Research

Stress response in Swedish ambulance personnel during priority-1 alarms

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Abstract

Introduction

Ambulance personnel consider themselves as being healthy, but studies show they often suffer from stress-related illnesses. However, research on the causes of these stress-related illnesses is limited. This study aimed to examine the stress response of Swedish of ambulance personnel during priority-1 alarms.

Methods

During 90 priority-1 alarms salivary cortisol concentrations were measured at alarm and after end of alarm, and heart rates measured every 15 seconds. Thirteen men and six women participated in the study. A questionnaire with background data was collected. Non-parametric statistical tests were used.

Results

Elevated heart rate (median +34.7%) was associated with the actual priority-1 alarm, and during the alarm for women. Median salivary cortisol concentrations at alarm and after end of alarm (14.0 and 14.2 nmol/L respectively) showed non-significant differences. There were individual non-identical responses to the alarms. Alarms concerning traffic accidents, fast track and children generated the highest cortisol concentrations. The stress response showed non-significant differences in age, gender or level of education. Salivary cortisol concentrations and response were lower in the afternoon shift (2pm to 8pm).

Conclusion

The alarm causes increased heart rate at the group level but with individual different responses. Predefined fast track schedules and traffic accidents appear to generate measurable stress. Cortisol concentration follows normal diurnal variation of cortisol regarding time point for priority-1 alarms. Time of day does not affect the heart rate.

Keywords:

alarms; ambulance personnel; cortisol; heart rate; stress response

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Introduction

Research has shown that ambulance personnel suffer stress-related illnesses. Despite this, knowledge is limited about the causes. This study aimed to answer one gap in this knowledge: the stress response of ambulance personnel during priority-1 alarms.

Ambulance personnel are vulnerable to a number of risk factors, including acute and chronic stress (1). Work-related stress is a risk factor for developing cardiovascular disease and stroke (2,3). The relationship between work-related stress and cancer is not as significant (4).

Although 98% of ambulance personnel stated good health in one study, two-thirds reported medical problems and one-third reported emotional symptoms (5). Similar results were seen in another study (6). Stress, burnout and post-traumatic stress disorder have been observed in up to one-third of ambulance personnel (7,8) and ambulance personnel run more than twice the risk of work-related death (9). Nevertheless, most ambulance personnel look forward to the more serious and acute call-outs (10).

Since 2005, emergency ambulances in Sweden have been manned by two personnel; at least one being a registered nurse (11) who has patient responsibility, including the administration of drugs. The other team member may be either a paramedic or a nurse. During initial patient care, ambulance personnel work as a team, but during transport in the ambulance the nurse cares for the patient and the paramedic drives the ambulance.

In Sweden, a paramedic is defined as an assistant nurse with pre-hospital education; there is no system using emergency medical services or emergency medical technicians, common in many parts of the world.

In Sweden there are three different levels of alarm: priority-1 alarms are defined as an ambulance assignment with the highest priority where the patient is expected to have the most life-threatening symptoms and requires the use of alarm device, lights and siren; priority-2 means acute assignment but not life-threatening symptoms without the need for lights and siren; and priority-3 means non-acute symptoms but the possible need for an ambulance. So-called 'fast track' involves the use of special schemes to identify different patient groups such as acute myocardial infarction and stroke. This is to save time and therefore minimise residual damage to patients (12).

Nurses have an increased risk of work-related stress (13). Emergency nurses experience higher stress than general ward nurses (14). Perceived work-related stress can affect patient care in pre-hospital care. This stress can persist to the following work-free day (15). Higher cortisol concentrations were

observed in the morning in ambulance personnel before a shift in an emergency ambulance, compared to personnel working in transport ambulance. Expectation of higher demands in the emergency ambulance could be one explanation for this observation (16).

Medical mistakes and poor patient care could be associated with work-related stress (17). Demanding job situations with limited opportunity to influence outcomes may lead to stress and lower patient safety (18). Simulated patient cases confirmed that the risk of pharmaceutically miscalculated doses (19), worse clinical performance and inadequate documentation (20) were greater at high stress levels.

