Statistical Validation of New Ventricular Tachycardia Detection Schemes

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The reliability of three new template matching techniques for detecting ventricular tachycardia (VT) using intracardiac waveform morphology was assessed using nonparametric tolerance intervals. These new techniques, the bin area method (BAM), the normalized area of difference (NAD), and the derivative area method (DAM), were compared with correlation waveform analysis (CWA), an established method of waveform analysis. All four methods are independent of amplitude fluctuations and produced a bounded similarity measure, H, between -1 and 1. Like CWA, BAM and DAM are independent baseline changes.

The BAM adds five consecutive sample points to form bins, removes the mean value, and compares each waveform with a similarly processed template. The NAD is identical to BAM, except that the mean is not subtracted. The DAM uses the zero-crossings of the derivative of the template to partition the template into areas. The same partitioning is then enforced on each subsequent waveform, and partitioned areas are compared to the corresponding areas in the template. The BAM and DAM required only $\frac{1}{10}$ and $\frac{1}{8}$ the multiplications of CWA, respectively.

Distal bipolar (1 cm) ventricular ECGs from 29 patients with 35 distinct VTs induced during cardiac electrophysiology studies were recorded (1–500 Hz). For each patient a sinus rhythm or atrial fibrillation (SR/AF) ventricular ECG template was used for analysis of subsequent passages of SR/AF and VT. A minimum of 50 ventricular depolarizations during both VT and SR/AF were for each patient evaluated using BAM, NAD, DAM, and CWA. For each patient and each method under analysis, a nonparametric tolerance interval was constructed for each passage of VT that bounded the ranges of 90% of the values of H during that VT with 95% confidence. Similar intervals were constructed during SR/AF. Success was declared if the tolerance interval during VT did not overlap with the tolerance interval for SR/AF.

At the original trigger location (maximum peak alignment), CWA, BAM, NAD, and DAM were successful in 29/35 (82%), 28/35 (80%), 28/35 (80%), and 31/35 (88%) instances. Using the best fit alignment between template and waveform, CWA, BAM, NAD, and DAM were successful in 31/35 (88%), 32/35 (90%), 32/35 (90%), and 30/35 (85%) instances.

In conclusion, template-matching methods such as BAM, NAD, and DAM will discriminate VT from SR/AF with the same degree of statistical accuracy as CWA, but with significantly reduced computational requirements.

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