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Anaesthetist stress is induced by patient ASA grade and impairs non-technical skills during tracheal intubation.

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Abstract

Background: The aims of this study were to determine if patient co-morbidity could increase stress in anaesthetists with a subsequent effect on non-technical skills.

Methods: Stress was measured using a validated objective (heart rate variability or heart rate) and subjective tool. We studied eight consultant anaesthetists during 16 episodes of intubation with a patient with no or mild systemic disease (ASA 1 or 2) versus a patient with severe systemic disease (ASA 3 or 4).

Results: Heart rate variability (r=0.60; p=0.002) better correlated with subjective stress when compared to heart rate (r=0.30; p=0.15). Patients with severe systemic disease provoked increases in both objective (median 4.92 versus 7.1; p=0.02) and subjective stress (median 7.5 versus 9.5; p=0.04). The agreement between anaesthetist non-technical score (ANTS) raters was acceptable (ICC=0.51; p=0.003). Objective stress negatively affected situation awareness (p=0.03) and decision-making (p=0.03), however this difference was not clinically significant.

Conclusion: This study suggests patient co-morbidity can increase stress in anaesthetists, which may impair non-technical skills.

Introduction

Stress is a physiological and psychological response to external stimuli. A degree of stress can optimise performance although when this reaches a certain threshold, performance deteriorates.[1] During the conduct of anaesthesia, there are many potential sources of mental stress. The majority of anaesthetists recognise that stress can negatively affect performance[2] while calmness under pressure is seen as a key quality of a model anaesthetist.[3] However, there has been a paucity of research into stress in anaesthetists during routine clinical practice.

The American Society of Anaesthesiologists (ASA) grade can be used to risk-stratify patients in the perioperative period, with higher ASA grades associated with increases in mortality.[4] With an ageing population and a rise in co-morbid conditions, there is an increase in the proportion of patients of higher ASA grade undergoing surgery.[5] It is unclear what effect this has on stress in the anaesthetist. More complex patients may induce more stress in the anaesthetist, which has possible implications for the specialty such as increases in cardiovascular disease,[6 7] depression, burnout, substance abuse and suicide.[8 9] Previous studies have demonstrated only minor manifestations of acute stress in anaesthetic practice, with a correlation between ASA grade and heart rate.[10] However, heart rate variability may offer a more sensitive marker of objective, indirect mental stress measurement when compared to heart rate alone.[11]

Heart rate variability measures the R-R variability in heart rate and reflects sympathetic nervous system activity. Increased sympathetic tone measured using heart rate variability has been associated with increases in cardiovascular mortality, arrhythmias, depression and diabetic neuropathy.[12] Heart rate variability has been utilised in numerous clinical studies as an indirect marker of mental strain in healthcare professionals, with increases in sympathetic activity associated with key tasks such as performing surgery.[13] As a non-invasive, indirect measure of stress, heart rate variability is an attractive option to measure real-time stress in anaesthetists during clinical practice. However, no current objective measurement of stress is ideal, and therefore concurrent measurement of subjective stress is recommended in order to provide more rigorous data.[14]

The effects of stress on clinical practice are diverse and may affect both technical and non-technical skills.[14] [15] Non-technical skills are a range of cognitive and social skills that do not include technical performance, which contribute to safe practice and task performance.[16] The recognition of the importance of non-technical skills led to the development of the anaesthetist's non-technical skills taxonomy (ANTS).[16] Since its development, several studies have been published which utilise the ANTS score,[17] [18] however these studies are often performed in simulation scenarios and therefore have limited fidelity when compared to routine clinical practice.[19] Stress is known to affect non-technical skills,[14] although no study has evaluated the direct effect of stress on non-technical skills in routine anaesthetic clinical practice.

The aims of our study were therefore firstly to observe if the physical status of the patient could influence the stress experienced by the anaesthetist during tracheal intubation in routine clinical practice, and secondly, to assess the influence of stress on anaesthetist's non-technical skills using a valid and reliable tool. Finally, we aimed to compare heart rate and heart rate variability as measures of stress in anaesthetists to help guide future research studies in the area.