Salivary cortisol correlates well with the serum concentration. It is a simple and well-established method to measure stress and the hypothalamic-pituitary-adrenal axis (21,22). Heart rate can serve as a clinical indicator of stress and is easily measured with a heart rate monitor (23).

This study aimed to examine the mental stress of ambulance personnel during priority-1 alarms.

Study design and methods

This study was conducted in an ambulance organisation in southern Sweden, consisting of 12 ambulances on duty for 24-hours shifts and eight ambulances on duty only during daytime shifts: 7.45am to 5pm or 7.45am to 11pm.

After both oral and written information at workplace meetings, a request for participation was sent to all personnel by mail and returned by those who agreed to participate. Exclusion criterion was if a participant was taking medication that affected the heart rate and/or cortisol concentration. We followed the methods of Karlsson et al (24).

Participants in the study wore heart rate watches (Polar RS 400™ Polar Electro, Bromma, Sweden). The watches logged heart rate every 15 seconds during the time span when salivary cortisol was collected. Before the start of data collection all participants were given oral and written instructions on how to handle the equipment.

Salivary cortisol was collected according to a schedule, one immediately at alarm (ie. when the crew received the priority-1 alarm) and one after end of alarm (ie. either an alarm call-off or when patient care was completed). Anonymised copies of all journals were collected to ascertain the nature of the alarms. Priority-1 alarms were classified into seven different groups: traffic accidents; children; internal medical problems; neurological problems; surgical or orthopaedic problems; cardiopulmonary resuscitation/death; and other.

Participants

The group consisted of 164 ambulance personnel: 129 nurses and 35 paramedics; 99 were men aged 31–62 years (median

age 42 years) and 65 were women aged 27–56 years (median age 41 years). Thirty-eight agreed to participate, of which 20 were randomly drawn; 14 men and six women. The median age was 43 years (32–53 years) for men and 41 years (31–44 years) for women. Eleven men and five women were nurses. One male nurse ended his participation immediately due to being allergic to the chest strap used with the heart rate watch. The remaining 19 participants completed the study with one exception, who did not complete more than two alarms before the study was closed for data collection.

Collection and analysis of salivary cortisol samples

All participants followed a well-described technique for the collection of salivary cortisol samples (25). A commercial competitive RIA-based method for salivary cortisol was used (Spectria, Cortisol I¹²⁵, Orion Diagnostica™).

Priority-1 alarms

The priority-1 alarms included were the first five that the participants received after they began data collection. All priority-1 alarms between 7:30am and 8pm were included and analysed.

Outcome measures

Outcome measures were salivary cortisol concentration and heart rate. The independent variables were gender, education, age, type of alarm and time of alarm.

Data analysis

Data were entered into Microsoft Excel Version 2013 (Microsoft Corporation, Redmond, Washington, USA). Statistica version 10.0 and 13.3 (StatSoft, Scandinavia AB, Uppsala, Sweden) and SPSS version 18.0 (SPSS Inc. Chicago, IL, USA) were used for statistical calculations. Non-parametric tests were used to adjust misalignment. The Mann-Whitney U test and the Kruskal-Wallis one-way analysis of variance were used to compare the groups. Wilcoxon's matched pairs signed ranks test analysed individual daily rhythms and the Spearman rank order correlation test analysed the correlation between cortisol and clinical characteristics. Statistical significance was present if p-value was less than 0.05.

Power estimation

The study includes 90 observations of priority 1-alarms. When we perform an estimation of 80% power for salivary cortisol, we need a change in salivary cortisol between mean values before and after alarms of 15% when n=90. Estimated power is 0.804.

Presentation

The total secretion of cortisol during the priority-1 alarms was calculated as the area under the curve (AUC) from zero level ($AUC_0 = AUC_G$) according to earlier research (26,27). Fekedulegn (27) has shown a significant association ($r>0.7$; $p=0.001$) between AUC_0 and cortisol concentration.

Ethics approval

All participants gave their written consent to participate in the study. Data collection followed the World Medical Association's principles in the Declaration of Helsinki (28). Ethical approval was obtained from the Regional Ethical Review Board in Gothenburg dated 25 June 2012 with Dno: 356-12.

