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Heart Rate Variability and Acute Stress Among Novice Airway Managers

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ABSTRACT

Background: The nature of medical emergencies places emergency physicians at risk for high levels of acute psychological stress (APS). Stress-modifying techniques like visualization, breath control, and mental practice may help mitigate APS, but objective markers of stress are difficult to measure in the clinical setting. We explored the relationship between heart rate variability (HRV), a real-time measure of autonomic arousal, and self-reported APS among emergency medicine (EM) residents learning to intubate on actual patients.

Methods: This was a prospective study of postgraduate year 1 (PGY-1) EM residents at a single academic medical center during their 1-month anesthesia rotation. We obtained repeated measures of HRV immediately before and during the first intubation attempt each day. Participants completed the modified Spielberger State-Trait Anxiety Inventory (STAI-6) before intubation attempts and scored intubation difficulty using the Intubation Difficulty Scale. We analyzed HRV using root mean square of successive differences and analyzed data using clustered data methods and Pearson correlation coefficients.

Results: We enrolled eight PGY-1 residents and recorded 64 intubations. Mean HRV in the 2 minutes before intubation (17.88 ± 9.22) and during intubation (21.17 ± 13.46) was significantly lower than resting baseline (32.09 ± 15.23; adjusted mean difference [95% CI] = –13.90 [–20.35 to –7.45], $p < 0.001$; and –10.77 [–17.65 to –3.88], $p = 0.02$). Preintubation anxiety was negatively correlated with HRV ($r = –0.39$ [–0.58 to –0.16], $p = 0.001$). Intubation difficulty was not significantly correlated with HRV ($r = –0.12$ [–0.36 to 0.13], $p = 0.35$).

Conclusions: HRV shows promise as a real-time index of autonomic arousal and may serve as an outcome measure in the evaluation of stress-modifying interventions.

The practice of emergency medicine (EM) demands the ability to lead teams, simultaneously diagnose and treat disease, and perform lifesaving procedures. The unpredictable and high-stakes nature of EM places physicians at risk for suboptimal performance and burnout.[1,2] While some degree of autonomic arousal may facilitate performance (known as the Yerkes-Dodson law), high degrees of acute psychological stress (APS) increase the risk of medical and procedural errors.[3–6]

Interest is growing in psychological skills training (PST) as a means to combat APS and improve resuscitation performance.[3,4] Originally derived from sports psychology, PST is a set of techniques including visualization, positive self-talk, and breath control. Due to a lack of robust metrics of APS that are measurable in the clinical setting, the efficacy of formalized PST is unknown. To address this need, we assessed an objective measure of autonomic arousal known as heart rate

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variability (HRV). HRV is the beat-to-beat variation in heart rate and reflects the real-time activity of the autonomic nervous system.[5] In general, highly stressed people exhibit reduced HRV as a result of the overactivity of the sympathetic nervous system and reduced activity of parasympathetic nervous system.[6] Understanding the physiologic changes among trainees learning a high-stakes procedure would provide an objective means for assessing APS as well as the efficacy of stress modifying interventions such as PST. As we enter the era of low-cost wearable technology, measuring physiologic data in the clinical setting becomes a realistic possibility.

We sought to measure HRV among postgraduate year 1 (PGY-1) EM trainees learning to intubate in a real-life clinical setting and to examine the relationship between HRV and self-reported anxiety and intubation difficulty. We chose to study this phenomenon in an authentic clinical context to elicit a high degree of psychological engagement from participants. We likewise chose novice (PGY-1) airway managers learning to intubate as they are less likely to have well-rehearsed strategies for mitigating acute stress compared to more experienced providers. Endotracheal intubation was chosen as the focus for this study due to its central importance to the practice of EM, its time-dependent and high-stakes nature, and its integration of cognitive and psychomotor skills. We hypothesized that residents would exhibit low HRV before and during intubation compared to baseline, indicating heightened autonomic arousal. We further hypothesized that HRV would be inversely correlated with self-reported anxiety and with procedural difficulty.

