ΔΗΜΟΣΙΑ ΣΥΝΕΔΡΙΑ ΤΗΣ 11ΗΣ ΔΕΚΕΜΒΡΙΟΥ 2003

ΑΝΑΚΟΙΝΩΣΗ

The use of the entropy in the natural time-domain to distinguish electric signals, by P. A. Varotsos, N. V. Sarlis, E. S. Skordas and M. S. Lazaridou*, διὰ τοῦ Ἀκαδημαϊκοῦ κ. Καίσαρος Ἀλεξόπουλου.

Abstract. In a previous paper (P. Varotsos, N. Sarlis and E. Skordas, *Phys. Rev. E, 68*, 031106, 2003), it was shown that the newly defined entropy S in the natural time-domain can classify the following types of electric signals: Seismic Electric Signals activities, "artificial" noises, and ionic currents fluctuations in membrane channels. Here, the natural domain analysis is applied to electrocardiograms by using a time-window of certain length sweeping through a fifteen minutes electrocardiogram and calculating the natural time entropy fluctuations. The method leads to the distinction (in advance) of healthy humans (H) from the (otherwise healthy) sudden cardiac death ones (SD). This is the leading cause of deaths worldwide, e.g., one death per almost 2 min in USA only (*1-3*). The paper also extends the analysis to distinguish SD from heart disease individuals in advance. The extension requires the combination of three kinds of complexity measures associated with the fluctuations δS of the entropy in the natural time-domain. These measures quantify the δS-variability upon: (i) varying the length of the time-window, (ii) changing the interval (RR, QRS, or QT), and (iii) "shuffling" (randomizing) the original data.

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1. INTRODUCTION

It is the aim of the present paper to propose a procedure, by means of which the sudden cardiac death risk can be identified in advance. The sudden cardiac deaths are a public health problem of major importance, killing millions of people worldwide annually (*1*), e.g., around 400,000 each year in the USA only (e.g., *2,3*). Up to one third of these individuals did not even know that they had heart disease. Many others may have known heart problems, but were not considered to be at risk of sudden death. The procedure proposed here, requires a new type of analysis of electrocardiograms, based upon the concept of the *natural time* suggested recently (*4-7*).

The entropy S in the natural time-domain, defined as (*4,7*) $S=\langle\chi\ln\chi\rangle - \langle\chi\rangle\ln\langle\chi\rangle$, where χ stands for the natural time (*4-5*), was found (*7*) to distinguish seismic electric signals (SES) activities from artificial noises (AN). More precisely, SES activities and AN have S values smaller and larger than that (S_u) of a "uniform" distribution, respectively (as the latter was defined in Refs. *4-7*). Furthermore, ion current fluctuations in membrane channels have S very close to S_u (*7*).

The entropy S enables the distinction of signals that look (in the conventional time) to be similar, but are emitted in reality from systems of different dynamics (*7*). This probably happens in the case when a nominally healthy individual suddenly suffers a cardiac arrest, although his/her electrocardiogram (ECG) looked to be similar to the normal one of healthy humans. Fig. 1A depicts, in the usual (conventional) time-domain, the recording of three consecutive heartbeats k, k+1, k+2 in an electrocardiogram (ECG, traditionally labeled with the letters P, Q, R, S and T on each of its turning points). The durations of the consecutive QT-intervals are marked with Q_k, Q_{k+1}, *and* Q_{k+2}. In Fig. 1B, we show how the QT-interval time-series can be read in natural time. The latter, in an electric signal consisting of N pulses, is introduced (*4, 5*) by ascribing to the k-th pulse the value $\chi_k=k/N$ and the analysis is then carried out in terms of the couple (χ_k, Q_k). Figures similar to Fig. 1B can be made for other intervals as well, e.g., the RR or QRS.

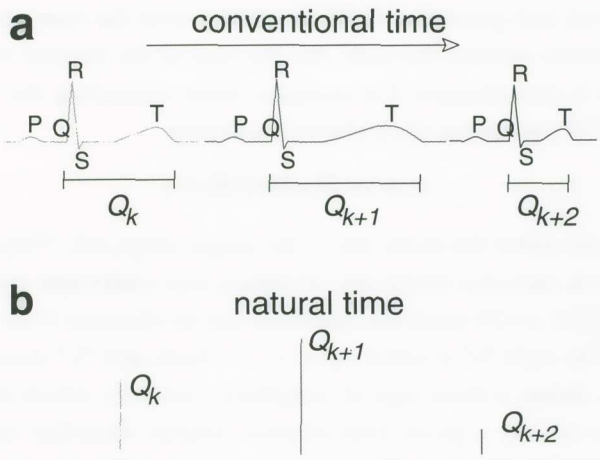

Fig. 1. (a) Schematic diagram (not in scale) of a three heartbeat excerpt of an ECG in the usual (conventional) time-domain. Only the durations Q_k, Q_{k+1}, Q_{k+2} of the QT-interval (marked in each single cycle of the ECG corresponding to one heartbeat) are shown. (b) The QT-interval time-series read in natural time; the vertical bars are *equally* spaced, but the length of each bar denotes the duration of the corresponding QT-interval marked in (A).

2. THE COMPLEXITY MEASURES

The extent, to which the entropy S fluctuates along an ECG, can be judged from its standard deviation δS, when calculating the S-value by means of a time-window of certain length, e.g., 5 beats, sweeping (each time by 1 beat) through the ECG (7,8). When this time-window length changes from a short value, e.g., 5 beats, to a shorter one, e.g., 3 beats, the corresponding δS-value also changes. This variation, in the short(s) scales, is quantified by the measure $\lambda_s \equiv \delta S_5/\delta S_3$ (where the subscript in δS denotes the time-window length chosen). If a longer (L) scale, e.g., 60 beats, changes to a short one, e.g., 3 beats, the corresponding variation is quantified by another measure $\lambda_L \equiv \delta S_{60}/\delta S_3$. Since these two measures, λ_s and λ_L, can be calculated for each type (τ) of interval, we define:

$$\lambda_s(\tau) \equiv \delta S_5(\tau)/\delta S_3(\tau) \quad (1) \qquad \text{and} \qquad \lambda_L(\tau) \equiv \delta S_{60}(\tau)/\delta S_3(\tau) \quad (2)$$

where τ=RR, QRS or QT.

Thus, we have in total six λ-values, each of which stands for a certain

type of interval and quantifies its δS-variability with the time-window length scale. If the latter remains the same, but the type of the interval changes, then the δS-value is also changed. For example, when comparing the RR-interval to QRS- or QT-, we define the (relative) measures:

$$\rho_s(\tau) \equiv \delta S_i(RR)/\delta S_i(\tau) \qquad (3)$$

where i denotes either the short, i=s, or the longer range, i=L. Thus, in total, we have four such measures (there are, of course, two additional measures when comparing QRS- to QT-intervals, but these can be obtained from the previous four ones). The scale "s" is taken equal to 3-4 beats and "L" around 60 beats.

We now define a third type of complexity measure, which (for a certain type of interval and a given time-window length) describes the δS-change upon randomizing the data. The latter means the following: instead of calculating the δS-value for the data corresponding to the heartbeats, as they occur consecutively in nature (i.e., as being recorded in ECG), we put them in *random order* (shuffling procedure indicated by the subscript, *shuf*) and repeat the calculation; we then find a new value designated by δS_{shuf}. The ratio $\delta S_{shuf}/\delta S$ (labeled with ν) gives a measure of the extent to which the *order* of the actual heartbeats regulates the δS-value. The calculation is usually carried out for a sequence of single (short or longer) windows (e.g., s=3, 4 beats, or 50 to 70 beats, respectively) and the average of the corresponding δS-values is designated by $\overline{\delta S}$. Thus, we study the two ratios $\nu_s(\tau)$ and $\nu_L(\tau)$, and hence (since τ=RR, QRS and QT) six ν-values, in total, result. Instead of the six ν-parameters, we can use the six λ_{shuf}-parameters (i.e., $\lambda_{s,\,shuf}(\tau)$, and $\lambda_{L,\,shuf}(\tau)$), where the latter are defined by Eqs. (1) and (2) applied to the randomized (shuffled) data. Note, however, that λ_{shuf} and ν refer to different aspects (though interconnected) of the heart dynamics.

