period in the working week.

Method

Volunteers

Sixteen junior staff—house officers, senior house officers, and registrars—involved with the admission of acute medical emergencies to the Western Infirmary, Glasgow, were studied. Exclusion criteria included current treatment with antihypertensive agents, non-steroidal anti-inflammatory drugs, corticosteroids, or

other medication known to alter salt or water retention; or the presence of hypertension, or significant cardiac, hepatic, renal, or endocrine disease. Subjects gave written consent to the study which had been approved by the local ethics committee.

Procedure

Twenty-four-hour ambulatory blood-pressure monitoring was performed in each subject on two occasions, an emergency receiving day and a routine working day. The emergency receiving day was any period when that doctor had a 24-hour responsibility for the admission of patients with acute medical conditions. The routine working day was any weekday when that doctor was not on call, and was separated by at least 24 hours from an acute receiving day. The two study days were not more than one month apart. For each subject the order of these two days was allocated by balanced randomisation. Blood-pressure and heart-rate measurements were made at 30-minute intervals using the SpaceLabs device (model 90207) on the same arm for both 24-hour periods. Ambulatory blood-pressure monitoring (including the oscillometric SpaceLabs device) has been validated as a means of determining blood-pressure changes throughout 24-hour periods [7,8]. During the two study days participants kept a diary of activities.

Data analysis

Mean hourly blood-pressure and heart-rate measurements were calculated for each subject. These measurements were used to give mean day-time (0700 hours to 2259 hours) and mean night-time (2300 hours to 0659 hours) values. The differences between day-time and night-time results for receiving and routine days were compared by one sample *t*-tests. Day-time and night-time blood-pressure and heart-rate variabilities were described using the standard deviations of the original data; these were then compared by signed ranks tests. Where data were available, mean waking and sleeping blood-pressure measurements were compared in the same way as day-time and night-time measurements.

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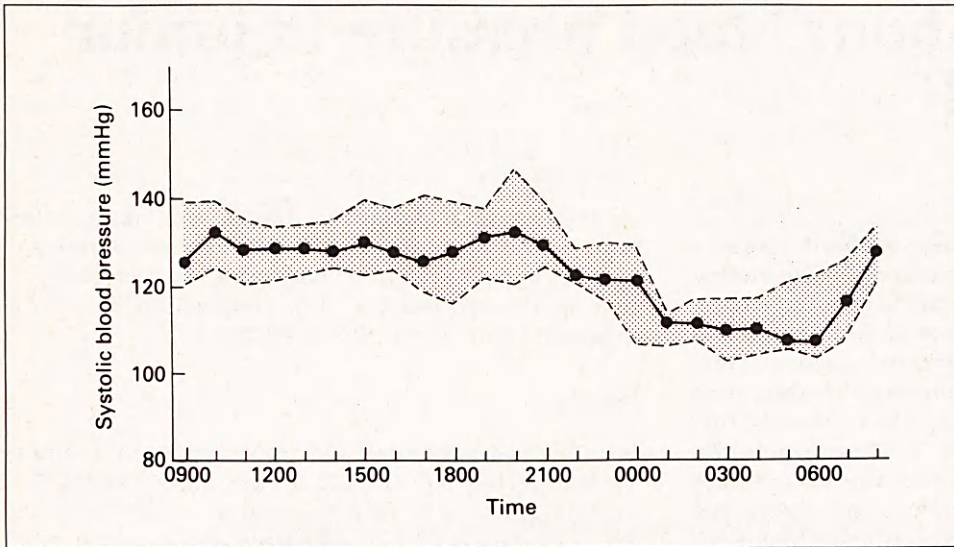


Fig. 1. Median and inter-quartile range for systolic blood pressure (mmHg) with time in junior medical staff during a routine day.

