Precise electrocardiographic measurements and clinical sense

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This editorial refers to ‘Accuracy of manual QRS duration assessment: its importance in patient selection for cardiac resynchronisation and implantable cardioverter defibrillator therapy’ by D.R. Tomlinson et al., on page 638

Practically, all aspects of our lives are subject to numerous rules, laws, and regulations that turn continuous scales into binary ‘YES/NO’ classifications. While driving in a residential street of London at 29 mph is perfectly legal, driving at 31 mph is a crime with possible consequences for the ‘perpetrator’. Everybody would agree that having a Highway Code restriction of this kind is necessary. However, it is obvious that the particular speed limit of 30 mph, derived from statistical observations, does not necessarily reflect the true risk of each situation. Driving one car under particular circumstances at 35 mph might easily be substantially safer than driving another car under different circumstances at 25 mph. Driving in a residential street very fast at, say 65 mph will always be dangerous while driving very slowly at, say, 10 mph, will be basically safe all the time irrespective of the conditions on the road (that is ignoring the possible traffic obstacle). However, as we get nearer and nearer to the speed limit of 30 mph from either side, the distinction between safe and dangerous driving becomes less and less clear. Also, for the Highway Code to be practical, the legal speed limit must be a round number. Indeed, the same statistical observations made on the Old Continent led to a speed limit of 50 km/h, which is equal to 31.2 mph. It would be naturally pointless to discuss whether the British or the Continental residential areas are more or less safe because of this difference. Statistical observations of the past are unlikely reproducible with this precision in the future. A sensible police officer has the obvious advantage of having strong word with another who makes 25 mph under clearly hazardous conditions.

With the advances of evidence-based medicine, even the continuous scales of medical judgement are converted into binary categories. One of such categories is discussed in this issue of the journal by Tomlinson et al.1 who considered the QRS complex duration and its implication for the prophylactic indication of implantable defibrillator and/or for offering heart failure patients cardiac resynchronization therapy. Briefly, they report that in standard clinical settings, the limit of 120 ms is difficult to evaluate exactly and reproducibly. Their findings are not too surprising, especially considering the small number of evaluated electrocardiograms (ECGs) and the unsophisticated approaches to the measurement. One would indeed expect that a faster recording speed would make the measurement somewhat more accurate but that it would not influence personal ECG judgement and interpretation made by different cardiologists. Tomlinson et al. appear clearly worried about the practical implications of their findings, but it is far from obvious that we should share their concern.

It is certainly true that previous studies showed that patients with a broad QRS complex over 120 ms benefited both systematically and in terms of prognosis from resynchronization therapy2,3 and that such findings were not systematically reported in populations of patients with QRS complex narrower than 120 ms (some studies used different cut-off limits4). Statistical results of these studies are not disputed, although different strategies to optimize the use of resynchronization therapy have also been suggested.5 Thus, everything else equal, we should follow this evidence and once we know that a patient has a QRS complex broader than 120 ms, offering the therapy should be considered. On the contrary, if we know that the QRS complex is narrow, the therapy is less likely indicated. This, of course, does not mean that every patient with QRS complex from 120 ms onwards will always benefit from resynchronization therapy or that it can help no patient if he/she has a QRS complex of 119 ms.6 There are many similarities with the Highway Code. If a patient has a fairly narrow QRS complex, say, 80 ms wide, it is apparent that the excitation of the ventricles is reasonably synchronous and that any resynchronization therapy has nothing to...
improve. On the contrary, if a patient has a very broad QRS complex, say, 170 ms wide, resynchronization therapy has a good chance of making the myocardial contractions more haemodynamically efficient. However, similar to the driving speed limit, the nearer we come to the boundary of 120 ms from either side, the more problematic the application of the statistical evidence becomes. Also, as far as I know, nobody ever investigated whether a cut-off point of QRS complex width of 122 or 118 ms would lead to a better separation of those who do and do not benefit from the therapy. Staying with reasonably round numbers and suggesting that a cut-off of 35 micro-hours is better would also make no sense since statistical prediction of the future cannot be this precise. Hence, in the grey area around 120 ms, common sense must prevail.

It would be most unfortunate if a discussion of whether a particular ECG shows QRS complex of 118 or 122 ms were ever the basis for a malpractice litigation case or for financial wrestling with the healthcare provider. For the purposes of clinical decisions concerning individual patients, it makes little sense to try to measure each ECG with such utmost precision. In standard clinical recordings obtained as paper printouts, the line of the tracing is several milliseconds wide and without additional tools, human eye certainly cannot judge the distances of 25 and 50 μm which corresponds to 1 ms at the recording speed of 25 and 50 mm/s, respectively. In spite of all the advances in computerized electrocardiography, the measurement provided by the ECG equipment cannot be trusted in every situation either – also with fairly normal ECGs of healthy subjects (Figure 1). Even when using proper measurement tools that might have the possibility of achieving the 1 ms resolution, characterization of a particular patient by one single ECG is still problematic. The width of the QRS complex not only depends on heart rate,7 but is also not necessarily reproducible at similar heart rates (Figure 2). When trying to judge a borderline case, multiple recordings need to be obtained and the concordance of the measurements sought. Additional evaluations might also prove helpful.5,8,9

It does not seem particularly relevant that the exact technology for measuring the ECGs was not published in the studies from

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**Figure 1** The top panel shows a scatter diagram of QRS measurement errors made by electrocardiographic equipment in a data set of more than 60 000 echocardiogram (ECG) tracings obtained in healthy subjects and subjected to careful manual ECG measurements with reconciliation and quality control according to previously published measurement methodology.7 The bottom panel shows an example of a normal ECG tracing with a narrow QRS complex (manual measurement of 84 ms), which the electrocardiograph measured as 140 ms wide, probably because of the low level noise.
which we take our statistical evidence on therapy benefits. Not only the day-to-day but also the hour-to-hour reproducibility of automatic algorithms providing QRS width measurement is far from absolute and human interpretation of the exact position of QRS onset and offset cannot be possibly standardized, especially if unsophisticated measurements are used as is the present practice. Technologies exist for fairly accurate ECG measurements, including QRS width assessment. However, these appear too demanding for everyday use and should therefore be perhaps applied only where truly necessary, e.g. when evaluating the potential of new pharmaceuticals to influence intra-cardiac conduction.

Solving these methodological problems in clinical practice would hardly be helpful for the classification of the very borderline cases that might easily be constantly flipping below and above the 120 ms ‘threshold’ (Figure 2). In those cases, we cannot and should not be guided by the QRS complex width. In other words, in these cases, our clinical judgement on whether the patient should or should not be offered the treatment must parallel the approach of the intelligent and sensible police constable rather than of the brainless and thoughtless speed camera.

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References


3. Linde C, Abraham WT, Gold MR, St John Sutton M, Ghio S, Daubert C. Randomized trial of cardiac resynchronization in mildly symptomatic heart failure patients and in asymptomatic patients with left ventricular dysfunction and previous heart failure symptoms. J Am Coll Cardiol 2008;52:1834–43.


