

The avoidance of transvenous leads is the key innovation of the Subcutaneous ICD (S-ICD) carrying the benefits of preventing longterm vascular complications & lead issues requiring potentially hazardous interventions especially extraction. However, this brings the challenge of ensuring optimal sensing of ventricular arrhythmias in the absence of intracardiac electrograms. By utilising the 3 sensing vectors to differentiate the R wave from T wave, very effective sensing is possible avoiding unnecessary shocks for SVT outperforming transvenous device algorithms for the latter¹. However, there are two major sources of concern : Surface ECG screening could “rule out” potentially eligible patients and the risk of T wave oversensing causing inappropriate shocks.

The risk of unnecessary exclusion relates to the possibility of human error with manual screening using a “ruler and paper”. Also, the printed ECG does not fully represent the signal the device *actually sees* because it is derived between 2 skin electrodes rather than between the subcutaneous lead & generator, it is also processed by a VectorSelect™ sensing algorithm in the implanted S-ICD .

Manual screening has a positive predictive value of only 59% and negative predictive value of 98% when compared to the S-ICD’s sensing². This has resulted in a drive to standardise the screening process and ideally match the signals & processing to the *in situ* S-ICD. The introduction of the Automated Screening Tool (AST) is the first step in this direction. In this issue, Sakhi et al & Theuns compared 256 pts with the manual (MST) versus the AST³. They demonstrate no significant difference in overall eligibility between the 2

techniques reflecting the findings of two other groups who have undertaken similar studies^{4,5}.

However, there are important differences in the details of the findings. Francia et al⁴, showed that there were significant much larger differences in the vector selection: At least two vectors were appropriate in 69% patients with MST and 80% patients with AST ($p = 0.008$) as opposed to only a 6% difference between the tools. This is important as having atleast one vector gives increased room for manoeuvre if subsequent oversensing issues arise and raises confidence in prescribing S-ICD over transvenous devices even though only 1 vector is required. The most frequent reason for screening failure with MST was a high-amplitude T-wave (31% of failures)⁴. With AST, 23% of recordings that failed with MST for high-amplitude T-wave were acceptable. This can be partially addressed by using right sided or sternal positions.

Bogeholz et al, showed similar rule out rates between the MST: 3.0% and AST: 6.1% but the implanted S-ICD worked flawlessly in *all these patients*⁵. Furthermore, the AST did not predict the finally selected sensing vector better than MST with a clear mismatch between AST and MST for the predicted eligibility of single vectors- only 49% of patients have identical single vectors selected by both approaches. These data highlight the discrepancies between the S-ICD VectorSelect™ sensing algorithm and the AST/MST parameters that are tested and raise some controversial questions as to the benefits of screening at all-this needs to be fully determined in a large S-ICD implanted cohort.

The populations screened also differ: Francia 90% cardiomyopathies, Bogeholtz 27% versus 50% in Sakhi et al which has implications in dissecting the details of the screening differences. The overall single vector pass rates for both the techniques at a level of >90% are certainly higher than in inherited cardiac conditions such as HCM with manual screening where 38% patients were ineligible for S-ICD with a single vector on the left side: 10% failed on exercise with large R waves being an important factor⁶. No studies have systematically compared left, sternal & right sided screening with both AST and MST. Generally, the main determinants of likelihood of screening failure in the overall S-ICD population using the AST are QRS widening/bundle branch block, decreased R/T-wave ratio in lead I and T-wave inversion in I, II, or aVF⁵.

Sakhi et al's study is an important step to standardise screening. It is vital to ensure a rigorous screening approach to maximize eligibility using all available lead positions & avoid inappropriate therapies or undersensing especially if patients have dynamic T wave changes on exercise e.g. Long QT Syndrome and Cardiomyopathy cases.

The key problem of T wave oversensing has been effectively addressed with the SMARTPASS filter. The SMARTPASS filter applies a high pass filter to remove low frequency T waves enabling only R waves to be detected by the device. This was initially tested on a retrospective dataset of inappropriate shock signals demonstrating a 40% reduction in T wave oversensing⁷. Subsequent clinical testing by Theuns et al in the LATTITUDE Remote Monitoring Registry has vindicated these findings: 1984 patients S-ICD were compared with the filter

enabled or off- inappropriate shocks were reduced to just 4.3% vs 9.7% matching that seen with transvenous systems without compromising appropriate therapies⁸.

Can the vectors that are sensed be further improved to reduce patient exclusion? An opportunity for refinement could come from a more detailed vector analysis of the signal between the S-ICD lead configurations to provide a reconstructed ECG for sensing. This concept is well established in the literature and was recently tested in a series of S-ICD recipients where 3 ECG vectors can be utilised to reconstruct the QRS-T wave morphology of an 8 lead ECG^{9,10}. Therefore, every patient could have a personalized optimal ECG vector to enable optimal sensing with a maximum R:T wave ratio difference & the 8 lead ECG could be reconstructed after an event from the S-ICD signals to provide diagnostic information and potentially guide VT ablation. Indeed discrimination algorithms could combine vectors to optimise discrimination further.

In conclusion, Theuns work to enhance S-ICD screening and sensing is to be commended^{3,8}. Automatic screening should enable standardization of S-ICD patient selection and with suitable software and hardware enhancements we will see further refinements in sensing and event data. Leadless pacing for ATP and bradycardia may also enable hybrid S-ICD systems to further reduce T wave oversensing & discrimination errors.

References

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