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COMMENTARY

The quest for achieving durable mitral isthmus block: probing the heights of the left lateral ridge

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Mitral annular flutter may occur either isolated or after catheter ablation for atrial fibrillation. It is oftentimes refractory to antiarrhythmics but amenable to catheter ablation. Two ablation approaches have been devised, one involving the creation of lesion lines across the mitral isthmus (MI), defined as the region extending between the left inferior pulmonary vein and the mitral annulus, and the second one consisting of lines along the left atrial (LA) anterior wall and connecting the right superior pulmonary vein with the mitral annulus [1]. Each of these strategies presents unique potential advantages and challenges. The MI line is directed along the shortest path between the mitral annulus and the left inferior pulmonary vein, albeit its completion oftentimes requires complementary ablation in the adjacent coronary sinus with the risk of left circumflex artery thermal injury, coronary sinus thrombosis, and pericardial tamponade [1, 2]. The anterior line is performed endocranially only. It is, however, longer than the MI line and may promote delayed activation of the LA appendage, atrio-ventricular electromechanical desynchrony, and possibly increased risk of thromboembolism. [3]

Regardless of the targeted region, it is imperative that both ablation strategies create lines that are durable, continuous, and transmural. The achievement of conduction block across each of these lines is however challenging due to multiple factors including the local transmural thickness of the atrial wall, oftentimes accompanied by endocardial trabeculations and crevices, as well as the convective cooling by the circumflex coronary artery [3, 4]. A further major complicating factor is the LA myocardial architecture and the subepicardial muscular bridges along the Bachmann's bundle, the septo-pulmonary bundle, the coronary sinus, and the ligament of Marshall (LOM) [4, 5]. It is notorious that elimination of residual epicardial conduction provided by these structures oftentimes requires extensive "touch-up" ablation sessions directed at putative connections to the LA musculature. Furthermore, failure to achieve durable conduction block is associated with increased risk of tachycardia recurrence, including new and complex reentry pathways through the surviving, incompletely ablated subepicardial fibers. [6]

In this issue of the Journal, Hori et al. [7] present a retrospective study aiming to assess the effect of empiric ablation of the LA lateral ridge as an adjunctive strategy to improve the outcome of conventional MI ablation. The study cohort consisted of 559 patients who underwent *de novo* MI radiofrequency ablation during or following pulmonary vein isolation (PVI). In the first 92 patients, enrolled between 2003 and 2013, only PVI and conventional MI ablation was performed. In the subsequent 467 patients, enrolled between 2013 and 2020, the PVI and MI line was complemented with electroanatomically-guided ablation of the LA lateral ridge. The authors postulated that ablation at the ridge would be able to disrupt the epicardial fibers attached to the LOM and thereby improve the success rate of MI ablation.

The main findings were as follows: (1) MI conduction block was achieved significantly more frequently in the group undergoing adjunctive ridge ablation compared to that undergoing PVI-MI ablation only (95 vs 85%); (2) the overall ablation energy and time required to achieve MI block were significantly reduced in the former group; (3) over a median follow-up of 977 days, the recurrence rate of atrial tachycardias was significantly lower in the ridge ablation group; and (4) the incidence of repeat MI ablation tended to be lower in the same group. In multivariate analysis, the ridge ablation and the LA diameter were independently associated with the risk of atrial tachycardia recurrence (hazard

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ratios: 0.55 and 1.03, respectively; 95% confidence intervals: 0.37–0.84 and 1.01–1.06).

When interpreting these results, a word of caution should be raised first. It is notable that the study was conducted over period of time of 17 years and the two groups of patients were enrolled sequentially over two distinct time periods, before and after 2013, respectively. The mapping and ablation technology has however evolved considerably since the start of the study, and especially so in the past 10 years. For example, the utilization of contact force sensing catheters and ablation lesion metric indices were likely different in the two groups, a concern with potential consequences regarding ablation lesion quality and procedural efficacy in each group.

Aside from these and other limitations mentioned by the authors, we would like to make the following comments.

Firstly, the present study once again brings into focus the complex network of epicardial fibers bypassing the MI and its implication regarding the creation of durable, complete ablation lines in this region. The major strength of the study is the large number of patients analyzed. The LOM is indeed located in the epicardial aspect of LA lateral ridge and its myocardial sleeves provide connections between coronary sinus, LA, and the left PVs [4, 5]. Previous reports have demonstrated its participation in post-PVI periatrial reentry refractory to conventional MI ablation but eventually cured by ablation targeting the LOM segment harbored by LA ridge [8]. Interestingly, pathology studies show that the LOM may run < 3 mm away from the endocardial aspect of the ridge [4]. It is therefore conceivable that endocardial ablation lesions deployed at the ridge may reach transmurally and thereby interrupt the underlying epicardial fibers.

Collectively, these data are consistent with the findings of Hori et al. and support the notion that the LA ridge ablation may indeed improve the outcome of conventional MI ablation. It should be remarked however that wider breakout areas adjacent to the ridge have been occasionally reported during tachycardias presumed to involve the LOM [8]. In addition, there have been instances when such tachycardias could not be interrupted by ridge ablation but only after additional ablation was deployed at the junction between the vein of Marshall and the coronary sinus [9]. These findings call for prudence when attempting to enforce MI ablation lines by empiric ridge ablation and suggest that additional ablation targeting difficult to predict residual epicardial connections may sometimes be necessary. Differential pacing, contrast-aided visualization, and/or direct recording of electrograms from the LOM should expedite the ablation in these cases.

Secondly, it is possible that the simple ridge ablation, even without the achievement of durable conduction block, may have contributed to the long-term outcome of the study by Hori et al., particularly the recurrence rate of atrial tachycardia. The LOM is recognized as a source of arrhythmogenic triggers and tachycardias [5]. Also, as previously mentioned, the LOM harbors fibers connecting the LA, the coronary sinus, and the PVs. Therefore, it is conceivable that the ridge ablation might have prevented tachycardias originating in the ridge. In addition, it is reasonable to assume that it consolidated the adjacent previously drawn PVI ablation lines at their anterior antral aspect, thereby diminishing the risk of PV reconnection and PV ectopy able to promote recurrent atrial tachycardia. [10]

Thirdly, it should be remarked that a similar and very low intraprocedural complication risk (1%) existed in the two groups studied. Nonetheless, cardiac tamponade occurred in five patients, all of them belonging to the ridge ablation group. Although no further details are presented in the paper regarding these complications, the exclusive occurrence of cardiac tamponade in the ridge group raises the question of possible accidental LAA perforation related to catheter manipulation and inadvertent ablation in this region. This concern appears reasonable given the variable albeit narrow width of this structure, thereby posing technical challenges during the ridge ablation [4]. Also unclear is to what extent, if at all, the mapping and ablation was assisted by intracardiac echocardiography, steerable sheaths, and general anesthesia, factors expected to assist in visualization of the ridge and improve catheter stability, lesion quality, and procedural safety.

In summary, the study by Hori et al. should be considered hypothesis generating within the limitations described. Further research is warranted to confirm and expand on the value, applicability, and safety of adjunctive empiric left lateral ridge ablation when MI block is deemed necessary.

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