In summary, in order to quantify the δS-variability of the RR-, QRS- and QT-intervals, we need 16 parameters, i.e., six for each of λ, ν (or λ_{shuf}) and four for ρ. Since all these parameters refer *only* to ratios of δS-values, we also include in the following investigation the δS-values themselves of one type of intervals. We preferred to use (*8*) those of the QT-interval (labeled δS(QT)), since prolonged values of the latter have been reported (e.g., *9,10* and references therein) to precede sudden cardiac death.

3. THE METHOD FOR THE DISTINCTION OF SD

The above 16 parameters (for either case, i.e., λ, ν, ρ or λ, λ_{shuf}, ρ), along with the $\delta S(QT)$-values, have been calculated for each one of 101 individuals, whose fifteen minutes excerpts of ECG were available in the so called QT Database (*11*). They belong to six groups of individuals. Four of them refer to patients (67 individuals in total) suffering from various heart diseases, i.e., 15 individuals from MIT-BIH Arrhythmia Database (labeled hereafter MIT), 13 from MIT-BIH Supraventricular Arrhythmia Database (MSV), 33 from the European ST-T Database (EST) and 6 from MIT-BIH ST change Database (MST), where BIH stands for the Beth Israel Hospital. The fifth group includes 10 healthy humans (H) and the sixth one 24 individuals who suffered sudden cardiac death (SD) (cf. the QT Database also contains a seventh group, which, however, consists only of a very small number, i.e., 4, individuals; thus, it was not considered in the present calculation). The detailed values of each of the parameters all 101 individuals are given in Tables I to III, where, for example, the values of λ, λ_{shuf}, ρ are presented (for reasons of brevity, in the Tables, the subscript *shuf* has been shortened to *sh*). The limits, i.e., the lowest (*min*) and the highest (*max*) value, found for every parameter, in each of the four groups of patients (thus intentionally leaving the 24 SD aside), along with the limits of H (labeled H_{min} and H_{max}, respectively), are summarized in Table IV (without parenthesis). For the determination of these limits, five out of 67 patients were disregarded, since they have been identified as "outliers" (because some of their parameters resulted in values that drastically differ from those in all the other individuals, see below). The appearance of such "outliers" is not surprising when using (as we did) an automatic threshold detector (*12, 13*) for the allocation of the intervals; this is so, because the allocation error becomes occasionally large, due to the fact that the morphology of the QRS, for example (e.g., *14*), is significantly distorted in some severely ill patients. Specifically, we omitted the five individuals: sel230, sel231, sele0612, sele0704 and sele0136 (i.e., two MIT and three EST). The first four resulted in ν_s(QRS)-values unusually larger than unity (cf. the values of all the other individuals scatter around unity) and the fifth one has a ρ_L(QRS)-value distinctly larger than the corresponding values of all the other patients. (cf. The omission, or not, of sele0136 does not alter our conclusions).

If we compare the parameters of each SD to the limits of H, we find that

a distinction between SD and H can be achieved by *any* of the following four procedures: (i) through δS(QT), (ii) by using both parameters λ, λ_{shuf}, (iii) using both λ, ρ, and (iv) through the ν-values. The first procedure uses the QT-intervals alone, the second one only the RR- and the other two procedures use, in principle, (but see the summary of the next paragraph), both the RR- and QRS-intervals. Details on each of these procedures will be shortly published elsewhere.

We now turn to the comparison of the parameters for each SD individual separately to the limits of both H and patients given in Table IV. Two facts emerge:

First, concerning the 16 parameters (λ, λ_{shuf}, ρ), twenty-two SD out of 24 (i.e., all SD except of the two: sel30 and sel34) violate some of the limits given in Table 1 of *both* the patients and the healthy (cf. if we alternatively use the 16 parameters λ, ρ, ν, we find that twenty SD out of 24 are distinguished). This points to the conclusion that they belong to a separate category of individuals, being neither patients nor healthy.

Second, concerning δS(QT), *all* SD have values that distinctly exceed those of H. (This is the basis of the procedure (i) mentioned above for the distinction between SD and H)

In other words, the aforementioned two facts reveal the following: The *ratios* of the δS-values (i.e., the measures λ, λ_{shuf}, ρ, or the measures λ, ρ, ν) are able to discriminate the vast majority of SD from all the others (i.e., healthy and patients), while the δS(QT)-values efficiently distinguish all SD from the healthy individuals. This motivates us to investigate whether a proper combination of these two facts can serve our purpose, which aims at identifying all SD among all the other individuals (patients and healthy). Thus, we now further proceed to the comparison of the parameters λ, λ_{shuf}, ρ (or λ, ρ, ν) of each SD to the corresponding parameters of only those among the patients that happen to have δS(QT)-values that exceed the corresponding values of H. The (new) limits of the latter patients are put in parenthesis in Table IV (whenever necessary, i.e., when they differ from the former limits written without parenthesis). The results of such a comparison are given in Table V and reveal that some of the 16 parameters λ, λ_{shuf}, ρ, of *all* SD lie outside the limits of these patients (cf. the same happens, of course, if we compare each SD to the limits of H). The same is found if we alternatively use the 16 parameters λ, ρ, ν.

The above results dictate the procedure to identify all 24 SD among 101 individuals. This can be summarized as follows: We first tabulate the limits of

the quantities λ, λ_{shuf}, ρ, (or λ, ρ, ν) and $\delta S(QT)$ for the H. Second, we tabulate the limits of the same quantities for those of the patients that happen to have $\delta S(QT)$-values larger than those in H. All these properties of H and patients become known, of course, in advance, since the precise study of such cases is always feasible. We can now identify all SD (that may exist in a given population), as being the individuals whom the parameters do not obey one or more of the known limits (determined in advance) of *both* H and patients.

The essence of the above procedure(s) is understandable in the following context: Since each of the aforementioned parameters focuses on certain "elements" of heart dynamics only, we naturally expect that in SD some of these "elements" (and hence their relevant parameters) should deviate from those in the patients and H.

4. THE INFLUENCE OF THE EXPERIMENTAL ERROR ON THE DISTINCTION OF SD

Beyond the error introduced by the use of an automatic threshold detector for the allocation of the corresponding intervals (cf. this is largest for the QT- and smallest for the RR-intervals), an estimation error emerges when analyzing -instead of the original time series of length $l \sim 10^3$- smaller lengths l', which, however, still significantly exceed the time-window lengths used, for example $l' \sim 2 \times 10^2$. The latter (percentage) estimation error was found to be around $\sim 10\%$ for the complexity measures λ, λ_{shuf}, ρ, ν associated with the RR- and QRS-intervals (cf. this is an *average* value; in general, the errors associated with the measures in the short range, s, are smaller from those corresponding to the longer range, L, because for the latter range the l/l'-values -due to the restricted length of the records available- are small, thus not allowing more reliable statistics). Furthermore, since the error in the dS(QT) may reach $\sim 20\%$, the estimation error in the complexity measures that involve dS(QT) may be as high as $\sim 30\%$. Upon considering such error-levels, labeled "plausible estimation errors" (ε_p) in Table VI, a study of each of the methods for the distinction of SD was made. The study was repeated by assuming larger (percentage) estimation errors, hereafter labeled "modified estimation errors" (ε_m), calculated from

$$\varepsilon_m = \varepsilon_p \left(1 + \frac{H_{\min} \quad H_{\max}}{H_{\min} + H_{\max}}\right)$$

for each parameter (see Table VI). *Both* studies led, however, more or less, to the *same* results. The calculation, in each study, was made as follows: Each parameter was assumed to be equal to its value (initially estimated from the original time-series available) multiplied by a number *randomly* selected in the range $1 \pm \varepsilon_p$ (or $1 \pm \varepsilon_m$, respectively) and then each of the methods for the distinction of SD was applied. This application was repeated for each method 10^3 times via Monte Carlo and relevant conclusions have been drawn for both studies. The extent to which these conclusions hold, was also investigated in the following *extreme* case: the limits of the parameters of H (and patients), which are automatically adjusted for each "random" selection of the values described above, have been assumed to *additionally* relax by (extra) amounts equal to ε_p or ε_m. (Such a "relaxation" faces the extreme possibility that the populations of H and patients treated here are not considered large enough to allow a precise determination of their limits, and hence future increased populations' studies could broaden these limits by amounts as large as $\pm \varepsilon_p$ or $\pm \varepsilon_m$). The following conclusions were finally drawn (see also Table VII):

