Capture management in high-power devices: an important step forward or a new gadget?

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This editorial refers to 'Manual vs. automatic capture management in implantable cardioverter defibrillators and cardiac resynchronization therapy defibrillators' by F.D. Murgatroyd et al., on page 811.

Automatic measurement of pacing thresholds was first introduced more than a decade ago with the purpose of ensuring ventricular capture for safety purposes and of enabling automatic adjustment of outputs to relatively low values with low safety margins, thus extending longevity of the devices and allowing for less frequent clinic visits. Over several years, the only commercially available algorithms were those operating in the right ventricle (RV). They were all based on various algorithms of detection of evoked response in the RV (while filtering the lead polarization created by the pacing pulse), with stepwise decrease in the output to the point of non-capture (= no evoked response), thus enabling automatic determination of capture threshold. Subsequently, pacing output was automatically adjusted. Threshold determination is performed periodically (typically once or several times a day) or continuously (beat to beat). Recommended safety margins varied by algorithms ranging from output multiplied by 2 of automatically determined threshold to 0.3 V above thresholds depending on the specific manufacturer and algorithm.

The effect on longevity varied between additional 50 and 100% of device longevity in devices with beat-to-beat measurements and 0.3 safety margin, to more modest results in other algorithms. Importantly, the algorithm that demonstrated the most favourable effects on longevity is still limited to specific ventricular lead types with low polarization properties that prevent its use with older, previously implanted leads models (after pace generators replacement). All algorithms have several weaknesses related to false detection of non-capture with resultant unnecessary increase in output and to the management of fusion beats. None of these algorithms have so far been introduced into high-power devices.

Atrial capture management has been developed later. Since atrial evoked response is smaller and thus more difficult to measure and to differentiate from lead polarization signal, the first and most commonly used algorithm was based on reset of the sensed sinus activity or on the ventricular response to paced beat in the atrium as a measure of atrial capture. Several publications confirmed the efficacy and reliability of this algorithm in both children and adults, but information is missing about its clinical importance and effect on longevity. Recently, an algorithm based on atrial evoked response has also been introduced.

Left ventricular (LV) pacing via the coronary sinus leads is an especially attractive target for automatic capture management, as thresholds tend to be higher on these leads, and pacing is expected to be continuous in order to achieve effective cardiac resynchronization therapy (CRT). In fact, CRT devices are known to have shorter longevity, probably due to the need to pace LV continuously at high outputs. The first algorithm for automatic threshold determination and capture management in the LV was introduced several years ago and was based on detection of RV activation following LV pacing with capture. This algorithm has been tested and was shown to be safe accurate and highly reliable and was introduced into CRT-defibrillation (CRT-D) devices of one of the manufacturers. Its effect on device longevity is still unknown. Other algorithms looking at different measures of LV capture such as evoked response are being actively investigated.

The present study

A group of investigators published their experience with the first implantable cardioverter defibrillator (ICD) and CRT-D devices that encompass RV, right atrial (RA), and LV (in CRT-D) capture management algorithms. Their study group included 160 patients with ICD (n = 80) or CRT-D (n = 80) devices of new models with this feature. Patients were followed for 6 months and the results of thresholds measured by the automatic algorithms were compared with manual threshold determination at 1 and 3 months post-implantation. The authors used the term ‘applicability’ to refer to the proportion of patients who had successful threshold measurement at a certain point of time.
Although the algorithms tested are similar to those previously used, the devices investigated in this study were, to the best of our knowledge, the first high-power devices using RV and RA capture management (so far they have been used in pacemakers only), and the first CRT-D to use capture management in all three chambers. The authors were able to demonstrate an impressive similarity between automatic and manual thresholds measured in RV and RA 1 month following implantation. Capture could be successfully assessed (algorithm applicability by their term) in the RA, RV, and LV in ~90, 99, and 90–97% of cases, respectively, at five time points after implantation. Cases of failure to perform automatic threshold measurements were mostly due to atrial fibrillation in RA and due to competing rhythms in RV and LV.

At 6 months 3–6% of patients demonstrated an increase in pacing output with each one of the leads, which was judged appropriate by the investigators in all cases. In most cases, the algorithms reduced pacing output considerably when compared with discharge values.

The application of automatic threshold determination and capture management is an important and natural step in the development of ICDs and CRT-Ds. This study demonstrates for the first time the feasibility of this concept in high-power devices and sets the stage for the widespread use of this technology in patients who need these devices.

**Methodology of the present study**

Several aspects of the study design should be noted. Accuracy of measurements of thresholds was verified only once (at 1 month) for RV and RA and was not verified for LV at all. The verification was against a manual measurement that was performed at a different time than the automatic measurement. Manual measurements were performed by the usual step-down methodology and it would be useful to compare them with the simultaneously performed manual test performed by the capture management method rather than with the results that were acquired automatically at a different time. Unfortunately, this option is not available in this device. Such a comparison would give us information on the difference between methods unrelated to any changes in threshold over time.

Despite these comments, the paper has clearly demonstrated the feasibility and reliability of multichannel capture management and is therefore an important step on the way to increased patient safety and device longevity in the presence of more automaticity and remote follow-up.

**Remaining questions**

Several questions remain to be answered in future studies:

(i) How will fusion beats, ventricular premature beats, and atrial fibrillation that are common in ICD patients affect the applicability of the algorithms?

(ii) What is the optimal frequency of automatic capture testing and will the algorithm perform better if done more than once daily?

(iii) Will algorithms based on evoked response perform better than the present ones in RA and LV?

(iv) To what extent will these algorithms translate into a significant gain in device longevity? Inappropriate increases in output due to false threshold determinations as well as low need for pacing in non-CRT-D devices may offset the favourable effects of the studied algorithms

(v) How will these algorithms perform over time in chronically implanted (rather the new) leads?

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**References**