Results

Characteristics of study participants

Comparison of study participants versus non-participants' (ie. all ambulance personnel invited to participate in the study) gender, age and education showed no significant differences (Table 1).

Table 1. Characteristics of participants

Population	Original		Study		p-value
	n	%	n	%	
Number	164	100	19	12	-
Gender (male/female)	99/65	60/40	13/6	68/32	0.57
Median age (years) (male/female)	42/43	-	41/41	-	0.93
Education (nurse/paramedic)	129/35	78/22	15/4	79/21	0.95

Priority-1 alarms

The duration on the alarms varied between 10 and 195 minutes. The median duration was 54 minutes. Twenty-one alarms were ended because the unit was not needed. In 52 of 90 alarms (58%) the nurse was the only ambulance personnel; at 38 priority-1 alarms (42%), either a nurse or paramedic was in attendance.

Heart rate

Increased heart rate was associated with the priority-1 alarms. Measured between the first and second cortisol sample the median heart rate in women (87bpm) was significantly higher compared to men (76bpm; $n=87$; $p=0.006$). When comparing heart rate at alarm and after end of alarm for all participants there was a significant difference ($n=88$; $p=0.013$). However, this difference in heart rate at alarm versus after the alarm ended was significant in men but not in women; men's median heart rate was lowered after alarm ($n=59$; $p=0.001$). Absolute heart rate was lower after the end of alarm in men compared to women ($n=61/29$; $p=0.038$) (Figure 1). Time point for alarm was 7:30am to 8:00pm. Neither the time point at the alarm and after the alarm nor the duration of the alarm affected measured values of heart rates.

When comparing the peak of heart rate at the actual alarm versus 10 minutes before the alarm there was an increase in 18 of the participants, and a lowering in one with a variation of between -17.7% (from 130 to 107 bpm) to +172.3% (from 47 to 128 bpm); mean heart rate change +37.6%, median +34.7%.

Salivary cortisol concentration

The median cortisol concentrations at alarm and after end of alarm, and the total secretion of cortisol during the priority-1 alarms are presented in Table 2. There were no differences between genders.

Table 2. Salivary cortisol concentrations (nmol/L) at and after end of alarm, and total cortisol secretion during the alarm (AUC_0), split by gender

	All (n=90)	Women (n=29)	Men (n=61)	p-value
Salivary cortisol at alarm	14.0 (6.9-68.2)	14.7 (7.2-37.0)	13.9 (6.9-68.2)	0.53
Salivary cortisol after end of alarm	14.2 (5.9-65.6)	14.2 (6.1-65.6)	14.1 (5.9-48.5)	0.52
AUC_0	789 (101-3829)	937 (288-3829)	707 (101-3581)	0.24

Values are given as median and (min-max)

Heart rate and cortisol responses versus type of priority-1 alarm

Different types of priority-1 alarm generate a salivary cortisol elevation defined as an increase of more than 10%. Traffic accidents, alarms involving children, and cardiac and neurological patients generated a higher frequency of elevated cortisol levels when compared to other priority-1 alarms. When including all alarms, no statistical changes in salivary cortisol concentration were seen between the first and second sample. In contrast, when comparing different types of alarms, there are variations in cortisol response.

We found no significant difference in heart rate and salivary cortisol concentration at the time of day or the duration of the alarm. We found no difference in the total cortisol secretion between working as a nurse or driver ($p>0.05$).

Discussion

Priority-1 alarm

There was an increased heart rate at the alarm for both genders, and during alarm only for female personnel. Previous research shows different results. In some it appears that men and women at the same occupational level respond similarly to stress (29), in others that men and woman tend to react differently (30).

Figure 1. Heart rate and salivary cortisol concentration (nmol/L) at alarm and after the end of alarm according to gender

We found no general difference in salivary cortisol concentration after end of alarm. The stress response shows to be dependent on type of alarms.