(i) Concerning the distinction between SD and H: Among the four methods suggested, the one that uses the measures λ, ρ (associated, however, with *all* three types of intervals, i.e., 10 parameters in total) seems to be *robust* in the following sense: even when assuming error-levels as large as those mentioned above, the use of λ, ρ still allow (with a confidence level above 99%) the distinction of *all* SD from H. The confidence level decreases to 63%, 49% and 32% respectively, when using four parameters *only* as follows: First: λ_i(RR) and ρ_i(QRS); second: λ_i(RR) and $\lambda_{i,sfuf}$(RR); third: ν_i(RR) and ν_i(QRS). *If* we investigate the extreme case of the *additional relaxation* of the *H*-limits (possibly arisen from a future study of an increased population of H, as discussed above), the distinction of *all* SD still remains with the following results: In the case of using all 10 parameters of λ, ρ, the confidence level distinguishing *all* SD is ~ 88%; it increases to ~ 99% if we allow, at the most, one SD -out of 24- to be misinterpreted as being H. When using, however, four parameters *only* in the aforementioned three combinations, the confidence level decreases to 90%, 36% and 8% respectively, *even* when allowing, at the most, two (instead of one) SD -out of 24- to be misinterpreted as being H.

(ii) Concerning the distinction of SD from the patients: Upon considering the error-levels mentioned above, *either* method suggested, i.e., using λ, ν, ρ, δ $S_{3\text{-}4}$(QT) or λ, λ_{shuf}, ρ, δ $S_{3\text{-}4}$(QT), is found to likely lead to the distinction

of *all* SD from the patients (and H). This dictates the *robustness* of either method (in the range, of course, of the aforementioned error-levels). *If* we allow one, at the most, SD –out of 24- to be misinterpreted as patient, the confidence levels are ~83% and ~91% for the two methods, respectively. The investigation of the extreme case of the *additional* relaxation of the limits of both patients and H, led to the following result: When using the quantities λ, λ_{shuf}, ρ, ν, $\delta S_{3\text{-}4}(QT)$- and $\delta S_{shuf,3\text{-}4}(QT)$-values *altogether* (i.e., considering the limits of only those of the patients whom *both* $\delta S_{3\text{-}4}(QT)$- and $\delta S_{shuf,3\text{-}4}(QT)$ exceed the corresponding values of H-), we find that with a confidence level ~86% only five SD (out of 24), at the most, can be misinterpreted as patients.

In summary, the study of the estimation errors reveals that we can satisfactorily distinguish the *totality* of SD from H as well as discriminate the vast majority of SD from the heart disease patients, upon employing preferably the following methods: λ, ρ (of *all* intervals) for the former distinction, and λ, λ_{shuf}, ρ, ν, $\delta S_{3\text{-}4}(QT)$, $\delta S_{shuf,3\text{-}4}(QT)$ *altogether* for the latter one (i.e., the first and the last method in Table VII).

5. CONCLUSIONS

1. Four procedures can distinguish H from (otherwise healthy) SD.

2. We also propose a procedure, which has been proven to be successful for the identification of 24 SD among 101 individuals, where the latter include H and heart disease patients. The procedure has the privilege that it requires data which are certainly available for an appreciably larger number of cases (especially for patients, who during their stay at the hospital suffered sudden cardiac arrest). Hence, a wider check of the efficiency of the procedure proposed is shortly feasible.

Remark. In the aforementioned procedure(s), the twelve independent quantities, i.e., the six: $\delta S_i(\tau)$ and the six ones for the randomized data $\delta S_{i,shuf}(\tau)$, where i=s,L, are in reality extracted from the experimental data. Thus, beyond $\delta S_{3\text{-}4}(QT)$, eleven (out of 16) additional parameters of the ratios: λ, ρ, ν or λ, λ_{shuf}, ρ are in principle required. These, however, should *not* be fortuitously selected, i.e., (i) priority should be given to the eight parameters associated with λ-values and λ_{shuf}- (or ν-) values of RR and QRS, (ii) using, at least, one ρ-parameter (involving $\delta S_{3\text{-}4}(QT)$), and (iii) examining whether the totality of the parameters used can actually reproduce the twelve δS-values

determined from the data, as mentioned above. However, in order to avoid the difficulty arising from the completeness (or not) of the aforementioned selection, it was recommended above to use all the 16 parameters of either combination λ, ρ, ν or λ, λ_{shuf}, ρ.

The following point should also be stressed. There are several studies in the ECG literature clarifying the decisive role of the *age* of the subjects on the values of various parameters. For example, consider the heart rate variability (HRV): younger healthy individuals have significantly higher HRV than elderly ones (e.g., see N. Wessel et al., *Phys. Rev. Lett.* **91**, 119801-1, 2003 and references therein). As a second example, we refer to the observation that various complexity measures reveal increased randomness in the heartbeat time series with *physiological aging* (e.g., A.C.-C. Yang et. al., *Phys. Rev. Lett.* **90**, 108103-1, 2003 and references therein). Such an influence of the *age* on the *limits* of some of the parameters used in the present investigation, has been indeed observed (cf. details will be published elsewhere). Thus, when investigating whether an individual could be characterized as SD, the following care should be taken of: his/her parameters should be compared to the *limits* (of the parameters) obtained for H and patients of the *same* age category (e.g., young, middle aged, elders) and preferably determined separately for male and female.