Results

Twelve males and four females aged 23–32 years completed the study; nine of them were house officers, four senior house officers, and three registrars. From the activity diaries median time spent in bed on routine days was 7 hours 55 minutes (range 7 hours 6 minutes to 9 hours 45 minutes) and 3 hours 30 minutes (range nil to 7 hours 5 minutes) on receiving days. Also, during receiving days, sleep was interrupted more often: median awakenings 2 (range 0–6) versus 0 (range 0–1).

Figures 1–4 show hourly blood-pressure measurements on routine and receiving days. Loss of the usual circadian rhythm for blood pressure is seen in Figs 2 and 4, ie during receiving days. In every subject, the overnight fall in blood pressure on the routine day was greater than that on the receiving day. Table 1 shows mean day–night difference in blood pressure and

heart rate for routine and receiving days. Mean overnight fall in systolic blood pressure on routine day minus receiving day was 10 mmHg (95% CI 6, 14 mmHg, $p < 0.001$) and diastolic 11 mmHg (95% CI 7, 14 mmHg, $p < 0.0001$). Similarly, overnight fall in heart rate was greater on the routine day; mean heart rate fall routine minus receiving day: 7 bpm (95% CI 3, 11 bpm, $p < 0.01$).

On routine days blood pressure and heart rate were generally more variable during the day than at night; the converse was true for receiving days. The difference in pattern of variability was significant for diastolic blood pressure ($p = 0.009$) and heart rate ($p < 0.001$). Blood-pressure and heart-rate variability for routine day were 11/10 mmHg, 14 bpm; routine night 11/9 mmHg, 8 bpm; receiving day 10/10 mmHg, 11 bpm; receiving night 11/12 mmHg, 13 bpm.

Comparisons of waking and sleeping blood pressure were only possible in 13 subjects; they included four

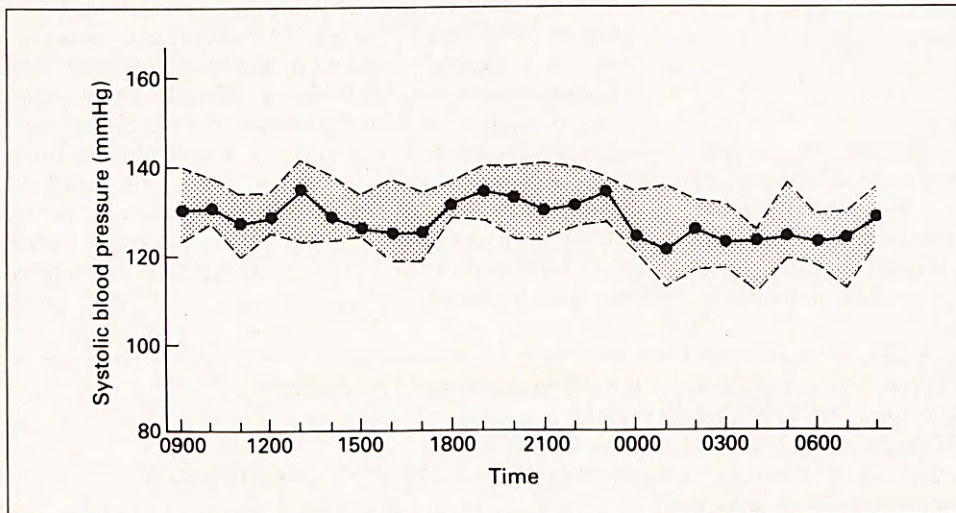


Fig. 2. Median and inter-quartile range for systolic blood pressure (mmHg) with time in junior medical staff during a receiving day.

