A Prospective Study of Heart Rate Variability in Endocrine Surgery: Surgical Training Increases Consultant's Mental Strain

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BACKGROUND: The aim of this study was to determine whether instructing surgical trainees in technically demanding procedures causes alterations in heart rate variability (HRV) and mental strain in supervising surgeons.

METHODS: A prospective study of HRV in two consultant surgeons and three endocrine surgical fellows undertaking 50 total thyroidectomy procedures was performed. Fellows and consultant surgeons performed 50 lobectomies as primary operator and 50 as assistants in a cross-over design. HRV was measured during dissection around the recurrent laryngeal nerve. The overall heart rate, time, and frequency domain parameters of HRV, specifically the low frequency/high frequency (LF/HF) ratio, which was used as a measure of cardiac and mental stress, were correlated with the surgical role, particularly teaching surgical fellows at critical points.

RESULTS: HRV data were collected between October 2009 and March 2010. There was no statistically significant difference in the mean heart rate for either group of participants regardless of role. Energy expenditure was greater for fellows when operating ($p = 0.03$). Fellows demonstrated a higher LF/HF ratio when acting as the primary operator ($p = 0.02$). All time domain parameters of HRV increased when attending surgeons were operating, denoting more cardiac relaxation. Similarly, the LF/HF ratio was significantly greater for attending surgeons when teaching ($p = 0.05$), suggesting an increase in mental strain.

CONCLUSIONS: The teaching of complex but common endocrine surgical procedures is associated with a measurable increase in mental strain of consultant surgeons, as determined by HRV. Fellows demonstrated increased levels of stress when acting as primary operators. (J Surg 69:453-458. © 2012 Association of Program Directors in Surgery. Published by Elsevier Inc. All rights reserved.)

KEY WORDS: endocrine surgery, thyroidectomy, heart rate variability, surgical training

COMPETENCIES: Patient Care, Professionalism, Practice Based Learning and Improvement

INTRODUCTION

Recent decades have seen a paradigm shift in the manner of surgical training.[1,2] Concerns regarding long working hours and the effects on the mental and physical health of trainees as well as on patient safety have lead to changes in workplace practice.[3,4] Within these limits, controversy remains over how best to teach surgical trainees operative skills without increasing surgical morbidity.[1] The supervision of surgical residents can be a stressful undertaking, particularly in technically demanding procedures. However, while there is a growing body of research on the association between work stress, performance, and cardiovascular risk, there is little published literature on the mental demands and strain of supervising and teaching more junior surgical colleagues.[5,6]

The autonomic nervous system plays an integral role in the functional properties of the heart, altering spontaneous sinus node depolarization and, thus, cardiac rhythms.[7,8] Previously published studies have demonstrated an association between the autonomic nervous system and cardiovascular mortality.[9-11] The heart rate variability, or the interval between consecutive heartbeats (RR interval), uses periodic fluctuations in the heart rate to assess the relative contributions of the parasympathetic and sympathetic nervous system. The analysis of heart rate variability is divided into time and frequency domains.[7] Time domain parameters typically reflect high frequency variations in heart rate, correlating with increased parasympathetic activity.[7,8] The frequency domain converts beat-to-beat variations to specific band frequencies.[7] The high frequency domain represents parasympathetic activity, whereas the low frequency domain is a

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TABLE 1. Characteristics of Surgical Participants

Participants ($n = 5$)	Age (Mean)	Sex (Male)	Medications	Smoker	Baseline HR (Mean)
Fellows ($n = 3$)	33	0%	None	No	69
Consultants ($n = 2$)	51	100%	None	No	71

combination of both sympathetic and parasympathetic activity. Heart rate variability also represents an indirect measure of mental strain and, therefore, analysis of HRV during surgical procedures may reflect the sympathovagal balance of an individual surgeon.[12,13]

The aim of this study was to establish whether the sympathovagal balance of an individual surgeon was altered dependent upon is/her surgical role during a specific operation and to establish if operative surgical teaching is associated with an increase in mental strain, as determined by heart rate variability in consultant surgeons.