Methods

We gained ethical approval from the University of Nottingham Ethics Committee prior to study commencement (L09102014). Written, informed consent was obtained from each participant. Inclusion criteria included anaesthetic consultants from one hospital within the UK. Exclusion criteria included consumption of caffeine, concurrent use of cardiovascular medication or any rigorous physical activity prior to recordings. We observed consultant anaesthetists undertaking one episode of tracheal intubation with a patient with no or mild systemic disease (ASA 1 or 2) and a further episode with a patient with severe systemic disease (ASA 3 or 4) as graded by the attending anaesthetist. We used real life clinical situations with real patients undergoing surgery at our institution.

To measure objective mental stress levels we used heart rate variability. Heart rate variability can be used to measure overall sympathetic tone and therefore act as an indirect measure of mental stress during procedures based on R-R variability from ECG recordings. We used the Polar RS800CX (Polar Electro 2011, Warwick UK) heart rate monitor, which has been validated for heart rate variability recordings.[20] The equipment included a heart rate monitor recorder worn by the anaesthetist during the procedure and a remote watch to which the monitor transmits data. Data can then be analysed offline using computer software (Polar ProTrainer Version 5).

We used frequency domain analysis using fast Fourier transformation to calculate power spectral density. This calculates three distinct values, very low frequency (<0.04Hz), low frequency (LF) (0.04-0.15Hz) and high frequency (HF) (0.15-0.4Hz) values.[13] As LF values are thought to reflect sympathetic nervous activity and HF parasympathetic activity, the LF/HF ratio can be used as a measure of overall sympathetic activity.[21] Normal values of LF/HF ratios of 1.5-2 have been suggested.[21] Recordings on each participant were taken at rest on the same working day and during tracheal intubation in both a patient with no or mild systemic disease and one with severe systemic disease. We also recorded the heart rate of the participant using the same equipment.

In addition to objective measures of stress, we also measured subjective stress. We used the short version of the State Trait Anxiety Inventory (STAI),[22] a valid and reliable tool, which has been used in previous clinical studies measuring stress in healthcare professionals.[14] Scores range from 6 (lowest) to 24 (highest). A combined objective and subjective approach to measuring stress has been recommended previously,[14] with increases in subjective scores above baseline to post-procedure regarded as subjectively stressful procedures.[23] STAI was administered both at rest on the same working day and as soon as possible after tracheal intubation in both groups of patients.

In order to measure the effect of stress on non-technical skills, we selected those procedures that were objectively stressful and analysed these as low stress versus high stress procedures. We used the anaesthetist non-technical skills score (ANTS) to rate non-technical skills, a previously validated and reliable tool.[24] We present scores at the category level and included half marks to convert the score to a seven-point Likert scale as described previously.[17] Training to use the tool included attending a one-day training course at the Royal College of Anaesthetists and dissemination of course materials including the handbook. Two raters assessed non-technical skills and following the procedure, non-technical skills were discussed and agreement reached by consensus. This method was chosen due to the ethical difficulties of video recording patient episodes, which has been utilised in previous simulation studies. Therefore, any non-technical skills not observed by one rater could be discussed and scores adjusted accordingly. When recording non-technical skill scores, raters were blinded to the stress status of the participant. We regarded average ANTS scores <3 as clinically significant as this is the level at which non-technical performance is a cause for concern.

Sample size calculations determined a sample size of 8 (with 16 recordings) was required to detect a mean difference in LF/HF ratio of 2 between the groups with a standard deviation of 1.5 using an α=0.05, 1-β=0.85 and a correlation coefficient of 0.5. Descriptive data are presented as mean ± standard deviation, median [inter-quartile range] or number (percentage) as appropriate. Objective stress, subjective stress and ANTS category scores were analysed with paired samples t test or Wilcoxon signed rank test. Patient baseline characteristics are analysed using the independent samples t test, Mann Whitney U test or Fisher's exact test. We tested the association between stress variables using Spearman's rank correlation coefficient. Inter-rater reliability for the ANTS scores was analysed using the intraclass correlation coefficient (ICC). All analyses were conducted on SPSS V21. We regarded results $p \leq 0.05$ as statistically significant.