METHODS

This was a prospective observational study conducted at a U.S. EM residency program. PGY-1 EM residents were eligible for participation in the study. Exclusion criteria were previous anesthesia or EM residency, nurse anesthetist or paramedic training, preexisting cardiac disease, or use of medications affecting heart rate. The study site was an affiliated community hospital where our PGY-1 EM residents spend 1 month on an anesthesia rotation. During this rotation they learn endotracheal intubation on surgical patients under the direct supervision of an attending anesthesiologist. The study was approved by the University of California Davis Institutional Review Board, and all participants provided written consent. Please see Data Supplement S1 (available as supporting information in the online version of this paper, which is available at http://onlinelibrary.wiley.com/doi/10.1002/aet2.10335/full) for a detailed description of our data collection and analysis.

Our primary outcome measure was HRV, which we assessed by comparing mean changes, relative to resting baseline, during the 2 minutes before and during intubation. Our secondary outcome measures were self-rated anxiety before intubating as measured by the modified Spielberger State-Trait Anxiety Inventory (STAI-6) and intubation difficulty as measured using the Intubation Difficulty Scale (IDS).[7,8] This was a pilot study using a convenience sample to provide proof of concept and establish a foundation for future studies and as such did not rely on a predetermined sample size. Eight of nine eligible PGY-1 EM residents were enrolled: five men (62%) and three women (38%) with mean ± SD age of 28 ± 1.92 years (range = 26–31 years); one eligible resident declined to participate. All were healthy subjects with no history of heart disease or medication use.

RESULTS

We collected HRV recordings on a total of 64 intubation attempts, with a mean of eight attempts collected per participant (range = 6–10). We failed to obtain HRV recording on two intubation attempts. Mean time to intubate was 2.5 minutes (range = 1–6 minutes) with a mean of 1.19 attempts (range = 1–3 attempts). Mean ± SD self-rated anxiety score before intubating on the STAI-6 instrument was 34.3 ± 8.9, and mean ± SD intubation difficulty score was 1.8 ± 2.4.

At baseline, mean HRV measured in the time domain of mean square of successive differences (RMSSD) was 32.1 ± 15.2, with an intracluster correlation coefficient of 0.50, indicating a mild level of test–retest reliability. Mean HRV was not significantly lower at baseline 2 compared to baseline 1: mean difference = –1.7 (95% CI = –9.3 to 5.9), p = 0.66. Mean HRV measured in the time domain of RMSSD during the 2-minute period immediately before and during intubation was significantly decreased compared to resting baseline (Figure 1). Adjusted mean differences based on our regression model were –13.90 milliseconds (95% confidence interval [CI] = –20.35 to –7.45) prior to intubation and –10.77 milliseconds (95% CI = –17.65 to –3.88) during the intubation period. Univariate correlation analysis of preintubation STAI-6 score and preintubation HRV showed a significant negative correlation (r = –0.39, p = 0.001), whereas

