ANSWER TO May 7th QUESTION

E. Left atrial appendage should be mapped

Explanation

Preexcitation on electrocardiogram: The 12-lead electrocardiogram in May 7th Question shows preexcitation localizing the accessory pathway to the lateral/superolateral mitral annular region.[1]

Antegrade atrioventricular conduction: The electrograms in sinus rhythm show evidence of preexcitation with earliest ventricular electrograms seen as similarly early far-field signals on coronary sinus (CS) 5-6, 7-8, 9-10 and ablation distal (ABLd) (Figure 1). We do not see a clear near-field accessory pathway potential or a singularly early near-field ventricular electrogram to be considered the ventricular insertion site for ablation (Option D is wrong).

Retrograde ventriculoatrial conduction:

Retrograde atrial activation sequence – The paraHisian pacing maneuver (Figure 2)shows a constant retrograde atrial activation sequence. The absence of more than one activation sequence suggests retrograde activation through the tracing occurring using the same connection. Activation occurring over a discrete accessory pathway across the annulus to the atrial myocardium would be expected to have a radial spread from an early site, with near field atrial electrograms on the CS catheter arranged in a chevron pattern. The earliest atrial electrograms seen in Figure 2 are similarly early far-field potentials on CS 1-2, 3-4, 5-6 and 7-8; closely followed by near-field activation on the same electrodes. Multiple electrodes activated at about the same time with far-field low frequency component preceding the near field suggests an activation wavefront propagating from a distant site to all the early recording sites. Focal early activation locally at any of the sites would have been distinctly earlier than the neighboring sites.[2]

Absence of ventriculoatrial fused electrograms – The local ventricular and atrial electrograms are spaced out without a fused ventriculoatrial signal usually seen with accessory pathway conduction. The separation of the local ventricular and atrial signals (double potential) has the following differential diagnosis:

- Slow conduction – If this accessory pathway has a long conduction time, this will separate out the local ventricular and the local atrial signal by the time is takes to conduct across the accessory pathway. This is similar to the atrio-His (AH) interval seen with slow conduction across the atrioventricular node.
- Accessory pathway slant – If the accessory pathway is slanted going across the atrioventricular annulus e.g. with ventricular insertion close to CS 7-8 and an atrial insertion close to CS 3-4, the ventriculoatrial conduction wavefront from will have to take a zig-zag

route (Figure 3). This introduces a longer conduction path length and physiological slowing of conduction velocity at sites of curvature. [3,4] Option B is incorrect because the ventricular insertion of the accessory pathway at CS1-2 is incongruous with the earliest antegrade ventricular electrograms seen on CS 5-6 to CS 9-10; and similarly atrial insertion at CS 7-8 does not explain the similarly early retrograde electrograms on CS 1-2 to CS 5-6.

- Absence of conduction (conduction block) – In this case there is no direct conduction from the local ventricular electrogram to the local atrial electrogram across an accessory pathway, but conduction from the ventricle to the atrium occurs at some remote site e.g. the aortic sinuses of Valsalva not being mapped by the available intracardiac electrodes. The local ventricular and local atrial activation is then just bystander activation (pseudointerval).[5]

ParaHisian pacing maneuver: The pace stimuluses A, B and C in Figure 2 respectively generate QRS complexes suggesting selective left bundle branch capture (stimulus-to-QRS delay and typical right bundle branch morphology), non-selective left-bundle/His-bundle capture along with local myocardial capture (narrower QRS), and local myocardial capture alone (wider QRS). The atrial activation sequence is unchanged excluding participation of two separate ventriculoatrial conduction pathways. Complexes A and B capture the left-bundle, while loss of direct left-bundle capture in complex C delays conduction time to the atrium. This suggests ventriculoatrial conduction dependent on the conduction system, in this case dependent on the left-bundle branch to get quickly to the left ventricular free wall where the accessory pathway connects to the atrium.6 The atrial activation sequence is eccentric (septal activation seen on HIS4 occurs after CS 1-2, 3-4, 5-6 and 7-8 excluding conduction through atrioventricular node (option C is incorrect). Absence of direct capture of the local ventricular myocardium in addition to the left conduction system at the paraHis pacing site in complex A as compared to complex B does not result in any change in stimulus-to-atrial conduction time and activation sequence, demonstrating the activation does not use a septal accessory pathway.[6]

Putting it all together: In light of the above points this case can be explained without having to invoke more than one accessory pathway (option A is incorrect). There is a bidirectionally conducting atrioventricular accessory pathway in the left superolateral mitral annular region. However, the temporal separation between the ventricular and atrial electrograms and the absence of the CS electrograms arranged in a chevron pattern, but with multiple electrodes activated about simultaneously would suggest the atrioventricular connection is not in proximity route (Figure 3). This introduces a longer conduction path length and physiological slowing of conduction velocity at sites of curvature. [3,4] Option B is incorrect because the ventricular insertion of the accessory pathway at CS1-2 is incongruous with the earliest antegrade ventricular electrograms seen on CS 5-6 to CS 9-10; and similarly atrial insertion at CS 7-8 does not explain the similarly early retrograde electrograms on CS 1-2 to CS 5-6.

