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A Physiological Approach for Early Detection of Hemorrhage

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Abstract : Hemorrhage is the loss of blood from the circulatory system and leading cause of battlefield and postpartum related deaths. Early detection of hemorrhage remains the most effective strategy to reduce mortality rate caused by traumatic injuries. In this study, we investigated the physiological changes via non-invasive cardiac signals at rest and under different hemorrhage conditions simulated through graded lower-body negative pressure (LBNP). Simultaneous electrocardiogram (ECG), photoplethysmogram (PPG), blood pressure (BP), impedance cardiogram (ICG), and phonocardiogram (PCG) were acquired from 10 participants (age:28 ± 6 year, weight:73 ± 11 kg, height:172 ± 8 cm). The LBNP protocol consisted of applying -20, -30, -40, -50, and -60 mmHg pressure to the lower half of the body. Beat-to-beat heart rate (HR), systolic blood pressure (SBP), diastolic blood pressure (DBP), and mean aerial pressure (MAP) were extracted from ECG and blood pressure. Systolic amplitude (SA), systolic time (ST), diastolic time (DT), and left ventricle Ejection time (LVET) were extracted from PPG during each stage. Preliminary results showed that the application of -40 mmHg i.e. moderate stage simulated hemorrhage resulted significant changes in HR (85±4 bpm vs 68 ± 5bpm, $p < 0.01$), ST (191 ± 10 ms vs 253 ± 31 ms, $p < 0.05$), LVET (350 ± 14 ms vs 479 ± 47 ms, $p < 0.05$) and DT (551 ± 22 ms vs 683 ± 59 ms, $p < 0.05$) compared to rest, while no change was observed in SA ($p > 0.05$) as a consequence of LBNP application. These findings demonstrated the potential of cardiac signals in detecting moderate hemorrhage. In future, we will analyze all the LBNP stages and investigate the feasibility of other physiological signals to develop a predictive machine learning model for early detection of hemorrhage.

Keywords : blood pressure, hemorrhage, lower-body negative pressure, LBNP, machine learning
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