Great teaching value can come from showcasing an unusual phenomenon that serves as an aid to explain how best to approach mundane, common problems. In this installment of teaching rounds, Wakabayashi et al.1 use an unusual activation sequence observed along the mitral annular atrial myocardium that was observed after ablation of the mitral isthmus to teach us about the pitfalls created by the complex terrain in the left atrium (LA).

Much of what we initially learned about linear ablation is from ablation of the cavitricuspid isthmus for typical right atrial flutter. Although this experience is helpful, we need to be alert to the fact that we cannot equate this relatively simple ablation approach to the complex-interlinked isthmus anatomy in the LA.

Transmural Ablation From the Mitral Annulus to the Left Lower Pulmonary Vein≠Mitral Isthmus Block

In their approach to this complex and instructional case, the authors stress the initial importance of pulmonary vein isolation when approaching mitral isthmus–dependent flutter. Unlike the human inferior vena cava, the left lower pulmonary vein does not serve as an anchor point for ablation of the mitral isthmus. This is because of the myocardial sleeves that extend into this pulmonary vein. As a result, to truly anchor the mitral isthmus line and obtain isthmus block at this site, either the ablation needs to go into the pulmonary vein (which would have a prohibitive risk of pulmonary vein stenosis) or the pulmonary vein must be circumferentially isolated with LA ablation.

Pulmonary Vein Isolation≠Pulmonary Vein Isolation

The usual method for determining whether the pulmonary vein is indeed isolated is to show entrance and exit block with a multielectrode catheter placed within the pulmonary vein. However, during isolation of the left veins, the operator may have inadvertently created the equivalent of 2 circular sets of lesions, a distal circle that may even be partly within the vein, and a proximal circle that may have gaps. The distal vein is isolated, but if the mitral isthmus ablation line anchors to the proximal circle, the myocardium between the 2 circles.

Mitrail Isthmus Block≠Elimination of Mitral Isthmus–Dependent Flutter

Perimitrail annular flutter necessarily traverses the mitral isthmus, and it should follow that bidirectional block across the isthmus eliminates the flutter. However, if we diagnose perimitrail flutter only by entraining the arrhythmia at 1 site near the mitral annulus, we may fail to recognize macro–re-entry that involves the myocardium at some sites near the mitral annulus and involves myocardium posterior to the mitral annulus, for example, through gaps in a superior portion of the venous isolation circles or through an attempted roof line between the upper pulmonary veins. Continued flutter may then lead to more aggressive attempts at ablating the mitral isthmus when it may already be blocked. Wakabayashi et al.1 dealt with this concern by ascertaining the presence of block across the roofline before further trying to explain the unusual sequence that they noted in their patient.

Coronary Sinus Electrograms≠Adjacent Left Atrium

Placing multielectrode catheters in the coronary sinus (CS) is commonplace and serves in general as a surrogate for adjacent LA activation. However, the CS, like the LA, has its own musculature and venous components. Thus, in some circumstances, CS activation may have a different pattern compared with the adjacent LA, and potentially, the CS muscle can serve as a conduit from 1 LA connection to another, thus bypassing atrial scar or even a complete LA myocardial ablation line.

Wakabayashi et al.1 emphasize the value of differential site pacing to distinguish between slow conduction and block. They noted that at the site of linear ablation, the conduction interval across the line shortened with proximal CS compared with distal CS pacing, suggesting the block. This maneuver is useful and generally accurate but has 2 important assumptions:

1. The line, recording electrode, and pacing sites are all in the same chamber.
2. There is no bypass or alternate route for conduction across the line other than through gaps in the line itself.

Because the LA and CS may connect at discrete sites,2–4 if a line is drawn between 2 sites and the CS musculature is still intact, it may allow the line to be bypassed in a manner...
analogous to lower loop conduction bypassing a cavitricuspid isthmus line. The opposite situation may also occur if the CS musculature has been ablated, for example, with cryoablation as part of an atrial maze procedure, but the ablation line in the adjacent LA myocardium is incomplete.

**Left Atrial Appendage Pacing≠Left Atrial Appendage Pacing**

To check for bidirectional block across a line, pacing as close as possible to the line but on either side of it is needed. For example, pacing just lateral to the isthmus line would be expected to completely reverse the activation sequence at all locations medial to the line. It may be critical in difficult cases to pace as close as possible to the line in the LA and with closely spaced electrodes spanning the ablation line. Many operators, however, will use the proximal CS instead of a medial LA perimitral site for pacing, and others may additionally use the LA appendage (LAA) instead of the distal perimitral LA myocardium. Just as the CS is distinct from the LA, so also is the LAA. There may be multiple potential paths for paced wavefronts via pectinates within the LAA, and slight variations in catheter position may result in anterior versus posterior exit the LAA. As a result, confusing activation patterns may occur, and if a posterior exit predominates, then a false appearance of block across the line may result.

Similarly, as noted in the present teaching series article, there was a change in activation near the LAA when the pacing site in the CS was varied. Although the authors meticulously sought out potential reasons, it should be noted that epicardial connections, such as via the vein of Marshall to the LAA, may still be present even though there is conduction block across the isthmus. Nevertheless, one must be concerned that such conduction from the medial LA to the LAA could allow nonperimitral flutters, and the authors astutely determined that ablation of the vein of Marshall ablation was required to eliminate this atypical sequence of activation.

**Left Atrial Ridge=Adjacent Endocardium to the Vein of Marshall**

Certain anatomic equations have also been demonstrated in the ablation era. Between the LAA and the anterior surface of the left pulmonary veins, there is an external sulcus and an internal ridge, both caused by the presence of the left superior vena cava in fetal life. As a result, the vein of Marshall, which is a remnant of the left superior vena cava, is necessarily epicardial to and adjacent to the LA ridge. The authors exploited this topographical relationship to eliminate the vein of Marshall conduction without needing to cannulate the vein or injecting it with alcohol for ablation.

Optimal teaching sessions include illustration of the best methods to learn. Optimal in depth learning occurs when we observe, question, and strive to completely explain what we have seen. Wakabayashi et al1 teach by narrating their reasoning in evaluating a difficult-to-explain activation sequence when attempting to assess mitral isthmus block, achieving an understanding that led to successful ablation.

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**References**


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