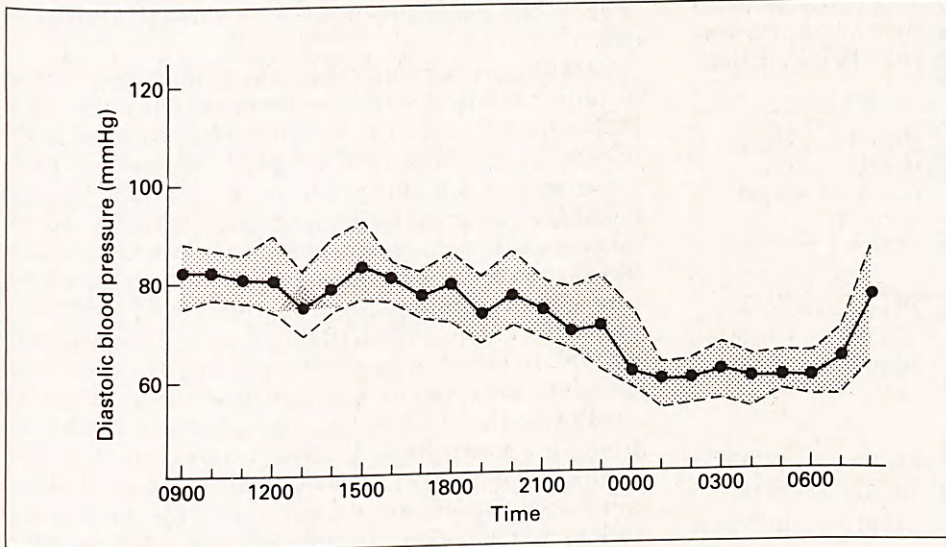


Fig. 3. Median and interquartile range for diastolic blood pressure (mmHg) with time in junior medical staff during a routine day.

subjects who had three or less measurements during sleep on the receiving day. Two individuals had no measurements during sleep on the receiving day; and in one case the diary of activities was incomplete. Mean circadian fall in blood pressure was 10/11 mmHg greater on the routine day than the receiving day whether analysed from day-night or awake-sleep comparisons, though confidence intervals were narrower for the former.

Discussion

Blood pressure exhibits a circadian rhythm; levels are maintained at a plateau during day-time hours, then decline steadily to a nadir around midnight. During the early morning hours blood pressure returns rapidly to day-time levels [3].

This study demonstrates that the normal circadian rhythm for blood pressure is abolished when junior medical staff have a 24-hour responsibility for the admission of medical emergencies. On routine working days mean night-time blood pressure was 15/16 mmHg lower than mean day-time blood pressure; whereas on receiving days the mean blood pressure overnight fell by only 5/5 mmHg. On receiving days medical staff spent less than half their usual number of hours in bed, and their bed time was frequently disturbed by telephone calls, etc. Numbers of blood-pressure measurements during sleep on receiving days were inevitably limited, but the loss of circadian blood-pressure variation between waking and sleeping was similar to that between day and night.

Previous investigators have examined the effect of shift work on circadian blood-pressure changes. In

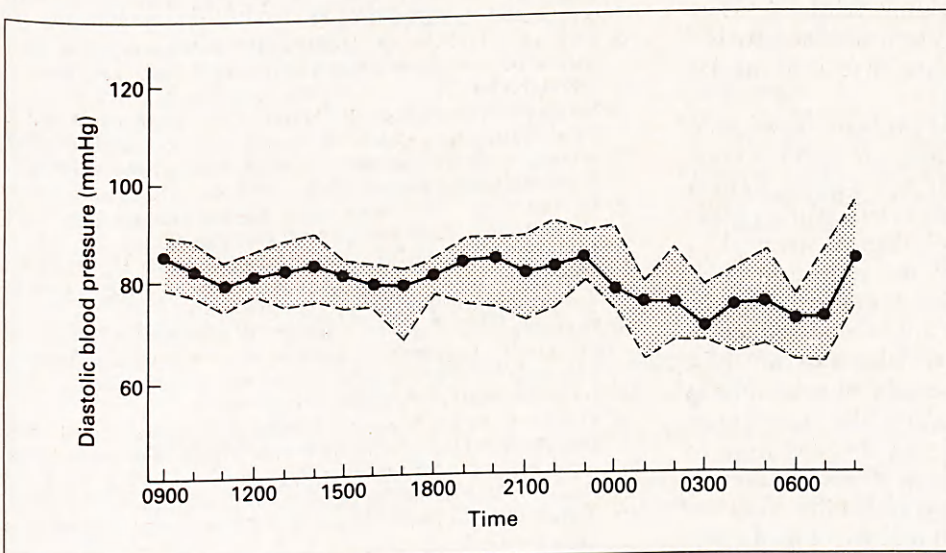


Fig. 4. Median and interquartile range for diastolic blood pressure (mmHg) with time in junior medical staff during a receiving day.