Results

We recruited eight consultant anaesthetists and observed 16 episodes of tracheal intubation. All participants used direct laryngoscopy. There were 6 male and 2 female participants with a mean age of 42 ± 4.7. The mean years of total anaesthetic experience was 14 ± 5.6. Excluding ASA grade, there were no statistically significant differences between the two patient groups (Table 1). There was a significant correlation between LF/HF ratio and STAI (r=0.60; p=0.002). However, there was no significant correlation between heart rate and STAI (r=0.30; p=0.15).

When compared to baseline, tracheal intubation was associated with an increase in objective (mean LF/HF ratio 4.56 versus 5.71; p=0.02) but not subjective stress (median STAI 8.5 versus 8; p=0.44). When compared to the ASA 1 or 2 patients, ASA 3 or 4 patients were associated with increases in both objective (median 4.92 versus 7.1; p=0.02) (Figure 1) and subjective stress levels in the participants (median 7.5 versus 9.5; p=0.04) (Figure 2).

In terms non-technical skills, the inter-rater reliability for the two raters on the ANTS score at the category level was acceptable (ICC=0.51; p=0.003). When analysing the effect of stress on non-technical skills, 14 episodes of tracheal intubation were analysed, as one reading did not induce an increase in the LF/HF ratio. An increase in objectively measured stress resulted in a statistically significant reduction in situational awareness and decision-making scores (Table 2). However, this was not clinically significant. Furthermore, stress had no significant effect on task management or team working.

Discussion

Our results suggest that patients with severe systemic disease induce more objective and subjective stress in anaesthetists during tracheal intubation than those patients with no or mild systemic disease. Moreover, increases in stress may negatively affect cognitive skills such as situational awareness and decision-making, although this difference was not clinically significant. Furthermore, analysis of objective and subjective stress measurement suggests that heart rate variability is a more sensitive tool to detect stress than heart rate, a commonly used tool in clinical studies of stress.

Stress in anaesthetists has gained a lot of attention recently, largely owing to concerns over the high suicide rate within the speciality.[9] However, it is unclear what effect an increase in the number of patients with severe systemic disease will have on the speciality.[5] Although increases in sympathetic tone, as measured using heart rate variability has been associated with increases in cardiovascular mortality and depression,[12] our study only measured stress for a short period of time during tracheal intubation. Therefore, it is difficult to conclude whether such short-term increases in stress will affect chronic stress in anaesthetists. This may be the subject of future research studies.

There has been little research conducted evaluating acute stress in the anaesthetist around the perioperative period. The most recent study evaluated acute stress in anaesthetists and found only a small, clinically insignificant increase in heart rate, with over 50% of participants achieving their highest heart rate during intubation.[10] Similar to our results, subjective stress did not increase following tracheal intubation and the ASA grade of patient was positively correlated with increases in heart rate (r=0.43; p=0.04). However, this study did not directly compare patients of different ASA grades. Our results suggest that only those patients with severe systemic disease may be able to induce detectable increases in mental stress in anaesthetists, which may explain the results obtained in the previous study.

A similar study design to ours has been utilised in simulation scenarios enrolling medical and surgical residents to induce both low stress and high stress environments, in order to measure changes in technical and non-technical skills.[15] Although the high stress scenario induced increases in cortisol and STAI scores, the reduction in ANTS score during the high stress environment was not statistically significant (p=0.13). However, this study did not analyse only those with a documented stress response, which limits any definitive conclusions from this study. Interestingly, heart rate was not found to change despite increases in cortisol and STAI, again suggesting a possible decreased sensitivity in detecting increases in objective measures of stress.

