Heart Rate Variability Responses to Skin Incision in 0.8 MAC Sevoflurane Anaesthesia, *International Journal of Bioelectromagnetism*
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Abstract. Assessment of nociception under anaesthesia is challenging. Heart rate and heart rate variability (HRV) are related to functioning of the autonomous nervous system and have been reported to provide information about the level of anaesthesia. We evaluated whether HRV may be used as an index for analgesia by studying responses to skin incision under sevoflurane anaesthesia. We found that heart rate and HRV change differently for sub- and supramaximal nociception. This suggests that HRV may provide valuable information about level of analgesia during anaesthesia.

Keywords: Heart Rate Variability; Anaesthesia; Analgesia; Nociception; Skin Incision

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1. Introduction

General anaesthesia is composed of three components: hypnosis, analgesia and muscle relaxation. Recent advances in EEG processing allow relatively reliable online assessment of the depth of hypnosis while efficiency of muscle relaxation may be objectively monitored by stimulating a motor nerve and measuring the movement response caused by the corresponding muscle [van Gils et al., 2003]. Online monitoring of the level of analgesia, however, is complicated and objective methods do not yet exist.

Nociception (unconscious perception of pain) during anaesthesia causes mainly sympathetic reactions. HRV, in turn, is related to the functioning of the autonomic nervous system (ANS), and has been suggested to reflect depth of anaesthesia [Pomfrett, 1999]. We studied whether HRV would be a useful marker of nociception under general anaesthesia.

2. Material and Methods

2.1. Subjects and Protocol

The study was approved by the local Ethics Committee, and written informed consent was obtained from the subjects. We analyzed data from 26 patients scheduled for abdominal hysterectomy. After induction with fentanyl 1 mg/kg iv and propofol 1 mg/kg iv anesthesia was deepened with sevoflurane 8% in 100% oxygen via facial mask until endotracheal intubation. Sevoflurane concentration was adjusted to equal 0.8 MAC (1.6% end-tidal). Surgery began 14 min after intubation. Any signs of arousal at skin incision were registered, and patients were grouped into groups of movers (N=12) and nonmovers (N=14) according to the existence or absence of arousal, respectively.

2.2. Signal Processing and Data Analysis

ECG was recorded by an AS/3 Anesthesia MonitorÒ (Datex-Ohmeda, Helsinki, Finland) with 300Hz sampling rate. ECG was analyzed off-line from pre-incision (120 seconds before stimulus) and post-incision (120 seconds after pain stimulus onset) periods. The calculated parameters were normalized to pre-stimulus values. R-to-R-interval (RRI) signal was derived from ECG automatically. The R-wave detection was manually verified and corrected when necessary. HRV was quantified both in time and frequency domains and also by Poincare analysis [Korhonen et al., 2001]. The time domain parameters computed were RRI standard deviation (SD) and root mean square of the squared difference of successive R-to-R intervals (RMSSD). Furthermore, a heart rate acceleration index (HRA index) [Korhonen, 2001], which aims to quantify sympathetic arousals in HRV signal, and RRI range (RRI_{max}-RRI_{min} within the analysis window), were computed. The quantitative Poincare analysis was carried out as suggested by Tulppo et al [Tulppo et al, 1996], and the standard deviations of the Poincare plot against the axes y=x (SD1), and y=-x+2*m (SD2), where m is the mean RRI during the epoch of interest, as well as their ratio (SD1/SD2) were calculated.

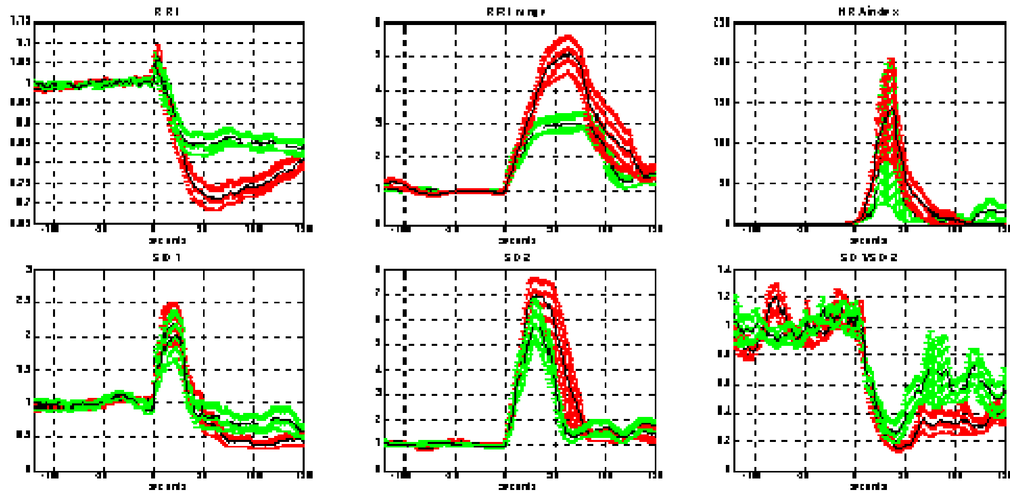

Figure 1. Group average HRV responses to incision for movers (solid line, N=12) and nonmovers (dashed line, N=14). Errorbars indicate standard error of mean.

3. Results

Mean RRI decreased to 88% (SD 8.2%) and 77% (8.0%) ($p<0.01$) and HRV SD increased to 347% (162%) and 631% (446%) ($p<0.01$) from pre-incision values in nonmovers and movers, respectively (Fig. 1). HRV difference was associated with low frequency variability: SD2 increased to 370% (189%) in nonmovers as compared to 695% (537%) by movers ($p<0.05$). Also SD1/SD2 ratio (33% (19%) vs. 18 %(11%), $p<0.05$), HRAindex (94ms (40ms) vs. 197ms (95ms), $p<0.05$), and RRI range (314% (124%) vs. 535% (262%), $p<0.001$) responses were different in nonmovers and movers, respectively. Frequency domain measures were not different in the groups.

4. Discussion

HRV changed to a greater degree in response to supramaximal noxious stimulation, as indicated by clear arousal during anesthesia, than to submaximal noxious stimulation (no arousal). The results support use of HRV as an indicator for level of analgesia. Time domain and Poincare analysis methods were more powerful than frequency domain parameters in quantifying the responses.

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