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ΠΕΡΙΛΗΨΗ

Ἡ χρήση τῆς ἐντροπίας στὸν φυσικὸ χρόνο γιὰ τὴ διάκριση ἠλεκτρικῶν σημάτων

Σὲ προγενέστερη ἐργασία (P. Varotsos, N. Sarlis and E. Skordas, *Phys. Rev. E, 68*, 031106, 2003) ἡ ἐντροπία S ποὺ ὁρίζεται στὸν φυσικὸ χρόνο εὑρέθη ὅτι διαχωρίζει τὶς ἀκόλουθες τρεῖς κατηγορίες σημάτων: Σεισμικὰ ἠλεκτρικὰ σήματα, τεχνητοὺς θορύβους καὶ τὶς διακυμάνσεις τοῦ ἰοντικοῦ ρεύματος σὲ βιολογικὲς μεμβράνες. Στὴν παρούσα ἐργασία προτείνεται μία νέα μέθοδος ἀνάλυσης τῶν ἠλεκτροκαρδιογραφημάτων ποὺ χρησιμοποιεῖ τὶς διακυμάνσεις δS ὅταν ἡ ἐντροπία S ὑπολογίζεται μὲ ἕνα κινούμενο παράθυρο χρόνου ὁρισμένου μήκους ποὺ διατρέχει ἕνα ἠλεκτροκαρδιογράφημα διαρκείας 15 min. Ἀποδεικνύεται ὅτι ἡ μέθοδος αὐτὴ μπορεῖ νὰ διακρίνει ἐκ τῶν προτέρων ὑγιῆ ἄτομα ἀπὸ ἐκεῖνα ποὺ εἶναι φαινομενικῶς ὑγιῆ ἀλλὰ ὑφίστανται αἰφνίδιο καρδιακὸ θάνατο. Αὐτὴ εἶναι ἡ κύρια αἰτία θανάτων παγκοσμίως, π.χ., στὶς ΗΠΑ ἕνας τέτοιος θάνατος σημειώνεται κάθε περίπου 2 min (*1-3*). Ἡ μέθοδος ἐπεκτείνεται στὴν ἐκ τῶν προτέρων διάκριση τῶν ξαφνικῶς θνησκόντων (ἀπὸ καρδιακὴ συγκοπὴ) ἀτόμων μεταξὺ ἐκείνων ποὺ ὑποφέρουν ἀπὸ συνήθεις καρδιακὲς ἀσθένειες. Ἡ ἐπέκταση αὐτὴ ἀπαιτεῖ τὴν εἰσαγωγὴ καὶ τὸν συνδυασμὸ τριῶν «μέτρων πολυπλοκότητας» ποὺ ποσοτικοποιοῦν τὴν ἐξάρτηση τοῦ δS ἀπό: (1) τὴν μεταβολὴ τοῦ μήκους τοῦ κινουμένου παραθύρου, (2) τὴν ἀλλαγὴ τοῦ χρησιμοποιούμενου διαστήματος (RR, QRS, ἢ QT) καὶ (3) τὴν μεταβολὴ ποὺ προκύπτει ὅταν ἀνακατανεμηθοῦν οἱ παλμοὶ τῆς ἀρχικῆς χρονοσειρᾶς σὲ τυχαία θέση ("shuffling").

TABLE I: The measures λ, λ_{sh} and ρ in the short (s) range and in the longer (L) range in EST (sele0104 to sele0704) and MST (sel301 to sel 310) along with the $\overline{\delta S}_{3-4}(QT)$-values.

individual	RR		QRS		QT		RR		QRS		QT		RR over QRS		RR over QT		
	λ_s	λ_L	λ_s	λ_L	λ_s	λ_L	$\lambda_{s,sh}$	$\lambda_{L,sh}$	$\lambda_{s,sh}$	$\lambda_{L,sh}$	$\lambda_{s,sh}$	$\lambda_{L,sh}$	ρ_s	ρ_L	ρ_s	ρ_L	$\overline{\delta S}_{3-4}(QT) \times 10^{-3}$
sele0104	0.99[a]	0.80[a]	1.23	0.51	1.27	0.43[a]	1.12	0.57	1.37	0.55	1.21	0.55	1.27	2.01	1.12	2.10	1.54[b]
sele0106	1.18[a]	2.46	1.23	0.49	1.10[a]	0.94	1.13	0.51	1.21	0.56	1.28	0.57	0.45	2.28	1.34	3.49	0.42
sele0107	1.45	2.67	1.15[a]	0.42[a]	1.27	0.72	1.13	0.53	1.27	0.51	1.25	0.67	0.34	2.18	0.32[a]	1.21[a]	1.83[b]
sele0110	1.84	2.82[b]	1.23	0.83[b]	1.23	0.66	1.24	0.54	1.30	0.70	1.56[b]	0.70	0.46	1.56	0.81	3.45	0.89[b]
sele0111	*1.67*	*6.66*[b]	*1.16*	*0.56*	*1.09*[a]	*0.66*	*1.06*	*0.47*[a]	*1.24*	*0.55*	*1.19*	*0.53*	*0.09*[a]	*1.13*	*0.51*[a]	*5.12*	*0.71*[b]
sele0112	1.42[a]	2.74[b]	1.22	0.71[b]	1.31	1.00	1.21	0.58[b]	1.33	0.58	1.15	0.55	0.74	2.86	2.87	7.86	0.33
sele0114	1.45	0.83[a]	1.12[a]	0.56	1.36	1.73[b]	1.13	0.51	1.22	0.54	1.16	0.52	1.39	2.08	4.63	2.22	0.90[b]
sele0116	0.94[a]	0.84[a]	0.99[a]	0.50	1.19	1.67[b]	1.23	0.53	1.19	0.54	1.18	0.55	1.54	2.61	2.03	1.03[a]	5.75[b]
sele0121	1.54	1.92	1.42[b]	1.63[b]	1.71[b]	1.91[b]	1.13	0.53	1.47[b]	0.96[b]	1.32	0.63	0.34	0.40	1.35	1.36[a]	0.40
sele0122	*1.55*	*4.69*[b]	*1.31*[b]	*0.82*[b]	*1.10*[a]	*1.25*[b]	*1.20*	*0.52*	*1.10*	*0.55*	*1.34*[b]	*0.55*	*0.27*	*1.55*	*0.51*[a]	*1.94*	*0.35*
sele0124	1.32[a]	1.84	1.48[b]	0.56	1.22	0.65	1.03[a]	0.46[a]	1.26	0.59	1.29	0.53	0.20	0.67	0.70	1.97	0.80[b]
sele0126	1.12[a]	1.13	1.25	0.64[b]	1.14[a]	0.48[a]	1.17	0.50	1.21	0.61	1.15	0.51	0.09[a]	0.15[a]	0.43[a]	1.01[a]	0.85[b]
sele0129	1.39[a]	2.59	1.22	0.98[b]	1.22	1.03	1.15	0.56	1.17	0.55	1.25	0.54	0.99	2.64	3.54	8.93	0.33
