Limits of heart rate variability analysis during conscious sedation associated with slow breathing: fast fourier transform vs autoregressive method.

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Introduction

Heart rate variability (HRV) is a widely diffused tool to study autonomic nervous system regulation on heart rate. It has been proposed as a method to measure sedation and anesthesia depth. HRV is based on separation of spectral components of tachogram into high frequency (HF) driven by vagal-respiratory coupling and low frequency components (LF) thought to be mediated by both sympathetic and vagal influences. Both components can be extracted from fast fourier decomposition (FFT) or autoregressive model analysis of the tachogram. During conscious sedation the HF component is entrained by respiratory rate (RR) reduction in the LF domain (0,04 – 0,15 Hz). When FFT analysis is performed, LF component is spuriously increased whereas HF power is decreased thus resulting in LF/HF (sympathovagal balance) ratio overestimation (1). Autoregressive methods (AR) based on LF and HF peak recognition in respective domains are also influenced by this bias. We analyzed the influence of RR reduction on HRV parameters and studied the influence of AR model complexity on HRV parameters to propose a best order choice criterion.

Methods

We prospectively enrolled 7 healthy volunteers and recorded continuously 3 leads ECG. respiratory rate by means of thoracic impedance and nasal capnometry (etCO2) during 7 minutes of spontaneous breathing, before and 7 minutes after infusion of fentanyl 1mcg/kg i.v. bolus.. LF power, HF power expressed in normalized units and LF/HF ratio were extracted both with FFT and AR methods of rising complexity (between 12 and 26). Visual analysis of cross power spectra between HRV and RR spectra was performed to evaluate HF peak frequency.

Results

3 patients showed a spontaneous respiratory rate <9 /min (<0.15 Hz) after sedation and were analyzed. FFT analysis showed a LF/HF increased from 3.2+/-1.24 (mean RR 13.1) to 12.09+/-3.13 (mean RR 7.2), AR method (order 10, automatically chosen by Akaike information criterion) from 2.8+/-1.5 to 13.65+/-3.43. No patient etCO2 increased above baseline level. This would suggest a sympathetic and vagolytic effect of fentanyl but respiratory bias is present (2). When AR order was risen above 10, LF normalized power after sedation decreased and HF power increased to a stable level (mean LF/HF: 2.79+/-1.88) above order 20. When this order was reached a spectral HRV component synchronous to respiratory spectrum appeared in the LF domain.

Conclusions

We suggest that FFT analysis can not be employed when analysing HRV in slow breathing patients since LF and HF bands superposition leads to LF overestimation. We propose that AR can be used if a proper high order of complexity (>20) is chosen allowing HF peak recognition in LF domain. Simultaneous analysis of cross power spectrum between RR and R-R interval spectra is mandatory to recognize these peaks.

References

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