Intermittently Decreased Beat-To-Beat Variability in Congestive Heart Failure

In a recent Letter, Costa *et al.* [1] used the multiscale entropy analysis to distinguish healthy hearts from those suffering congestive heart failure (CHF) or atrial fibrillation (AF). They mainly conclude that healthy and pathologic groups can be consistently differentiated using this multiscale entropy, while conventional algorithms fail. We point out here two major weaknesses of this study: First, the age of the patients and the healthy subjects they considered is significantly different. Second, in contrast to their main statement we show in the following that a rather simple measure of complexity from symbolic dynamics [2] is already able to discriminate clearly between the CHF patients and even age-matched healthy subjects. Moreover, for patients with AF this parameter is zero and we therefore do not have to consider them here.

It is well known in cardiology that heart rate variability (HRV) depends strongly on the age of the subjects; younger individuals have a significantly higher HRV than elderly ones [3]. By simply combining Figs. 3 and 4 of Costa *et al.* [1], it immediately becomes clear that CHF patients and the elderly volunteers have approximately the same entropy values. Surprisingly, Costa *et al.* [1] did not compare elderly healthy with elderly CHF groups, but compared young healthy subjects (32 ± 6 yr) with elderly CHF patients (56 ± 11 yr [4]). So it can be concluded from their analysis only that their methods robustly separate young healthy volunteers from both elderly cardiac patients and elderly healthy subjects, and this is similar to comparing apples with oranges.

Next, we analyze the data of 15 CHF patients (11 male, 4 female, ages 56 ± 11 yr) and the 24 h time series of 18 young healthy persons (13 female, 5 male, ages 34 ± 8 yr) available from Physionet [4]. To go beyond their inappropriate comparison [1], we additionally consider the beat-to-beat-intervals of 15 healthy elderly subjects (11 male, 4 female, ages 56 ± 5 yr). After preprocessing, we calculate standard time and frequency domain parameters as well as parameters based on symbolic dynamics which have been recently successfully applied to other cardiological problems [2,5,6]. Almost all show highly significant differences between young healthy and CHF patients. The best univariate parameter, however, we have found is the simple measure POLVAR20 based on symbolic dynamics [5], which detects intermittently decreased HRV [CHF: 0.68–0.90 interquartile range (IQR); young healthy: 0.05–0.13 IQR, $p < 10^{-8}$, Mann-Whitney U test] and completely discriminates the young healthy and the CHF group. The elderly healthy persons show intermediate POLVAR20 values (0.21–0.42 IQR) which are significantly different from those of the younger healthy group ($p < 10^{-4}$) as well as different from the CHF patients ($p < 10^{-5}$). Figure 1 demonstrates that even the age-matched elderly healthy can be separated almost completely from the CHF group (93% correctly classified for a cutoff of 0.5).

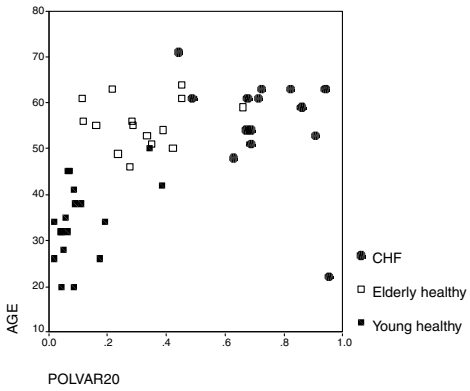

FIG. 1. Discriminating healthy from CHF patients. An increased intermittent low variability (POLVAR20) in the CHF group (circles) leads to a complete separation from the young healthy group (solid squares). Elderly healthy patients (open squares) show intermediate POLVAR20 values which, however, are clearly below to those of CHF patients.

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