sele0133	1.26[a]	1.22	1.20	0.82[b]	1.41	1.17[b]	1.14	0.43[a]	1.13	0.51	1.16	0.50	0.82	1.22	5.07	5.29	0.20[a]
sele0136	*1.77*	*2.25*	*1.25*	*0.57*	*1.09*[a]	*1.04*	*1.09*	*0.48*	*1.15*	*0.50*	*1.18*	*0.54*	*1.92*[b]	*7.52*[b]	*1.01*	*2.17*	*1.29*[b]
sele0166	1.86	5.07[b]	1.30[b]	0.86[b]	1.14[a]	0.69	1.16	0.48	1.25	0.55	1.26	0.55	0.21	1.22	0.58[a]	4.31	0.81[b]
sele0170	1.54	3.07[b]	1.15[a]	0.71[b]	1.18	0.88	1.24	0.53	1.31	0.63	1.16	0.51	0.31	1.34	1.25	4.36	0.37
sele0203	1.16[a]	0.95[a]	1.29	0.64[b]	1.24	1.06	1.19	0.58[b]	1.23	0.58	1.23	0.60	0.45	0.68	0.56[a]	0.51[a]	2.89[b]
sele0210	2.33[b]	3.00[b]	1.39[b]	0.74[b]	1.19	0.49[a]	1.24	0.55	1.43	0.77[b]	1.10[a]	0.49	0.12[a]	0.49	0.61[a]	3.76	0.79[b]
sele0211	*1.20*[a]	*3.20*[b]	*1.29*	*0.67*[b]	*1.23*	*0.53*	*1.15*	*0.51*	*1.36*	*0.70*	*1.30*	*0.56*	*0.03*[a]	*0.13*[a]	*0.19*[a]	*1.18*[a]	*0.64*[b]
sele0303	0.95[a]	0.73[a]	1.17	0.54	1.15[a]	0.48[a]	1.00[a]	0.48	1.17	0.55	1.19	0.53	0.67	0.90	0.53[a]	0.80[a]	1.13[b]
sele0405	2.08[b]	5.60[b]	1.24	0.65[b]	1.19	0.73	1.24	0.56	1.11	0.54	1.18	0.52	0.14[a]	1.21	0.50[a]	3.82	0.91[b]
sele0406	1.50	2.61	1.11[a]	0.72[b]	1.11[a]	0.66	1.26	0.56	1.15	0.55	1.18	0.54	0.29	1.06	0.94	3.75	0.56[b]
sele0409	1.25[a]	3.21[b]	1.38[b]	0.80[b]	1.17	0.56	1.17	0.54	1.27	0.75[b]	1.12	0.52	0.04[a]	0.15[a]	0.15[a]	0.84[a]	1.44[b]
sele0411	*0.99*[a]	*0.61*[a]	*1.26*	*0.60*	*1.25*	*0.72*	*1.21*	*0.56*	*1.36*	*0.68*	*1.24*	*0.55*	*0.76*	*0.78*	*3.37*	*2.86*	*1.03*[b]
sele0509	0.79[a]	0.48[a]	1.24	0.85[b]	1.54[b]	1.16[b]	1.01[a]	0.45[a]	1.25	0.69	1.19	0.53	0.91	0.52	10.04[b]	4.19	0.38
sele0603	1.66	2.85[b]	1.14[a]	0.89[b]	1.58[b]	2.82[b]	1.17	0.57	1.27	0.59	1.30	0.60	0.71	2.29	3.35	3.38	0.27
sele0604	1.70	3.37[b]	1.34[b]	0.88[b]	1.34	1.01	1.18	0.53	1.28	0.70	1.20	0.55	0.07[a]	0.26[a]	0.33[a]	1.11[a]	1.57[b]
sele0606	1.17[a]	1.41	1.18	0.90[b]	1.28	0.73	1.18	0.54	1.27	0.67	1.27	0.56	0.64	1.00	1.73	3.31	0.58[b]
sele0607	*1.09*[a]	*2.41*	*1.15*[a]	*0.69*[b]	*1.03*[a]	*1.00*	*1.20*	*0.50*	*1.15*	*0.52*	*1.15*	*0.54*	*0.32*	*1.11*	*0.99*	*2.38*	*0.50*
sele0609	1.00[a]	1.57	1.38[b]	0.86[b]	1.23	0.82	1.26	0.55	1.19	0.68	1.23	0.52	0.71	1.29	1.15	2.21	1.05[b]
sele0612	1.60	5.76[b]	1.25	2.29[b]	1.12[a]	1.63[b]	1.29[b]	0.54	1.25	0.56	1.33[b]	0.58	0.08[a]	0.21[a]	0.23[a]	0.83[a]	1.12[b]
sele0704	0.97[a]	1.95	1.33[b]	1.26[b]	1.30	1.50[b]	1.25	0.54	1.19	0.54	1.39[b]	0.60	0.60	0.92	0.98	1.28[a]	1.21[b]
min[c]	0.79	0.48	0.99	0.42	1.03	0.43	1.00	0.43	1.10	0.50	1.10	0.49	0.03	0.13	0.15	0.51	0.20
	0.79	0.48	0.99	0.42	1.03	0.43	1.00	0.43	1.10	0.51	1.10	0.49	0.03	0.13	0.15	0.51	0.20
max[c]	2.33	6.66	1.48	2.29	1.71	2.82	1.29	0.58	1.47	0.96	1.56	0.70	1.92	7.52	10.04	8.93	5.75
	2.33	6.66	1.48	1.63	1.71	2.82	1.26	0.58	1.47	0.96	1.56	0.70	1.54	2.86	10.04	8.93	5.75
sel301	1.01[a]	1.39	1.20	0.58	1.38	1.36[b]	1.21	0.56	1.10	0.51	1.24	0.57	0.52	1.25	1.09	1.11[a]	0.75[b]
sel302	1.42[a]	2.68	1.22	0.63[b]	1.19	0.69	1.20	0.51	1.31	0.66	1.17	0.52	0.20	0.86	0.53[a]	2.07	0.66[b]
sel306	1.72	3.75[b]	1.29	0.68[b]	1.28	1.43[b]	1.18	0.50	1.22	0.55	1.28	0.53	0.37	2.04	2.43	6.38	0.29
sel307	1.54	1.90	1.30[b]	0.71[b]	1.18	1.09	1.11	0.52	1.17	0.50	1.18	0.54	0.99	2.62	4.98	8.70	0.22[a]
sel308	1.01[a]	0.45[a]	1.28	0.70[b]	1.18	0.67	1.16	0.51	1.43	0.69	1.22	0.52	0.96	0.61	1.97	1.32[a]	1.33[b]
sel310	1.38[a]	2.17	1.28	0.70[b]	1.28	0.84	1.17	0.52	1.31	0.62	1.19	0.53	0.17[a]	0.51	0.57[a]	1.47[a]	0.63[b]
min	1.01	0.45	1.20	0.58	1.18	0.67	1.11	0.50	1.10	0.50	1.17	0.52	0.17	0.51	0.53	1.11	0.22
max	1.72	3.75	1.30	0.71	1.38	1.43	1.21	0.56	1.43	0.69	1.28	0.57	*0.99*	*2.62*	*4.98*	*8.70*	*1.33*

