Measuring Transient Heart Rate Changes During Noxious Stimulation in Laparoscopic Surgery

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Introduction: Evaluating the surgical noxious stimulation in general anesthesia requires the interpretation of physiological signals. While the heart rate (HR) and blood pressure readings displayed on the patient monitor provide convenient information, those readings are too static to measure the transient response from dynamic noxious stimulation, in particular the transient change of beat-to-beat heart rate, which we referred to as *Instantaneous Heart Rate* (IHR).

Since opposite impacts of noxious stimulation on the autonomic system –sympathetic activation causes tachycardia, whereas noxious stimulation could elicit a transient bradycardia via vagal activation, the HR readings on the patient monitor is the averaging sum of both opposing effects on the heart rate, providing limited information. It requires one of the opposing effect greatly overpowers the others to make a notable change of HR value.

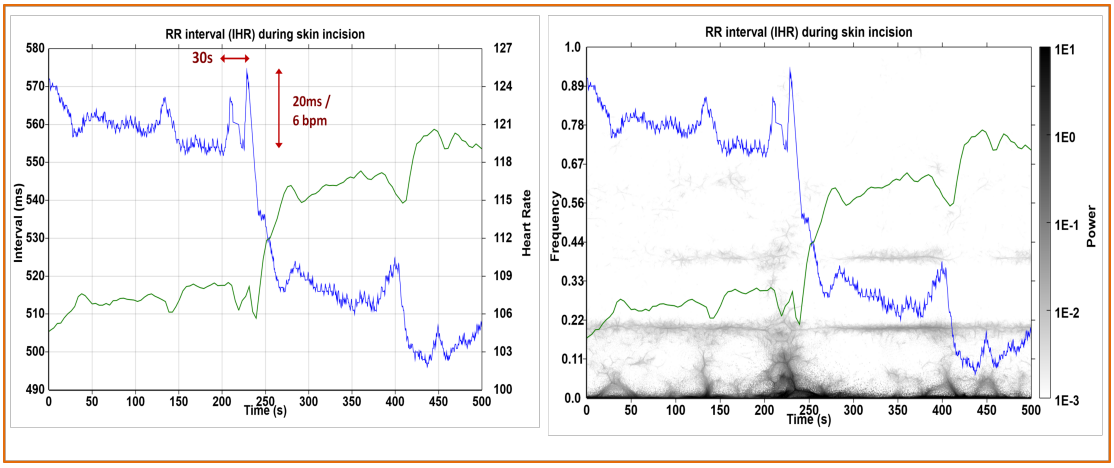
The analysis of IHR is traditionally known as heart rate variability (HRV) analysis, whose techniques are short of quantifying the dynamical information in IHR, particularly the transient change in response to the noxious stimulation. The recent development of time-frequency analysis could provide a functional “time-varying power spectrum” in high resolution to fulfill the above requirement. Our previous study has revealed the potential of the new method referred to as Concentration of Frequency and Time (ConceFT). Hence in the present study, we hypothesize that surgical noxious stimulation of different intensity and different location exhibits differential dynamic feature in IHR.

Method: The study was approved by the local institutional Research ethics Board and written consents were collected from subjects. We conducted a prospective observation study by enrolling patients undergoing laparoscopic cholecystectomy. The standard monitoring signals, including the electrocardiogram (ECG) in 500Hz sampling rate, was collected from the Philips IntelliVue™ patient monitor. We registered the accurate timestamps of noxious stimulation events, including umbilical skin incision (10 mm), umbilical trocar penetration by laparoscopic trocar (10 mm), xiphoid skin incision (5 mm), xiphoid trocar penetration of xiphoid area (5 mm), subcostal skin incision (3 mm), subcostal

trocar penetration (3 mm). IHR was obtained by automatic R-peak detection from ECG waveform and cubic spline interpolation. ConceFT method was applied to analyze IHR data from the ECG recording.

Results: We enrolled data from 41 patients for analysis. From IHR, we used ConceFT as a scale to measure the intensity of noxious stimulation. The time-varying spectra also reveals that trocar penetration causing more transient bradycardia than skin incision in the corresponding area. We proposed an algorithm to measure the scale

Conclusion: We quantify the scale of transient HR change during noxious stimulation. Also we quantify the relative difference between noxious stimulation from superficial and deep structure. The two-dimensional measurement of noxious stimulation in laparoscopic surgery could help the management in clinical anesthesia.



Difficulty of observing the transient heart rate, which changes as 20ms difference in interval and appears within 30s, can be seen (left). Conceft as a time-varying power spectrum quantify this transient event in the heart rate (right).