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COMMENTARY

# No pain, no gain: intraprocedural myocardial injury current and conduction system pacing lead performance

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His bundle pacing (HBP) and left bundle branch area pacing (LBBAP) have emerged as two approaches to pace the conduction system [1, 2], with mounting evidence that conduction system pacing (CSP) avoids the deleterious effects of right ventricular myocardial pacing [3]. Additionally, CSP can leverage patients' dormant bundles and fascicles for cardiac resynchronization, with potential advantages over traditional biventricular pacing [4]. However, implanting CSP leads with existing tools and techniques can be challenging and is not always feasible even for experienced CSP implanters. Additionally, HBP leads have an infamous reputation for higher capture thresholds at time of implant that may rise over time, necessitating lead revision [5]. Although LBBAP leads typically provide low and stable capture thresholds, confirmation of CSP with these leads can be challenging and septal myocardial pacing may masquerade as "successful" CSP. Considering (1) the large and growing volume of device implants worldwide; (2) the potential of CSP to prevent iatrogenesis and correct cardiomyopathy attributable to electrical dyssynchrony; and (3) current limitations with CSP technology and implantation technique, *CSP research and development should be a priority for the electrophysiology community*.

In this issue of the *Journal of Interventional Cardiac Electrophysiology*, Chung et al. [6] describe the association of myocardial injury current and CSP lead performance both at time of implant and at follow-up. Notably, the authors defined myocardial injury current as a delta between the lead pre- and post-screw-in myocardial ventricular electrogram (> 0.2 mV or > 25% elevation of the ST segment; and > 10 ms prolongation). In this retrospective analysis, 94 consecutive patients who received CSP leads (HBP: 43 patients; LBAAP: 51 patients) were compared to 88 historic controls who received right ventricular septal pacing (RVSP) prior to the introduction of CSP. Top-level findings from this investigation include:

1. HBP leads were the least likely to cause myocardial injury current (HBP: 48%, LBBAP: 76%, RVSP 67%; $P_{\text{HBP vs. LBBAP}} = 0.005$, $P_{\text{HBP vs. RVSP}} = 0.045$).
2. HBP leads with myocardial injury current had similar capture thresholds and lower sensing, at time of implant, as compared to LBBAP leads with myocardial injury current (threshold: $0.84 \pm 0.4$ vs. $0.75 \pm 0.3$ V @ 0.4 ms, $P = 0.329$; sensing: $5.70 \pm 3.4$ vs. $10.35 \pm 6.0$ mV, $P = 0.002$).
3. HBP leads with myocardial injury current had higher capture thresholds and lower sensing, at time of implant, as compared to RVSP leads with myocardial injury current (threshold: $0.84 \pm 0.4$ vs. $0.50 \pm 0.1$ V @ 0.4 ms, $P < 0.001$; sensing: $5.70 \pm 3.4$ vs. $11.24 \pm 4.9$ mV, $P < 0.001$).
4. HBP leads with myocardial injury current, as compared to those without injury, had lower capture thresholds at time of implant ($0.84 \pm 0.4$ vs. $1.24 \pm 0.6$ V @ 0.4 ms, $P = 0.014$) and at follow-up ($0.98 \pm 0.5$ vs. $1.55 \pm 1.0$ V @ 0.4 ms, $P = 0.023$).
5. The capture threshold of four patients with HBP leads increased to > 2.0 V @ 0.4 ms during follow-up, none of which myocardial injury current during implant.

The EP communities' initial enthusiasm for HBP has largely shifted to LBBAP. However, the beauty of a narrow paced-QRS, that matches intrinsic, is self-evident to any electrophysiologist. Findings of the current study suggest that myocardial injury current after HBP lead implant is associated with lead parameters (both acutely and at follow-up) that are competitive with LBBAP. Notably, conduction system injury current, both for HBP and LBBAP,

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have been described and associated with superior lead performance [7, 8]. Interestingly, reported frequency of conduction system injury current in these previous publications (HBP: 37%; LBBAP: 67%) approximates the frequency of reported myocardial injury current for HBP and LBBAP, respectively, in the current study. It is unknown whether this is a coincidence or the result of conduction system and myocardial injury current frequently occurring in conjunction. All together, these findings suggest that if injury current is created at the time of HBP, that one of the main limitations of this pacing modality may be overcome (i.e., high and rising thresholds). However, considering myocardial injury current could not be reliably obtained in the current study, injury current may be most useful as an intraprocedural indicator of when to consider abandoning HBP. However, it is conceivable that these findings may have greater practical value if developments in CSP implant technology and technique reduce barriers to successful HBP.

Importantly, the current study is limited by its definition of capture threshold, which was myocardial capture as opposed to conduction system capture. As such, it is possible that reported capture thresholds are lower than what was needed to capture conduction system (e.g., non-selective His bundle capture that transitions to myocardial capture only at lower outputs). Additionally, LBBAP was utilized as a bail out strategy after failed HBP with patients who received LBBAP having more structural heart disease. As such, lead performance in a randomized comparison between LBBAP and HBP may differ.

The current study emphasizes the importance of myocardial injury current for predicting optimal lead performance for HBP and LBBAP. However, it is uncertain whether these findings will inspire converts to CSP or swing the pendulum back from LBBAP to HBP. Put simply, when it comes to CSP, no pain, no gain.

## Declarations

**Conflict of interest** Perino AC: Research materials from Medtronic Inc. Consultancy from Medtronic Inc., Biotonik, Haemonetics.

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