Heart rate variability analysis (HRV) is used to quantify autonomous nervous system (ANS) responses to psychological stress (PS), but standard short term (SST) HRVa (5-minute intervals) might be too long to assess transient ANS response to acute PS during acute stress due to police tactical task (PTT) when ANS response due to physical effort (PHE) and PS may overlap. This study aimed to evaluate if Ultra-short term (UST) HRV analysis can provide information useful to differentiate ANS response induced by PHE and PS.

Methods: 12-lead ECG continuously recorded in 130 healthy volunteers. 80 police officers during PTT training; 50 during maximum exercise testing with a bicycle ergometer. SSTHRVa was performed according to ESC. USTHRVa was performed from 30 sec and 60 sec recording intervals.

Results: SSTHRVa didn’t evidence short-lasting fluctuations of LF/HF ratio correlated with acute stress. USTHRVa showed LF predominance at the beginning of exercise and at medium workload. LF decreased at the maximum workload, almost disappeared at the zenith of HR and reappeared in the early recovery. The % decrease of LF was higher in PS in respect of PHE, whereas the % increase of HF was higher in PS. The % decrease of LF/HF ratio was similar in PS and PHE. Interval selection did not affect USTHRVa in PHE, but was critical evaluating acute stress. Quantitative estimate of FD parameters evidenced significant differences between PS ad PHE.

Discussion: USTHRVa is inadequate to detect short-lasting ANS response due to acute stress. USTHRVa identifies fluctuations of FD components, at the onset/offset of sudden PS, similar to those found during maximum PHE. Quantitative estimate of HRV parameters was significantly affected by interval duration in PS (being 60 s too long to detect short-lasting changes due to acute stress response) and evidenced significant differences between PS and PHE, which suggest that different mechanisms might contribute to HR adaptation during PS.

Heart rate variability analysis (HRV) is commonly used to quantify autonomic nervous system (ANS) responses caused by psychological stress (PS), including that acutely occurring during police tactical task (PTT) implying life-threatening situations and the use of force.

Standard short term (SST) HRVa (calculated in 5-minute intervals) is too long to assess the ANS response to acute PS. Ultra-short term (UST) HRVa has been proposed to monitor PS in dynamic settings, and optimal time intervals for USTHRVa in a mobile setting have been reported (Salahuddin L et al, IEEE EMBS, 2007; Nussinovitch U et al, ANE 2011). Under dynamic PTT, the ANS response due to physical effort (PHE) and to PS may overlap. Therefore it might be difficult to interpret HRV data obtained during PTT because:

- Data on USTHRVa during PHE are unavailable;
- USTHRVa has shown that changes in HF and LF powers and in LF/HF ratio observed during exercise do not reflect the decrease in vagal activity and the activation of sympathetic system occurring at increasing loads, but are expression of changes in respiratory, baroreflex and muscle activity (Perini R et al, Eu J Appl Phys 2003).

Multiple studies (Perini R et al, IEEE EMBS 2007, Nussinovitch U et al, ANE 2011) have suggested that different mechanisms might contribute to HR adaptation during PS. Therefore it might be difficult to interpret HRV data obtained during PTT because:

- Data on USTHRVa during PHE are unavailable;
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Exercise

- USTHRVa evidenced that LF were predominant at the beginning of exercise and at medium workload, decreased at the maximum workload, and almost disappeared at the zenith of HR (low TP, relative predominance of HF components and inversion of the LF/HF ratio) and reappeared in the early recovery (Fig. 4).

Discussion

- SSTHRVa is inadequate to evidence short-lasting changes of ANS response due to acute stress.
- USTHRVa identifies fluctuations of FD components, at the onset/offset of sudden PS, which are not appreciable in SSTHRVa and similar to those found during maximum PHE activity (Perini R et al, Eur J Appl Phys 2003).

Quantitative estimate of FD parameters was significantly affected by interval duration in PS (being 60 s too long to evidence short-lasting changes due to acute stress response (Table 1)). Quantitative estimate of FD parameters evidenced significant differences between PS ad PHE, which suggest that different mechanisms (i.e. circulating stress hormones, saturation kinetics of the ANS efferent nerve activity on the sinus node, alteration of the respiratory rate/rhythm…) might contribute to HR adaptation during PS (Table 2).

Beat-to-beat HRV analysis might be necessary to differentiate ANS response due to PS and PHE during police tactical activity.