Title: EVALUATION OF SPECTRUM ANALYSIS OF HEART RATE VARIATIONS DURING ANESTHESIA

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Introduction: Spectral analysis of heart rate variations were recently performed to assess autonomic nervous control of the heart in conscious humans.[1] Their studies showed that low frequency variations (below 0.12 Hz) were jointly mediated by the sympathetic and parasympathetic nervous systems. In comparison high-frequency variations, which were respiratory-linked variations in heart rate, were mediated solely by the parasympathetic system. The purpose of this study was to evaluate the usefulness of heart rate spectral analysis in anesthetized patients as an index of autonomic nervous activity.

Methods: Seven patients (6 men and one woman) undergoing open heart surgery were studied following institutional approval. The anesthetic management of these patients followed our standard procedure. They were premedicated with morphine sulfate (0.1 mg/kg). Anesthesia was induced with fentanyl (50-70 µg/kg) and diazepam (0.15-0.3mg/kg). Pancuronium (0.1mg/kg) was administered to facilitate endotracheal intubation. Time sequential heart periods (i.e., R-R intervals) were measured in tenths of a msec from the output of the EKG monitor before anesthesia (C), and after intubation (F+D). Power spectra of these data were computed using a fast Fourier transform. The areas of the spectral peaks for each patient within each period of measurement were calculated as follows. On the basis of a previous study[1], the low-frequency peak area (LO-FR) was computed by integrating the spectra from 0.04 and 0.12 Hz. The high frequency peak area (HI-FR) was computed by integrating the spectra over the entire peaks of respiratory bandwidth. In addition, we computed the ratio of HI-FR to LO-FR, and mean heart period for each patient within each period of measurement.

Results: Each patient developed a heart rate oscillation with a period of about 14 seconds, causing the peak within the LO-FR band before anesthesia; following induction of anesthesia this peak decreased by 75% from the control values. The mean areas were as follows: (C) 8.7×10^{-5}, (F+D) 2.1×10^{-5} ($p<0.05$). The peak centered at 0.23 Hz and 0.19 Hz were in the HI-FR band at (C) and (F+D), respectively; while spontaneous breathing at (C) caused wide HI-FR band, positive pressure ventilation during anesthesia caused a narrow HI-FR band. There was no difference in the peak amplitude of HI-FR band area between (C) (8.3×10^{-4}) and (F+D) (9.9×10^{-4}), but the area of this peaks decreased from (C) (4.1×10^{-5}) to (F+D) (1.2×10^{-5}) ($p<0.05$). Ratio of HI-FR to LO-FR increased from (C) (45 %) to (F+D) (62 %) ($p<0.05$). There was no difference in mean heart periods between (C) and (F+D).

Discussion: Our data demonstrated that fentanyl-diazepam anesthesia reduced both the area of LO-FR and HI-FR, suggesting a decrease in vagal outflow as well as a decrease in sympathetic outflow. These decreases in autonomic nervous activity may provide a quantitative means for monitoring the level of anesthesia. This is in contrast to previous findings in which fentanyl activated central vagal tone.[2] This discrepancy might be due to 1) sympathomimetic effect of pancuronium or 2) central effects other than vagal activity. An increase in the ratio of parasympathetic area (HI-FR) to sympathetic-parasympathetic area (LO-FR) during anesthesia suggests that autonomic control of the heart in response to anesthesia (F+D) changed a balance between the activities of the parasympathetic and sympathetic nervous systems and power spectra of heart rate variation may provide a quantitative measure of this balance. We believe heart rate spectral analysis will be a powerful noninvasive tool for monitoring autonomic nervous system activity during anesthesia as well as monitoring the level of anesthesia.

Reference:

1. Pomeranz B, Macaulay RJB, Caudill MA,et al: Assesment of autonimic function in humans by heart rate spectral analysis. Am. J. Physiol.248:H151-H153, 1985.
2. Reitman JA, Stengert KB, Wymore ML, Martucci RW: Central vagal control of fentanyl-induced bradycardia during halothane anesthesia. Anesth Analg 57:31-36, 1978.

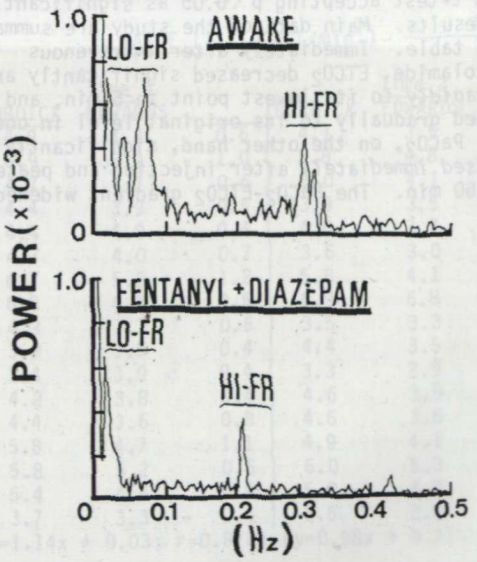

Figure 1. An example of power spectrum in one patient of the influence of fentanyl-diazepam anesthesia on heart rate variations.