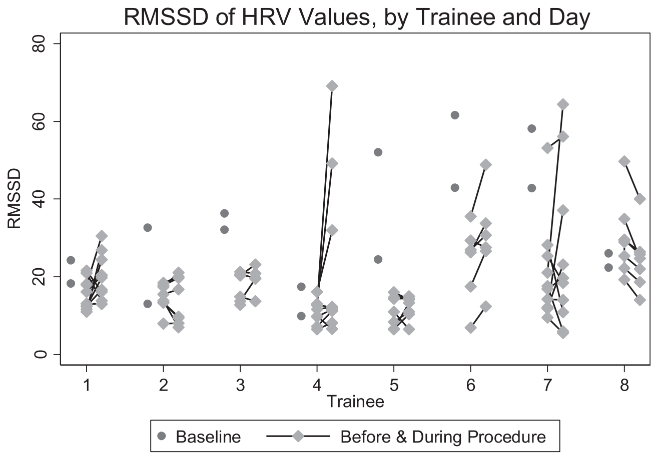

Figure 1. Depiction of observed heart rate variability measured in the time domain of root mean square of successive differences (RMSSD; milliseconds) at resting baseline (two 2-minute measurements per trainee, mean ± SD = 32.1 ± 15.2, intracluster correlation coefficient [ICC] = 50%) and twice during the first procedure of training days, with the first measurement from the 2 minutes before intubation (mean ± SD = 17.88 ± 9.22, ICC = 36%) and the second from 1 to 6 minutes during intubation (mean ± SD = 21.17 ± 13.46, ICC = 3%). Compared to baseline, mean HRV was significantly reduced before and during intubation (adjusted mean differences [95% CI] = –13.90 [–20.35 to –7.45] and –10.77 [–17.65 to –3.88], respectively). Mean change from preintervention to during intervention was 3.4 (–1.2 to 8.0).

scored intubation difficulty did not correlate significantly with HRV (r = –0.12, p = 0.35).

DISCUSSION

In this study, we demonstrated HRV to be significantly lower (indicating increased autonomic arousal) in residents just before and during intubation compared to resting baseline. Self-rated anxiety correlated significantly with lower measures of HRV, consistent with our hypothesis. While this was a limited sample, our baseline HRV measurements were consistent with published norms for resting HRV and the direction of correlation was consistent with prior studies using RMSSD as a measure of HRV under stressful conditions.[9,10]

Notably, in 36 of the 62 measurements, preintubation HRV was lower than intraintubation HRV with the proclivity for a higher measurement associated with learner (Fisher's Exact test p-values = 0.03). This finding suggests that, for some learners, anticipatory APS appears to be higher than that observed during the procedure itself. We found no relationship between intubation difficulty and HRV during intubation. The majority of intubations in our study sample were determined to be relatively easy per the IDS (in which an intubation with a score > 5 is considered difficult),[8] and this may have attenuated the relationship between intubation difficulty and HRV.

Higher resting HRV is associated with greater emotional regulation,[5,11] and successful regulation of emotion can likewise increase HRV.[12] EM residents who encounter fear with procedures may benefit from interventions such as breath training and biofeedback that help bring HRV under conscious control.[13,14] Future directions of this research will include describing the expected ranges of HRV while intubating in comparison to rest, as well as recovery times. Understanding the physiological profile of trainees performing stressful procedures may help identify those with exaggerated or prolonged stress responses. In this way, HRV may prove to be an essential tool for both shaping and exploring the efficacy of PST interventions.

LIMITATIONS

This was a small pilot trial conducted at a single institution, and as such our findings are of limited generalizability. While we found evidence of test–retest reliability within our sample, three or more baseline measurements would be desirable to achieve a mean baseline score with suitable reliability (>70%) for research purposes.[15] Additionally, a number of potentially confounding factors were not measured, including participants' caffeine consumption, concurrent stressful life events, and the social interaction between study participants and anesthesia attendings on the airway rotation. We also chose to conduct our study in a controlled (operating room) setting rather than in the ED to standardize our testing conditions and minimize potential confounders, but this was done as a knowing trade-off in terms of generalizability to the ED setting. Our use of the IDS scale also relied on the subjective assessment of Cormack-Lehane grade by an individual novice observer. Future studies would benefit from the use of video laryngoscopy and multiple observers to address this limitation. Finally, we intentionally limited our investigation to PGY-1 residents early on in their airway training, and as such our findings may not generalize to more experienced practitioners.

CONCLUSIONS

Our study demonstrates that heart rate variability is lower among emergency medicinie trainees just before and while intubating compared to rest and that lower heart rate variability ratings correspond to higher degrees of self-reported anxiety. These findings suggest that emergency medicine trainees experience acute psychological stress while learning to perform the procedure of endotracheal intubation.

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Supporting Information

The following supporting information is available in the online version of this paper available at http://onlinelibrary.wiley.com/doi/10.1002/aet2.10335/full

Data Supplement S1. Detailed description of research methods.