ECTOPIC BEATS IN HEALTHY HUMANS AND TRAUMA PATIENTS: LIMITATIONS FOR USE OF HEART PERIOD VARIABILITY INDICES IN MEDICAL MONITORING

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ABSTRACT

Heart period variability calculations require continuous, noise- and ectopy-free ECG waveforms. The purpose of this study was to review the ECG waveforms of healthy human subjects as well as trauma patients to further elucidate the practical utility of heart period variability assessments in patient monitoring. We hypothesized that ECGs from trauma patients exhibit a greater frequency of ectopic beats (EB) than those from healthy human research subjects. Methods: Continuous ECGs were recorded on 20 healthy human subjects at rest, 108 healthy human subjects undergoing experimentally-induced hypovolemia via lower body negative pressure (LBNP), and 245 prehospital trauma patients. ECG waveforms were analyzed and manually scanned for the presence of electromechanical noise and EB. Results: ECG waveforms from 20% of resting healthy human subjects contained at least 1 EB. Similarly, at least 1 EB was found in 17.6% of the healthy subjects undergoing LBNP. Because these records were obtained under laboratory conditions, there was no evidence of electromechanical noise. In the 245 ECG waveforms from trauma patients, 35.9% were found to contain either EB (34.7%) or electromechanical noise (1.2%). Conclusions: A significant number of EB occur in healthy subjects both at rest and during LBNP, and trauma is associated with a near doubling of this incidence. As both EB and noise invalidate heart period variability calculations, these metrics as currently calculated could not be used in approximately 36% of trauma patients. Our findings indicate that medical monitors with continuous heart period variability measurement capabilities may not be useful for pre-hospital decision-support in trauma.

BACKGROUND

- In the pre-hospital trauma setting, recent studies have revealed that heart period variability (HPV) could distinguish trauma patients who:
  - needed life-saving interventions (LSI) from those who did not (No-LSI) (2), and;
  - lived or died (1,3,4).
- HPV calculations require continuous, noise- and ectopy-free ECG signals (6).
- Some HPV metrics also require extended ECG waveforms of up to 800 R-R intervals, increasing the risk of the ECG containing ectopic beats (EB) and/or noise.
- As the presence of EB would exclude that portion of the ECG from HPV monitoring, the aim of this study was to determine the incidence of EB in trauma patients.

HYPOTHESIS

We hypothesized that ECGs from trauma patients would exhibit a greater frequency of EB than those from healthy human research subjects.

METHODS

- ECG waveforms of at least 800 R-R intervals were recorded for the following groups:
  - **Resting/Healthy Group:** 20 healthy, non-smoking subjects (14 M/6 F; age, 30 ± 2 years) at rest.
  - **LBNP Group:** 108 healthy, nonsmoking subjects (63 M/45 F; age, 28 ± 1 years) undergoing experimentally-induced hypovolemia via lower body negative pressure (LBNP).
  - **Trauma Patient Group:** 245 pre-hospital trauma patients with normal standard vital signs (166 M/79 F; age, 38 ± 1 years). ECG records were collected in transit from the scene of incident to a Level 1 trauma center via helicopter transport.
- Each ECG waveform was manually scanned for the presence of electromechanical noise or ectopy.
  - **LBNP subjects:** Ectopy was defined by manual comparison of the ECG with the continuous blood pressure waveform; an EB was detected if an apparent "premature" heart beat was associated with an incomplete blood pressure cycle. The entire ECG waveform from the LBNP experiment (2331 ± 34 sec, range 1657-3100 sec) was used for analysis.
  - **Resting healthy subjects and trauma patients**: both groups had only ECG waveforms available. Ectopy was defined as an RRI that was <80% or >120% of the previous RRI value (5). For these two populations, 800 R-R interval segments were used for analysis.
- Statistical Analysis:
  - Chi-square (χ^2) analysis was used to test whether the frequency of EB was independent of population (resting subjects, LBNP subjects, trauma patients).

RESULTS

- **Resting/Healthy Group:** ECG waveforms from 4 of the 20 (20%) resting healthy human subjects contained at least 1 EB (Figure 1).
  - Of these 4 subjects, 2 ECG records contained 1 EB, 1 contained 4 EB and 1 contained 5 EB.
- **LBNP Group:** At least 1 EB was found in 17.6% of the healthy subjects undergoing LBNP. Because these records were obtained under laboratory conditions, there was no evidence of electromechanical noise.
- **Trauma Patient Group:** In the 245 ECG waveforms from trauma patients, 117 waveforms were found to contain:
  - EB (85 waveforms; 34.7%);
  - Electromechanical noise (3 waveforms; 1.2%), or;
  - <800 heart beats (29 waveforms; 11.8% of total).
- EB were more prevalent in trauma patients compared with healthy subjects at rest and during LBNP (χ^2 = 11.48, P=0.003).

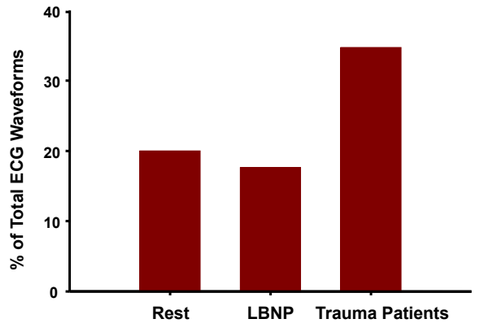

Figure 1 The percentage of total ECG waveforms containing ectopic beats in healthy resting humans (Rest, n = 20), healthy humans undergoing lower body negative pressure (LBNP, n = 108), and in trauma patients (Trauma Patients, n = 245).

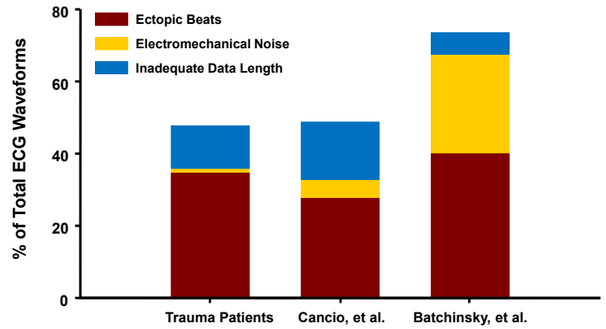

Figure 2 Percentage of total ECG waveforms from trauma patients excluded from further analysis in this study (Trauma Patients) and in previously published studies by Cancio *et al.* (2) (LSI vs. No-LSI) and Batchinsky *et al.* (1) (Lived vs. Died).

CONCLUSIONS

- A significant number of EB occur in healthy subjects both at rest and during LBNP; trauma is associated with a near doubling of this incidence.
- As both EB and noise produce invalid heart period variability calculations, these metrics as currently calculated could not be used in approximately 36% of trauma patients.
- Our findings indicate that medical monitors with continuous heart period variability measurement capabilities may not be useful for pre-hospital or emergency room decision-support in trauma.

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