The stress response in the form of increase in salivary cortisol seen in personnel working on traffic accidents was surprising. This type of assignment is relatively common and all personnel have undergone practical and theoretical training in pre-hospital trauma care such as pre-hospital trauma life support (31) or other internal trauma training. To meet the need for pre-hospital leadership at the scene of an accident all personnel has undergone pre-hospital leadership management courses. These findings are supported to some extent by a study where traffic accidents and medical emergencies were stated as the most stressful for ambulance personnel (32).

Patient groups where standardised fast-track schedules are used for heart attack and stroke patients were highly represented in the study in terms of increased cortisol value.

We found no differences either in heart rate response or salivary cortisol response between working as a driver or nurse. This is in contrast to Backé et al who found a more intensive endocrine response as driver (16).

We found a difference in salivary cortisol response, but not in heart rate response, between morning and afternoon shifts. This agrees with the diurnal cortisol rhythm with 2–3-fold higher cortisol concentrations in the morning compared to in the afternoon. The cortisol response, the difference at alarm and end of alarm, appears to be lower in general in the afternoon, not only the absolute values. We cannot conclude if this is a central pituitary or adrenal difference in response because we did not measure the pituitary released adrenocortical hormone simultaneously with cortisol. We have previously measured the cortisol arousal reaction in the morning in this study population (not published) and found normal cortisol arousal reaction but with some difference in intensity.

In contrast, the sympathetic-adreno-medullar-system (epinephrine, nor-epinephrine) appears to react similarly independent of time point for alarm. If these different responses between the HPA-axis and the sympathetic-adreno-medullar-axis during the day have a practical consequence of less alertness and precision of work in the afternoon is hard to see and not the aim of this study.

Although a limited sample, a tendency is seen for an increase in cortisol levels associated with alarms involving children. This confirms earlier qualitative research showing that emergency care for children is a stressful part of pre-hospital care (33).

The initial heart rate increase associated with the alarm appears not to be related to a physical effort. Increase in heart rate during the alarm, between the two cortisol tests, may be

explained by the increased physical effort involved in working with patients.

Limitations

Strengths and weaknesses

The internal dropouts were few, with 18 of 19 participants completing all five priority-1 alarms. Of these, two saliva samples were incomplete due to a small amount of saliva. One participant only completed two priority-1 alarms. Of the alarms, four were incomplete for the measurement of heart rate, all others were analysable. No participant had access to their own results.

One weakness was that the group was small, and the number of women was too small to draw firm conclusions based on gender differences or level of education. There was uncertainty regarding cortisol response during priority-1 alarms because the Regional Ethical Review Board only allowed two samples to be taken, at alarm and after the end of alarms. The considerable time span between the two samples (10–195 minutes) may have impeded reliable registration of cortisol increases related to stress or registration of a possibly completed return to baseline. In how many cases, and if this really happened, is impossible to say. In order not to miss any cortisol secretion, regular measurement occasions are required to ensure the individual's stress response. No collection of data during the night shift (8pm to 7:30am) was carried out.

Validity, reliability of the instrument used

According to information from the manufacturer, the error for heart rate is $\pm 1\%$ on the heart rate watches used, which means that these values were highly reliable. In the analysis of the salivary cortisol samples collected during priority-1 alarms, the uncertainty limit was set at 10% according to the coefficient of variance for this method. This limit was set at that level to reduce the risk of misinterpretation and we have used this limit ($>10\%$) to define significant difference in salivary cortisol concentration. Salivary cortisol concentration is consistent and clearly linked to serum concentrations of cortisol (22,34) and it is a safe and well-documented method.

Conclusion

Stress response was not dependent on gender, age and level of education, but our findings show that some incidents trigger stress responses. A future larger study focussing on priority-1 alarms should be carried out with fixed time intervals for cortisol samples, eg. every 15 minutes for 2 hours. This is essential to capture any indication of stress that may have been overlooked in this study. A larger study could also provide answers to whether the differences regarding gender (as we observed) persist. It could also support our interpretation that fast track generates stress on the individual or that other explanations may appear.

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Competing interests

The authors declare no competing interests. Each author of this paper has completed the ICMJE conflict of interest statement.

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