Stress is intrinsically linked with, and often cited as an important component of non-technical skills. However, its exclusion from the ANTS taxonomy is largely due to the difficulties observing it directly.[16] Although there is limited data thus far directly applicable to anaesthetic practice, data from the psychological literature is available. Complex cognitive functions such as working memory, attention and decision-making require intact prefrontal cortex activity. Heart rate variability has been directly linked to prefrontal cortex activity, with increases in sympathetic activity negatively affecting functions. Studies in cohorts of police and naval cadets have shown a positive correlation between parasympathetic activity as measured by heart rate variability and improved situational awareness.[25] In addition, studies have found stress negatively affects decision-making tasks[26 27] and neuro-imaging studies have demonstrated decision-making regions of the brain are susceptible to stress-induced changes.[28] Within clinical practice, previous research conducted during surgical procedures has found that stressful clinical situations can negatively affect decision-making.[14]

Many previous clinical studies measuring stress have been conducted, most within a surgical cohort. Objective measures of stress used include heart rate, biochemical analysis and heart rate variability.[14] Each has their own limitations, which led to recommendations for a combined objective and subjective approach to stress measurement.[13] Newly developed tools such as the Imperial Stress Assessment Tool (ISAT),[23] which utilise subjective and objective measures have been published. This tool however utilises heart rate as a continuous objective measure. Previous research has suggested heart rate may lack sensitivity when compared to heart rate variability.[11] Our results suggest a better correlation between LF/HF ratio and STAI when compared to heart rate measurement, which may therefore indicate the LF/HF ratio is a more sensitive tool to use in future research studies.

There are several limitations with this study. Firstly, the relatively small sample size limits any conclusions. However, due to the repeated measures design of the study, the reduced systematic variability between participants allowed a smaller sample size. We also encountered significant logistical difficulties while attempting to study participants in clinical practice, which may limit future studies in the area. Secondly, there is dispute over the measurement of LF domains of heart rate variability analysis, as these may also include a parasympathetic component. However, our analysis revealed this measure was significantly correlated with subjective stress, suggesting its use is robust in this context. Thirdly, as we were only able to study routine clinical practice, it is unclear whether crisis situations will have a more clinically significant effect on non-technical skills. Logistically these are difficult to capture in reality due their rarity and are perhaps more appropriately studied in simulation scenarios.[19] Finally, the modest inter-rater reliability of the ANTS scores limit the conclusions derived from these measurements. However, our inter-rater reliability values were acceptable and similar to those studies published previously.[15 18 24]

Despite the limitations of this study, we believe we can make some recommendations for future studies and clinical practice. Firstly, future studies measuring stress in anaesthetists should use both subjective and objective measures of stress, with heart rate variability possibly being a more sensitive measure when compared to heart rate. Secondly, as the STAI was well correlated with heart rate variability, use of the short form STAI in anaesthetic training may help supervisors assess the impact of stress on trainee's non-technical skills due to its simplicity and ease of use. Thirdly, although not assessed formally, non-technical skills appeared related to significant perioperative events such as tachyarrhythmias. Therefore future studies focussing on stress during this period may aim to record the relationship between adverse perioperative events and non-technical skills.

In conclusion, patients with severe systemic disease were found to induce significant increases in objective and subjective stress levels in consultant anaesthetists. In addition, heart rate variability appears a more sensitive tool to assess objective stress when compared to heart rate. Moreover, increases in stress resulted in decreases in situational awareness and decision-making. This is to our knowledge, the first study to assess the influence of stress on non-technical skills in routine anaesthetic practice.

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Competing interests

No external funding or competing interests declared.

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Table 1: Baseline characteristics of both groups of patients. Mallampati and Cormack-Lehane grade as assessed by the attending anaesthetist. Frequency working with the ODP was assessed on a Likert scale with 1=not at all; 2=on a few occasions; 3=monthly and 4=daily to weekly. Values are median [IQR] or number (percentage).