METHODS

Participants and conditions

Two consultant surgeons (male, mean age 51) and 3 endocrine surgical fellows (female, mean age 33) participated voluntarily in this prospective study. The 3 fellows were postgraduate year 8, 8, and 9, respectively, and had on average performed 15 thyroid lobectomies before study commencement. Fifty total thyroidectomies (100 thyroid lobectomies) were performed from October 2009 to March 2010, within the Endocrine Surgical Unit of the University of Sydney, a tertiary referral center. The consultant group performed 50 lobectomies as the primary operator with an almost even split (28:22 lobectomies) and 50 as the surgical assistant/teacher. Similarly, the group of fellows performed 50 lobectomies as the primary operator, with again an almost even split (16:15:19) and 50 as the surgical assistant. Within each total thyroidectomy the consultants performed 1 lobectomy and the fellows, the other, determined randomly. Thus, the study was performed in a cross-over manner (both surgical teacher and primary operator within the same case) allowing individual surgeons to act as their own controls and standardizing for surgical complexity. Each surgeon had a 5-minute "rest" period before commencement of operating, during which time baseline measures of heart rate were taken. None of the participants required regular medication nor had a history of either cardiovascular disease or diabetes. All were of average physical fitness and were nonsmokers (Table 1). Caffeinated drinks were forbidden for 1 hour preoperatively. Recurrent laryngeal nerve monitoring was not utilized for any cases in this study. The indications for the total thyroidectomy included thyroid carcinoma, benign multinodular goiter with/without retrosternal extension, Grave's disease, and Hashimoto's disease (Table 2). A unilateral central compartment dissection was performed in 18 patients.

HRV was chosen as a surrogate marker for mental strain. Spectral analysis of the HRV allows assessment of the sympathetic and vagal activities that regulate the heart. We differentiated between mental stress and strain. Stress encompasses all factors influencing an individual, whereas strain is defined as the physical and psychological effects of stress on an individual.

HRV recordings

Measurements of HRV were made using the Polar RS 800 heart rate Monitor (Polar Electro, Inc., Lake Success, NY). This is a noninvasive wireless monitor with an elastic electrode belt which allows detection of RR interval with a resolution of 1 ms. Previous studies have demonstrated good correlation with more cumbersome methods of analysis of HRV.[14] The electrocardiogram was run throughout the total thyroidectomy allowing signal reconstruction without amplitude or phase distortion. An observer (CYH) carefully documented the time of commencement of dissection around the recurrent laryngeal nerve at each operation. The data were subsequently transferred to a personal computer and analyzed off-line using commercially available software (Polar precision performance program).

The overall heart rate, time, and frequency domain analysis was performed according to the recommendations of the Task Force of the European Society of Cardiology and the North American Society of Pacing and Electrophysiology.[7] The tachogram was analyzed for a 5-minute period at the time of dissection and exposure of the recurrent laryngeal nerve. Within the time domain, analysis of the overall variability [standard deviation of the normal to normal interval (SDNN)], short-term variability [the square root of the mean normal to normal interval (RMSSD)], and the percentage of adjacent pairs of normal to normal intervals differing by more than 50 ms in the recording (pNN50)] was conducted. Spectral analysis was performed with the fast Fourier transformation of data to quantify the power spectral density of the high frequency (HF) (0.15-0.4 Hz) and the low frequency (LF) (0.04-0.15 Hz) bands. Additional calculations included low frequency and high frequency expressed in normalized units (percentage of the total power) and the ratio of low/high frequency. The very low frequency

TABLE 2. Surgical Indications for Total Thyroidectomy

Indication for Surgery	Total Number
Thyroid carcinoma Papillary/follicular/medullary	26
Multinodular goiter	30
Multinodular goiter with retrosternal extension	18
Graves disease	16
Hashimoto's disease	1