EDITORIAL COMMENTARY

Perforation of the interventricular septum with left bundle branch area pacing: Diagnosis and management

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Delayed postoperative perforation of the interventricular septum is a rare complication of left bundle branch area pacing (LBBAP), with an incidence of 0.08%–0.33%.[1–4] It usually occurs within days or weeks of implantation, and can result in a rise in capture threshold and/or ventricular undersensing. Overt perforation into the left ventricular cavity may theoretically also result in thromboembolic events, although this complication has yet not been reported. In this issue, Hsieh and colleagues[5] present a case of delayed (postoperative) LBBAP septal perforation on the night following implantation, which resulted in sustained ventricular tachycardia (most probably induced mechanically). Ventricular tachycardia induced by the LBBAP lead (without perforation) has otherwise been described in another case report,[6] and is also extremely rare.

The pathogenesis of delayed perforation is unclear. A likely cause is microperforation of the helix at implantation, which may go unnoticed owing to lack of symptoms and adequate electrical parameters. Forward forces resulting from myocardial contraction cycles may result in progression of the lead within the septum, ultimately leading to overt perforation. A protective factor against this complication is the left septal "endocardial barrier" effect, which was encountered in 20% of lead positions in the cadaveric heart model.[7]

Microperforation of the lead tip may be fortuitously visualized by echocardiography at follow-up, and if electrical parameters are stable and acceptable, repositioning is not warranted.[8] Apparent protrusion of the lead tip into the left ventricular cavity may also be artefactual, owing to side lobes of the echographic beam,[9] and it is advisable to evaluate different views to confirm lead tip position. Overt perforation, however, requires lead revision owing to thromboembolic risk and possible damage to the mitral valve, as well as risk of mechanical proarrhythmia with mobile leads.[5]

Acute peroperative LBBAP lead perforation is relatively frequent and has been reported in up to 14% of patients.[3,10,11] Unless the perforation is overt, it is not recognizable by fluoroscopy alone, and capture/sensing thresholds may be within normal limits. The unipolar sensed myocardial current of injury (COI) amplitude is probably the most promising parameter for identifying perforation peroperatively.[10,12] Perforation should be suspected with sensed COI amplitudes <3–5 mV, or if a QS, RS, or rS morphology of the ventricular electrogram is visualized.[8,10] Another sign is tip < ring COI amplitude (positive and negative predictive values for perforation of ~60% and 100%, respectively[12]). *Paced* myocardial COI amplitude may also be evaluated during continuous pacing while the lead is being deployed within the septum, but how well this compares to *sensed* COI remains to be evaluated. Another factor that warrants further study is the impact on COI amplitude of the high-pass filter settings (typically set to 0.05 Hz[12] or to 0.5 Hz[10]). Other parameters that may suggest perforation are disappearance of fascicular potentials (which may otherwise indicate micro-dislodgement if the COI amplitude remains high) or a fall in pacing impedance (eg, by >200 Ω). Pacing impedance of <450 Ω has also been reported to indicate perforation,[10] but it should be noted that absolute values of pacing impedance also depend upon a variety of other factors (lead length, connection cables, etc). Finally, contrast injection via the delivery sheath may reveal perforation with leakage of the dye into the left ventricle, although it should be borne in mind that performing this maneuver via an unflushed catheter into the systemic circulation may not be advisable owing to thromboembolic risk.

Septal perforations are usually related to the operator striving to achieve the best possible paced QRS and "overshooting" the desired subendocardial target zone. Lead design does not seem to play a major role, as the complication has been described with various models, without significant differences in incidence.[3,8]

If acute peroperative microperforation is diagnosed, lead repositioning is recommended.[13] This may avoid progression to delayed overt perforation (which is nevertheless rare) or possibly to lead dislodgement (which is more frequent) owing to reduced anchoring by the helix. Postprocedure echocardiograms in patients who have had leads repositioned following

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https://doi.org/10.1016/j.hrcr.2023.12.017

septal perforation do not show evidence of ventricular septal defects.[10]

In summary, acute septal perforation of the LBBAP lead may be elusive to diagnose, as it is asymptomatic and may be associated with good sensing/capture thresholds. However, careful evaluation of the myocardial COI, as well as monitoring of additional parameters such as pacing impedance, should enable diagnosis. Repositioning the lead may avoid later complications such as lead dislodgement (owing to reduced tissue anchoring by the partially perforated helix) and delayed overt perforation. Current leads are not specifically designed for LBBAP, and do not seem to differ in terms of risk of septal perforation. Hopefully, future leads that are tailored for LBBAP will facilitate septal penetration (thus increasing success rate and reducing the risk of dislodgement due to the "drill" effect[7,8]) without the tradeoff of an increased risk of perforation.

Disclosures: H.B. has received speaker honoraria, consulting fees, or institutional fellowship/research support from Abbot, Biotronik, Boston Scientific, Medtronic, and Microport.

Funding Sources: None.

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