	ASA 1 or 2 (n=8)	**ASA 3 or 4 (n=8)**	**p value**
Patient age	56 [51-61]	57 [46-68]	p=0.38
Patient sex (F)	4 (50%)	5 (63%)	p=1
ASA grade	2 [1.2-2.5]	3	**p<0.001***
Duration of intubation (secs)	21.5 [15.5-27.5]	21 [3.1-38.9]	p=0.72
Mallampati grade	1.5 [0.5-2.5]	2 [1.5-2.5]	p=0.38
Cormack-Lehane grade	1.5 [1-2]	1.5 [0.8-2.2]	p=0.72
Bougie used	1 (13%)	1 (13%)	p=1
Frequency working with ODP	3 [2-4]	2.5 [1.5-3.5]	p=0.65

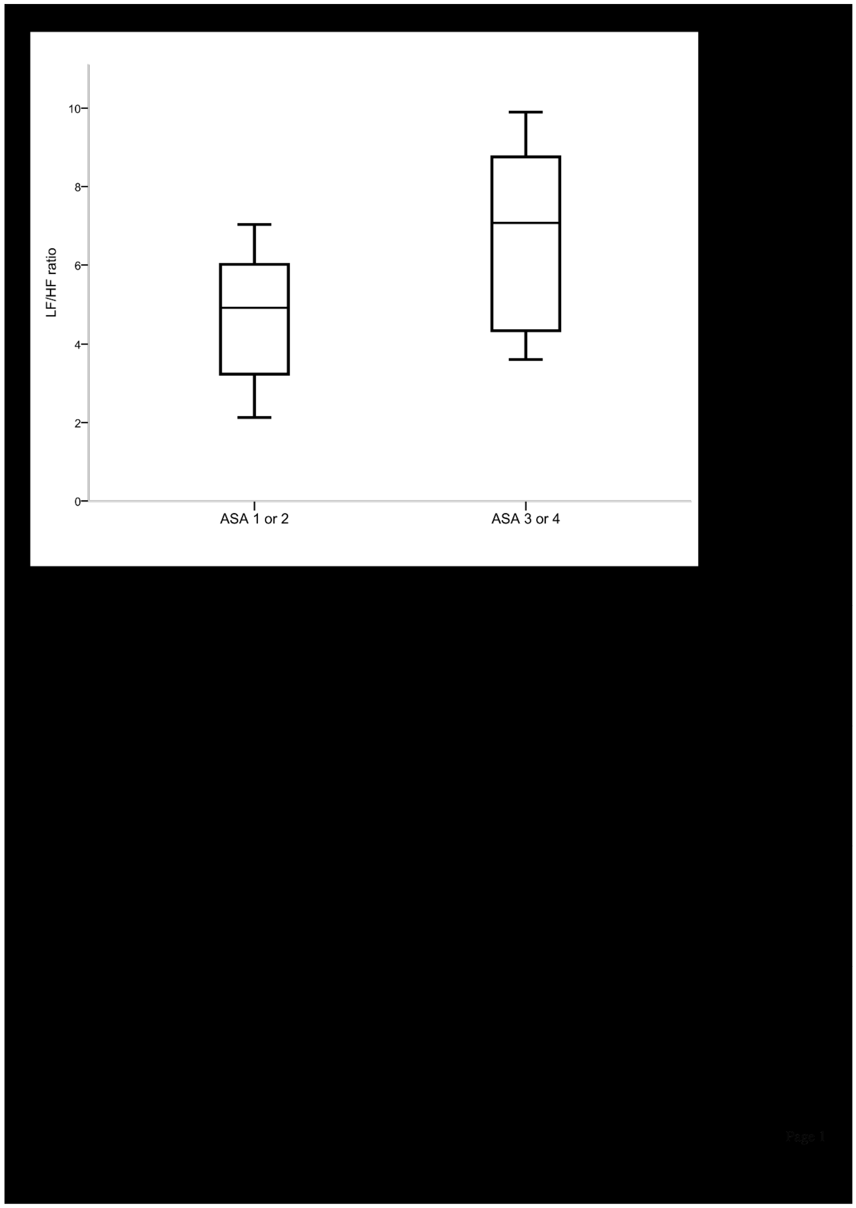
Table 2: Effect of anaesthetist objective stress on non-technical skills (ANTS) score.