Table 1. Comparison of the day-night difference in blood pressure and heart rate on routine days and on receiving days in junior medical staff: mean (standard deviation) results in 16 subjects.

	Systolic blood pressure (mmHg)	Diastolic blood pressure (mmHg)	Heart rate (bpm)
<i>Routine day</i>			
Day (0700–2259 hrs)	129 (9)	78 (7)	79 (7)
Night (2300–0659 hrs)	114 (9)	62 (5)	63 (8)
Day-night difference	15 (7)	16 (6)	17 (6)
<i>Receiving day</i>			
Day (0700–2259 hrs)	130 (8)	81 (6)	84 (10)
Night (2300–0659 hrs)	125 (7)	76 (6)	75 (8)
Day-night difference	5 (7)	5 (6)	10 (7)
Day-night differences routine day minus receiving day	10 (8)**	11 (7)***	7 (8)*

* $p < 0.01$ ** $p < 0.001$ *** $p < 0.0001$

shift workers blood-pressure curves adapt to varying activity and sleeping phases such that peak blood-pressure levels occur during work, and trough levels during sleep [6,9,10].

Twenty-four-hour blood-pressure profiles are governed both by internal regulatory mechanisms and by an individual's activities. Plasma renin, aldosterone, cortisol, and atrial natriuretic peptide concentrations all show a circadian variability which corresponds to blood-pressure changes [4,5]. However, activity appears to have the predominant effect on blood pressure [11]. This finding is supported by studies of orthopaedic patients immobilised by plaster casts [12], as well as of shift workers on rotating shifts [6]. Modelling techniques have also suggested that activity is a better predictor of blood pressure than time of day [13].

The absence of a fall in blood pressure in working junior medical staff on duty during the night is compatible with the view that activity has a greater effect on blood pressure than hormonal levels. Work, particularly when associated with psychological stress [13], physical exercise [11], and caffeine ingestion [14], raises blood pressure, whereas blood pressure drops by 10–20% during sleep [15]. The night-time reduction in blood pressure on routine working days was of a similar magnitude to this, supporting its relationship to time spent asleep. On the routine day blood pressure variability was greater during the day than at night, whereas on receiving days it was greater at night. The greatest blood-pressure variability occurred during the receiving night when activity ranged from

sleep to the management of acute medical emergencies.

Recently the working hours and problems of fatigue in junior medical staff have been much publicised [1,2]. One consequence of their current working practices is the loss of normal circadian changes in blood pressure. It is not known which aspect of ambulatory blood-pressure monitoring correlates best with risk of target-organ damage or mortality. Mean day-time blood pressure, mean night-time blood pressure, percentage of recordings over a specified fixed level, area under the curve, and variability have all been suggested [16]. In elderly hypertensive patients loss of diurnal blood-pressure variation is associated with increased cardiovascular disease [3]; the relevance of this to young normotensive individuals is not clear. A review of the literature [17] indicates that shift work is, after allowance for socioeconomic class, age, body-mass index, and smoking, an independent risk factor for cardiovascular disease, although not all findings have been consistent [18]. In contrast to shift workers [6,9,10], mean 24-hour blood pressure was higher and normal day-night variation was lost in junior doctors during receiving days, changes which might place these subjects at even greater risk. Further investigation is required to ascertain whether such frequent disturbance in blood-pressure pattern has a long-term effect on health. However, the possible health risk of an increased 24-hour blood-pressure load must be added to the mental stress and social inconvenience of the current rotas and workloads of junior medical staff.

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