[a]These values are smaller than the H_{min} which corresponds to each column

[b]These values are larger than the H_{max} which corresponds to each column

[c]Two values are given in each column: The upper is obtained when considering all the patients, while the lower when omitting sele0136, sele0612 and sele0704 (see the text)

TABLE II: The measures λ, λ_{sh} and ρ in the short (s) range and in the longer (L) range in MIT (sel100 to sel233) and MSV (sel803 to sel 891) along with the $\overline{\delta S}_{3-4}(QT)$-values.

individual	RR		QRS		QT		RR		QRS		QT		RR over QRS		RR over QT		
	λ_s	λ_L	λ_s	λ_L	λ_s	λ_L	$\lambda_{s,sh}$	$\lambda_{L,sh}$	$\lambda_{s,sh}$	$\lambda_{L,sh}$	$\lambda_{s,sh}$	$\lambda_{L,sh}$	ρ_s	ρ_L	ρ_s	ρ_L	$\overline{\delta S}_{3-4}(QT) \times 10^3$
sel100	1.13^a	0.68^a	1.39^b	0.62^b	1.04^a	0.33^a	1.25	0.51	1.15	0.55	1.21	0.47^a	0.57	0.62	0.45^a	0.91^a	3.39^b
sel102	1.35^a	0.49^a	1.25	0.63^b	1.62^b	0.96	1.04	0.37^a	1.16	0.51	1.13	0.49	1.10	0.85	1.71	0.88^a	0.90^b
sel103	1.96	1.74	1.31^b	0.63^b	1.77^b	0.55	1.15	0.49	1.16	0.51	1.22	0.53	0.21	0.58	0.86	2.70	0.80^b
sel104	1.26^a	0.31^a	1.63^b	0.46^a	1.10^a	0.44^a	1.20	0.56	1.15	0.47	0.89^a	0.37^a	0.48	0.33^a	0.67	0.48^a	3.71^b
sel114	0.98^a	0.38^a	1.26	0.63^b	1.24	0.46^a	1.08	0.46^a	1.32	0.71	1.24	0.55	1.08	0.65	2.07	1.69^a	2.00^b
sel116	0.95^a	0.24^a	1.35^b	0.71^b	1.39	0.61	1.07	0.48	1.46^b	0.75^b	1.08^a	0.50	0.88	0.29^a	4.20	1.62^a	0.95^b
sel117	0.80^a	0.75^a	1.07^a	0.53	1.11^a	0.52	0.92^a	0.44^a	1.14	0.50	1.16	0.54	0.29	0.42	1.09	1.58^a	0.79^b
sel123	1.40^a	1.29	1.16	0.52	1.21	0.59	1.17	0.61^b	1.26	0.57	1.06^a	0.54	0.68	1.67	1.92	4.20	0.92^b
sel213	1.01^a	0.17^a	1.17	0.63^b	1.15^a	0.46^a	1.14	0.48	1.37	0.70	1.20	0.53	0.33	0.09^a	1.69	0.62^a	0.80^b
sel221	1.08^a	0.37^a	1.47^b	0.50	1.19	0.53	1.16	0.55	1.33	0.73	1.09^a	0.48^a	0.82	0.61	3.40	2.36	2.18^b
sel223	0.82^a	0.26^a	0.99^a	0.61	0.99^a	0.41^a	1.18	0.50	1.25	0.59	1.14	0.53	1.33	0.56	2.04	1.28^a	2.68^b
sel230	1.86	3.17^b	1.54^b	1.75^b	1.39	1.18^b	1.08	0.47^a	1.29	0.59	1.16	0.54	0.22	0.39^a	0.60^a	1.62^a	1.17^b
sel231	1.32^a	3.19^b	1.24	2.24^b	1.21	2.80^b	1.23	0.57	1.14	0.47	1.25	0.54	0.60	0.86	1.02	1.16^a	1.78^b
sel232	1.57	0.95^a	1.19	0.56	1.19	0.51	1.34^b	0.92^b	1.13	0.51	1.16	0.47^a	2.04^b	3.45	5.96^b	11.03^b	1.50^b
sel233	0.92^a	0.18^a	1.24	0.50	1.22	0.68	1.24	0.55	1.30	0.65	1.26	0.57	0.76	0.27^a	2.67	0.71^a	2.71^b
min^c	0.80	0.17	0.99	0.46	0.99	0.33	0.92	0.37	1.13	0.47	0.89	0.37	0.21	0.09	0.45	0.48	0.79
	0.80	0.17	0.99	0.46	0.99	0.33	0.92	0.37	1.13	0.47	0.89	0.37	0.21	0.09	0.45	0.48	0.79
max^c	1.96	3.19	1.63	2.24	1.77	2.80	1.34	0.92	1.46	0.75	1.26	0.57	2.04	3.45	5.96	11.03	3.71
	1.96	1.74	1.63	0.71	1.77	0.96	1.34	0.92	1.46	0.75	1.26	0.57	2.04	3.45	5.96	11.03	3.71
sel803	0.92^a	0.55^a	1.36^b	0.61	1.30	0.70	1.13	0.51	1.37	0.80^b	1.16	0.54	0.89	0.80	6.70^b	5.35	0.65^b
sel808	0.99^a	1.87	1.19	1.06^b	1.32	0.64	1.18	0.53	1.24	0.67	0.85^a	0.48^a	0.41	0.72	1.41	4.11	0.63^b
sel811	1.09^a	0.64^a	1.20	0.47^a	1.16	0.53	0.96^a	0.48	1.18	0.52	1.22	0.52	0.79	1.07	3.88	4.66	0.45
sel820	0.96^a	0.17^a	1.22	0.67^b	1.14^a	0.53	1.19	0.45^a	1.29	0.69	1.17	0.55	2.81^b	0.73	0.87	0.29^a	4.59^b
sel821	1.05^a	0.16^a	1.36^b	0.63^b	1.16	0.50	1.16	0.51	1.28	0.65	1.14	0.54	1.50	0.38^a	3.38	1.09^a	1.17^b
sel840	1.22^a	1.51	1.23	0.61	1.16	0.74	1.16	0.53	1.32	0.60	1.23	0.56	0.52	1.29	1.87	3.84	0.61^b
sel847	0.85^a	0.32^a	1.12^a	0.53	1.16	0.56	1.09	0.48	1.15	0.54	1.10^a	0.60	0.93	0.56	6.76^b	3.82	0.61^b
sel853	0.92^a	0.18^a	1.27	0.72^b	1.24	0.56	1.05	0.51	1.24	0.73	0.99^a	0.48^a	1.56	0.38^a	2.87	0.91^a	1.24^b
sel871	0.95^a	1.27	1.27	0.69^b	1.20	0.74	1.22	0.54	1.27	0.54	1.06^a	0.43^a	1.01	1.85	1.87	3.18	1.12^b
sel872	0.97^a	0.55^a	1.32^b	0.58	1.24	0.53	1.15	0.48	1.16	0.69	1.21	0.55	0.91	0.86	4.63	4.78	0.63^b
sel873	1.02^a	0.90^a	1.20	0.54	1.26	0.53	1.24	0.52	1.20	0.52	1.22	0.49	0.24	0.40	1.04	1.78^a	0.89^b
sel883	0.98^a	0.36^a	1.09^a	0.47^a	1.18	0.60	1.22	0.50	1.17	0.49	1.10^a	0.47^a	0.70	0.54	2.78	1.68^a	0.96^b
sel891	0.92^a	0.23^a	1.16	0.56	1.10^a	0.56	1.15	0.53	1.16	0.52	1.22	0.51	2.02^b	0.82	3.74	1.52^a	1.17^b
min	0.85	0.16	1.09	0.47	1.10	0.50	0.96	0.45	1.15	0.49	0.85	0.43	0.24	0.38	0.87	0.29	0.45
max	1.22	1.87	1.36	1.06	1.32	0.74	1.24	0.54	1.37	0.80	1.23	0.60	2.81	1.85	6.76	5.35	4.59

[a]These values are smaller than the H_{min} which corresponds to each column

[b]These values are larger than the H_{max} which corresponds to each column

[c]Two values are given in each column: The upper is obtained when considering all the patients, while the lower when omitting sel230 and sel231 (see the text)

TABLE III: The measures λ, λ_{sh} and ρ in the short (s) range and in the longer (L) range in H (sel16265 to sel17453) and SD (sel30 to sel17152) along with the $\overline{\delta S}_{3-4}(QT)$-values.