	Low stress (n=7)	High stress (n=7)	p value
Situational awareness	3.5 [0]	3 [2.5-3.5]	**p=0.03***
Decision making	3.5 [0]	3 [2.75-3.25]	**p=0.03***
Task management	3.5 [3.25-3.75]	3 [2.75-3.25]	p=0.56
Team working	3.5 [3.25-3.75]	3.5 [0]	p=1

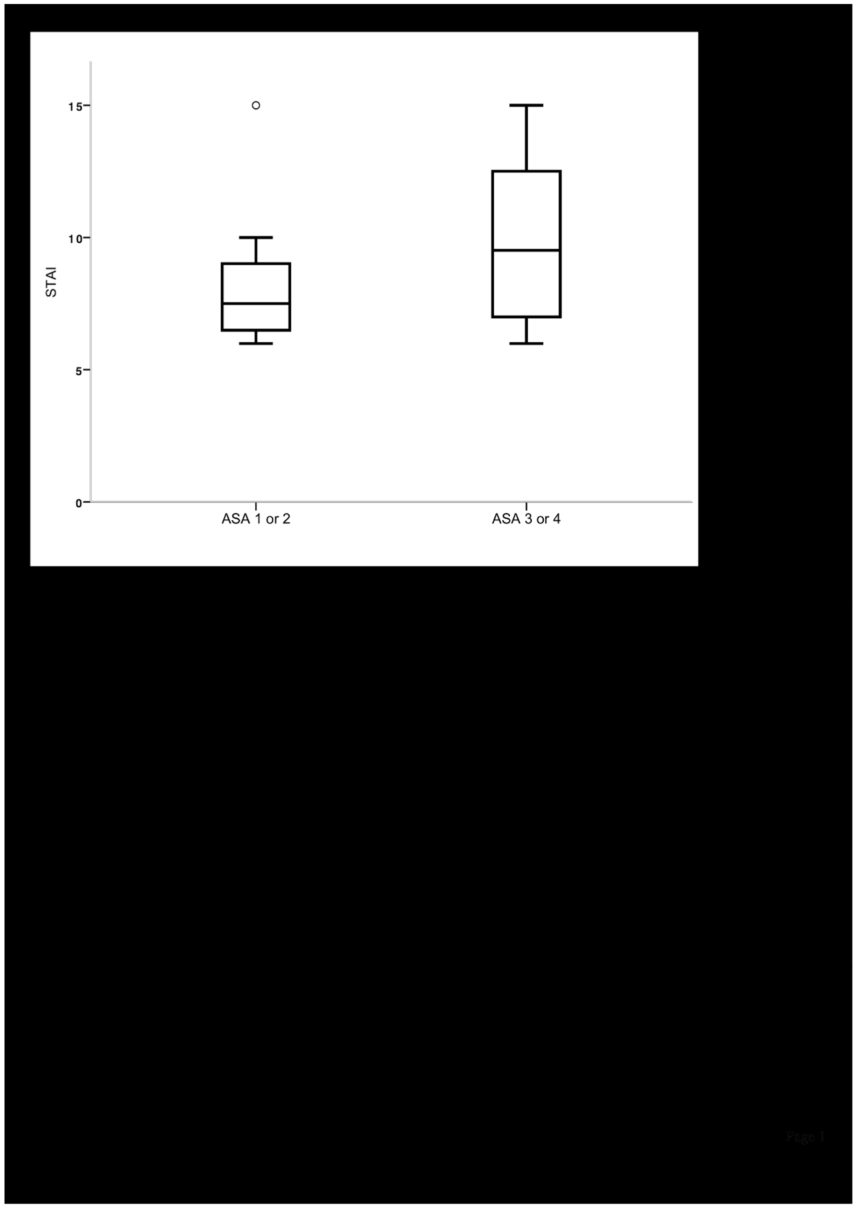
Caption for Figures

Figure 1: Objective anaesthetist stress measured using LF/HF ratio of heart rate variability in low and higher risk patients.

Figure 2: Subjective anaesthetist stress measured using the short STAI in low and higher risk patients.



Objective anaesthetist stress measured using LF/HF ratio of heart rate variability in low and higher risk patients.
297x420mm (300 x 300 DPI)



Subjective anaesthetist stress measured using the short STAI in low and higher risk patients.
297x420mm (300 x 300 DPI)