individual	RR		QRS		QT		RR		QRS		QT		RR over QRS		RR over QT		
	λ_s	λ_L	λ_s	λ_L	λ_s	λ_L	$\lambda_{s,sh}$	$\lambda_{L,sh}$	$\lambda_{s,sh}$	$\lambda_{L,sh}$	$\lambda_{s,sh}$	$\lambda_{L,sh}$	ρ_s	ρ_L	ρ_s	ρ_L	$\overline{\delta S}_{3-4}(QT) \times 10^3$
sel16265	1.72	2.38	1.19	0.52	1.27	0.88	1.09	0.51	1.17	0.51	1.12	0.49	0.88	4.01	2.44	6.62	0.38
sel16272	1.69	1.35	1.29	0.61	1.21	0.50	1.27	0.57	1.44	0.73	1.32	0.57	0.18	0.40	0.67	1.79	0.48
sel16273	1.61	2.69	1.16	0.59	1.30	1.11	1.19	0.53	1.16	0.52	1.16	0.53	1.11	5.05	3.17	7.65	0.24
sel16420	1.51	1.74	1.22	0.48	1.37	0.66	1.04	0.48	1.19	0.54	1.17	0.52	0.96	3.46	1.97	5.21	0.36
sel16483	1.43	2.37	1.23	0.49	1.31	0.68	1.24	0.55	1.29	0.58	1.15	0.53	0.25	1.22	0.96	3.37	0.35
sel16539	2.00	1.94	1.26	0.50	1.41	1.08	1.21	0.55	1.19	0.52	1.16	0.54	1.85	7.10	5.57	10.04	0.52
sel16773	1.92	2.61	1.21	0.49	1.31	0.70	1.17	0.51	1.10	0.46	1.22	0.70	0.90	4.84	1.49	5.54	0.55
sel16786	1.71	1.57	1.19	0.51	1.31	0.84	1.16	0.55	1.14	0.50	1.16	0.52	1.16	3.56	3.97	7.43	0.22
sel16795	1.77	0.99	1.24	0.55	1.16	0.56	1.19	0.57	1.21	0.54	1.17	0.53	0.77	1.37	2.87	5.08	0.56
sel17453	1.87	1.67	1.26	0.54	1.22	0.68	1.18	0.52	1.14	0.51	1.24	0.56	1.49	4.59	2.91	7.12	0.34
H_{min}	1.43	0.99	1.16	0.48	1.16	0.50	1.04	0.48	1.10	0.46	1.12	0.49	0.18	0.40	0.67	1.79	0.22
H_{max}	2.00	2.69	1.29	0.61	1.41	1.11	1.27	0.57	1.44	0.73	1.32	0.70	1.85	7.10	5.57	10.04	0.56
sel30	1.11[a]	0.89[a]	1.20	1.05[b]	1.28	0.56	1.22	0.57	1.40	0.76[b]	1.20	0.53	0.51	0.43	1.73	2.73	1.04[b]
sel31	0.96[a]	0.34[a]	1.39[b]	0.89[b]	1.30	0.84	1.16	0.53	1.43	0.89[b]	1.00[a]	0.43[a]	1.10	0.42	0.80	0.32[a]	3.01[b]
sel32	0.96[a]	0.67[a]	1.26	0.96[b]	1.16	0.65	1.43[b]	0.60[b]	1.19	0.59	1.11[a]	0.53	0.23	0.16[a]	0.63[a]	0.64[a]	1.14[b]
sel33	1.14[a]	0.77[a]	0.96[a]	0.52	1.21	0.53	1.25	0.63[b]	1.16	0.49	1.14	0.51	0.79	1.17	2.41	3.50	0.76[b]
sel34	1.87	3.04[b]	1.33[b]	1.22[b]	1.15[a]	0.85	1.18	0.51	1.32	0.91[b]	1.14	0.50	0.40	1.00	1.16	4.12	0.69[b]
sel35	1.12[a]	0.52[a]	1.24	0.66[b]	1.12[a]	0.44[a]	1.20	0.55	1.13	0.70	1.21	0.50	1.72	1.36	0.83	0.99[a]	6.45[b]
sel36	1.31[a]	0.62[a]	1.12[a]	0.51	1.26	0.60	1.21	0.57	1.13	0.47	1.00[a]	0.46[a]	2.35[b]	2.88	1.45	1.52[a]	2.08[b]
sel37	0.92[a]	0.71[a]	1.26	0.87[b]	1.11[a]	0.78	0.98[a]	0.41[a]	1.13	0.53	1.14	0.47[a]	0.71	0.58	1.19	1.07[a]	3.30[b]
sel38	0.91[a]	0.34[a]	1.27	0.65[b]	1.03[a]	0.50	0.94[a]	0.44[a]	1.20	0.53	1.17	0.52	0.65	0.34[a]	0.37[a]	0.25[a]	2.71[b]
sel39	0.81[a]	0.11[a]	1.23	0.72[b]	1.17	0.58	1.15	0.51	1.35	0.73	1.15	0.50	0.80	0.12[a]	1.53	0.28[a]	2.44[b]
sel40	1.66	0.81[a]	1.14[a]	0.55	1.19	0.43[a]	1.09	0.49	1.22	0.51	1.18	0.61	0.12[a]	0.18[a]	0.20[a]	0.38[a]	3.43[b]
sel41	1.14[a]	0.48[a]	1.18	0.70[b]	1.22	0.56	1.67[b]	0.69[b]	1.27	0.55	1.09[a]	0.51	0.21	0.15[a]	0.80	0.68[a]	1.53[b]
sel42	1.10[a]	1.81	1.16	0.51	1.31	1.01	1.06	0.51	1.12	0.51	1.13	0.50	0.95	3.40	1.62	2.89	0.95[b]
sel43	1.69	3.04[b]	1.24	0.77[b]	1.26	0.68	1.28[b]	0.54	1.17	0.52	1.19	0.55	0.06[a]	0.23[a]	0.11[a]	0.48[a]	2.23[b]
sel44	1.18[a]	0.18[a]	1.52[b]	0.43[a]	1.02[a]	0.34[a]	1.20	0.52	1.25	0.66	1.17	0.51	0.59	0.25[a]	1.08	0.58[a]	4.12[b]
sel45	0.92[a]	0.42[a]	1.16	0.73[b]	1.37	0.68	1.10	0.47[a]	1.50[b]	0.67	1.03[a]	0.39[a]	1.46	0.85	1.14	0.71[a]	1.71[b]
sel46	0.94[a]	0.43[a]	1.05[a]	0.71[b]	1.12[a]	0.55	1.08	0.45[a]	1.27	0.63	1.29	0.56	1.35	0.82	1.59	1.26[a]	3.44[b]
sel47	1.54	2.07	1.19	0.54	1.36	0.57	1.00[a]	0.50	1.13	0.53	1.28	0.60	0.16[a]	0.63	0.14[a]	0.49[a]	2.85[b]
sel48	0.84[a]	0.30[a]	1.23	1.08[b]	1.14[a]	1.00	1.16	0.51	1.14	0.56	1.34[b]	0.51	0.91	0.26[a]	1.36	0.41[a]	1.75[b]
sel49	0.93[a]	0.33[a]	1.17	0.83[b]	1.16	0.50	1.19	0.48	1.15	0.55	1.32	0.60	1.27	0.50	1.08	0.71[a]	3.96[b]
sel50	1.32[a]	0.59[a]	1.28	0.46[a]	1.21	0.32[a]	1.26	0.52	1.15	0.58	1.43[b]	0.73[b]	1.78	2.31	1.21	2.26	5.21[b]
sel51	1.83	0.72[a]	1.14[a]	0.42[a]	1.24	0.66	1.17	0.52	1.23	0.48	1.19	0.51	0.16[a]	0.27[a]	0.30[a]	0.33[a]	1.83[b]
sel52	1.40[a]	0.73[a]	1.32[b]	1.02[b]	1.29	1.01	0.89[a]	0.44[a]	1.29	0.63	1.18	0.58	0.14[a]	0.10[a]	0.42[a]	0.31[a]	1.66[b]
sel17152	1.06[a]	0.93[a]	1.31[b]	0.58	1.13[a]	0.54	1.25	0.55	1.20	0.55	1.16	0.52	0.06[a]	0.10[a]	0.23[a]	0.40[a]	1.15[b]
min	0.81	0.11	0.96	0.42	1.02	0.32	0.89	0.41	1.12	0.47	1.00	0.39	0.06	0.10	0.11	0.25	0.69
max	1.87	3.04	1.52	1.22	1.37	1.01	1.67	0.69	1.50	0.91	1.43	0.73	2.35	3.40	2.41	4.12	6.45

[a]These values are smaller than the H_{min} given in each column
[b]These values are larger than the H_{max} given in each column

TABLE IV: The limits of the complexity measures in H and in four groups (MIT, MSV, EST, MST) of heart disease patients. The limits which change when considering only the patients who have $\delta S(QT)$ values larger than those in H, are put in parenthesis.

parameter	H		MIT		MSV		EST		MST	
	min	max	min	max	min	max	min	max	min	max
$\lambda_s(RR)$	1.43	2.00	0.80	1.96	0.85	1.22	0.79(0.94)	2.33	1.01	1.72(1.42)
$\lambda_L(RR)$	0.99	2.69	0.17	1.74	0.16	1.87	0.48(0.61)	6.66	0.45	3.75(2.68)
$\lambda_s(QRS)$	1.16	1.29	0.99	1.63	1.09	1.36	0.99	1.48	1.20	1.30(1.28)
$\lambda_L(QRS)$	0.48	0.61	0.46	0.71	0.47	1.06	0.42	1.63(0.90)	0.58	0.71(0.70)
$\lambda_s(QT)$	1.16	1.41	0.99	1.77	1.10	1.32	1.03(1.09)	1.71(1.36)	1.18	1.38
$\lambda_L(QT)$	0.50	1.11	0.33	0.96	0.50	0.74	0.43	2.82(1.73)	0.67	1.43(1.36)
$\lambda_{s,sh}(RR)$	1.04	1.27	0.92	1.34	0.96(1.05)	1.24	1.00	1.26	1.11(1.16)	1.21
$\lambda_{L,sh}(RR)$	0.48	0.57	0.37	0.92	0.45	0.54	0.43(0.46)	0.58	0.50(0.51)	0.56
$\lambda_{s,sh}(QRS)$	1.10	1.44	1.13	1.46	1.15	1.37	1.10(1.11)	1.47(1.43)	1.10	1.43
$\lambda_{L,sh}(QRS)$	0.46	0.73	0.47	0.75	0.49	0.80	0.51	0.96(0.77)	0.50(0.51)	0.69
$\lambda_{s,sh}(QT)$	1.12	1.32	0.89	1.26	0.85	1.23	1.10	1.56	1.17	1.28(1.24)
$\lambda_{L,sh}(QT)18$	0.49	0.70	0.37	0.57	0.43	0.60	0.49	0.70	0.52	0.57
$\rho_s(QRS)$	0.18	1.85	0.21	2.04	0.24	2.81	0.03	1.54	0.17	0.99(0.96)
$\rho_L(QRS)$	0.40	7.10	0.09	3.45	0.38	1.85	0.13	2.86(2.61)	0.51	2.62(1.25)
$\rho_s(QT)$	0.67	5.57	0.45	5.96	0.87	6.76	0.15	10.04(4.63)	0.53	4.98(1.97)
$\rho_L(QT)$	1.79	10.04	0.48	11.03	0.29	5.35	0.51	8.93(5.12)	1.11	8.70(2.07)
$\overline{\delta S}_{3-4}(QT) \times 10^{-3}$	0.23	0.56	0.79	3.71	0.45(0.61)	4.59	0.20(0.56)	5.75	0.22(0.63)	1.33

TABLE V: The precise limits of the complexity measures λ, λ_{sh}, ρ and $\delta S_{3-4}(QT)$ which are violated by each one of the 24 SD.

individual	λ_s	λ_L	λ_s	λ_L	λ_s	λ_L	$\lambda_{s,sh}$	$\lambda_{L,sh}$	$\lambda_{s,sh}$	$\lambda_{L,sh}$	$\lambda_{s,sh}$	$\lambda_{L,sh}$	ρ_s	ρ_L	ρ_s	ρ_L	$\delta S_{3-4}(QT)$
sel30	a	a		abce		c	c	cd	d	abc				c		c	a
sel31	ac	ace	acd	abc		d			d	abcde	ace	ace	c	c	d	abce	ac
sel32	ac	a		abce	c	c	abcde	acde			ac		d	acd	ad	ac	a
sel33	a	a	abcde	c		c	cd	acde		ce	c	c			c	c	ab
sel34	cd	abcd	ac	abcde	ac	d				abcde	c	c				c	ab
sel35	a	ae		a	ac	acd		d	d	c		c	ce	c	d	ac	abcde
sel36	ad	a	ac	c		c		cd	d	cde	ace	ace	abce	cde		a	ac
sel37	ace	a		abc	ac	d	acde	acde	d		c	ace				ac	ac
sel38	ace	ace		a	acde	c	acde	acde						acd	abcd	abcde	ac
sel39	acde	abcde		abc	c	c	c			c	c	c		acde		abcde	ac
sel40	cd	a	ac	c		acd	c	c				bcd	abcd	acd	abcd	abce	ac
sel41	a	ae	c	a		c	abcde	acde			ace	c	d	acd	d	ac	ac
sel42	a	b	c	c		bd	c		bd		c	c		cde		c	a
sel43	cd	abcd		abc			acde						abcd	acd	abcde	ace	ac
sel44	a	ace	acde	abcd	acde	acde						c		acd		ac	abc
sel45	ace	ace	c	abc	de		c	ac	abcde		ace	acde	c			ac	ac
sel46	ac	ace	acd	ac	ac	c	c	ace			bcd		c			a	ac
sel47	cd	bd	c	c	d	c	acd	c	d		bcd	bc	abcd		abcde	ace	ac
sel48	acde	ace		abcde	ac	bd			d		abcd	c		acd		abce	ac
sel49	ace	ace	c	abc	c	c		c			bcd	bc	c	c		ac	abc
sel50	ad	ae		acd		abcde	cd				abcd	abcde	ce	cd		c	abcd
sel51	cd	a	ac	abcd		c				cde		c	abcd	acd	abcd	abce	ac
sel52	ad	a	ac	abce		bd	abcde	acde				bc	abcd	acde	abcd	abce	ac
sel17152	a	a	ac		ac	c	cd	d			c		abcd	acde	abcd	abce	a

Where a, b, c, d, e denote the cases where the limits of H, MIT, MST, MSV, EST are violated, respectively.

TABLE VI: The percentage errors of the various parameters investigated

parameter	plausible estimation error (ϵ_p, %)	modified estimation error (ϵ_m, %)
$\lambda_s(RR)$	10.00	11.66
$\lambda_L(RR)$	10.00	14.62
$\lambda_s(QRS)$	10.00	10.53
$\lambda_L(QRS)$	10.00	11.19
$\lambda_s(QT)$	30.00	32.92
$\lambda_L(QT)$	30.00	41.37
$\rho_s(QRS)$	10.00	18.23
$\rho_L(QRS)$	10.00	18.93
$\rho_s(QT)$	30.00	53.56
$\rho_L(QT)$	30.00	50.92
$\nu_s(RR)$	10.00	13.47
$\nu_L(RR)$	10.00	12.73
$\nu_s(QRS)$	10.00	10.97
$\nu_L(QRS)$	10.00	11.33
$\nu_s(QT)$	30.00	36.96
$\nu_L(QT)$	30.00	37.33
$\lambda_{s,sh}(RR)$	10.00	11.00
$\lambda_{L,sh}(RR)$	10.00	10.86
$\lambda_{s,sh}(QRS)$	10.00	11.34
$\lambda_{L,sh}(QRS)$	10.00	12.27
$\lambda_{s,sh}(QT)$	30.00	32.46
$\lambda_{L,sh}(QT)$	30.00	35.29
$\rho_{s,sh}(QRS)$	10.00	17.71
$\rho_{L,sh}(QRS)$	10.00	18.29
$\rho_{s,sh}(QT)$	30.00	53.11
$\rho_{L,sh}(QT)$	30.00	50.69
$\delta S_s(QT)$	20.00	28.51
$\delta S_{s,sh}(QT)$	20.00	28.50

TABLE VII: The confidence levels to distinguish SD from either H or patients when considering the estimation errors ϵ_m given in Table VI

Method Employed				Confidence levels to distinguish SD						
				Using the limits from the data analyzed			Using broader limits[c]			
Aim	Measures	Type of intervals	No. of parameters	All SD %	All but one SD %	All but two SD[d] %	All SD %	All but one SD %	All but two SD %	All but five SD[d] %
Distinction of SD from H	λ, ρ	RR, QRS, QT	10	>99	>99	>99	88	99	>99	>99
	λ, ρ	RR, QRS	4	63	95	>99	8	43	90	>99
	λ, λ_{shuf}	RR	4	49	90	99	1	11	36	97
	ν	RR,QRS	4	32	74	96	<0.5	1	8	60
	$\delta S_{3-4}(QT)$	QT	1	59	93	>99	11	39	77	>99
Distinction of SD from patients	λ, ρ, ν, $\delta S_{3-4}(QT)$[a]	RR, QRS, QT	17	51	83	95	<0.1	<0.1	<0.1	1
	λ, ρ, λ_{sh}, $\delta S_{3-4}(QT)$[a]	RR, QRS, QT	17	62	91	98	<0.1	<0.1	<0.1	1
	λ, ρ, λ_{sh}, ρ_{sh}, ν, $\delta S_{3-4}(QT)$, $\delta S_{sh,3-4}(QT)$[b]	RR, QRS, QT	24	95	>99	>99	16	41	68	98

[a]Considering the limits of those patients that have $\delta S_{3-4}(QT)$ larger than those in H

[b]Considering the limits of those patients that have *both* $\delta S_{3-4}(QT)$ and $\delta S_{sh,3-4}(QT)$ larger than those in H

[c]by amounts ϵ_m given in Table VI

[d]When stating, e.g., "All but one", it means that when allowing *at the most*, one SD -out of 24- to be misinterpreted as being H or patient, respectively