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Non-annular atrioventricular connections: The atrial and ventricular myocardium are contiguous during embryonic development but are separated except at the atrioventricular node with development of the fibrous annular tissue. Failure of this process is thought to be responsible for most accessory pathways located on the annuli. Other than the atrioventricular annuli, the right and left atrial appendages are in contact with the right ventricular outflow and the left ventricular inflow respectively. The appendages and the ventricles however develop from embryologically distinct and separate tissues and their respective myocardium is separately covered by the visceral pericardium precluding to-and-fro conduction. However, acquired accessory pathways have been described from either of the appendages to the adjacent ventricular myocardium. This may be hypothesized to occur with healing after a localized myopericarditis and sometimes is acquired in deposition disorders like Fabry's cardiomyopathy. Right atrial appendage to right ventricular outflow tract. connections can develop in patients with the classic right atrial appendage-right ventricular outflow tract Fontan. Similarly, the venous myocardium from the CS extending into a CS diverticulum or the coronary veins can develop an epicardial connection to the adjacent ventricular myocardium. Other unusual sites for atrioventricular connection could be through the aortomitral continuity and conceivably from the non-coronary cusp to the adjacent atrial muscle.

References:

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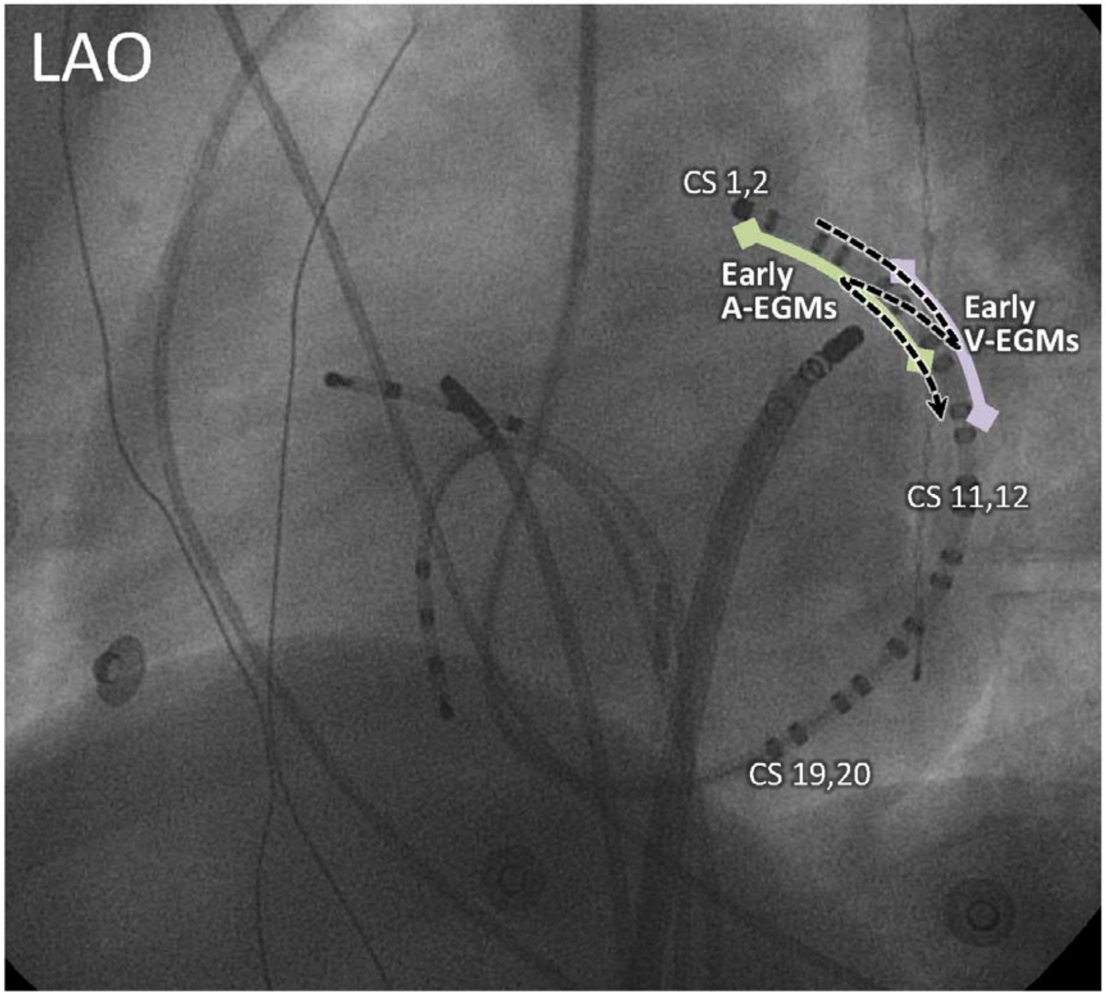

Figure 1. Intracardiac electrograms during sinus rhythm. Similarly early far-field ventricular activation is seen on electrograms at CS 5-6, 7-8, 9-10 and ABLd. There is no definite earliest ventricular electrogram or accessory pathway potential as the target of ablation on the ABLd electrogram (arrow). P1 ART is the arterial blood pressure tracing; I, II, aVF and V1 represent surface electrocardiogram leads; RVa, right ventricular apex; HRA, high right atrium; HIS 4 to HIS 1, His bundle electrograms proximal to distal; ABL p, ablation catheter proximal; ABL d, ablation catheter distal; CS 19,20 to CS 1,2, coronary sinus catheter proximal to distal.

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Figure 2. ParaHisian pacing maneuver. Complexes A, B and C respectively show selective His/left-bundle branch (LBB) capture, His/LBB + ventricular capture and pure ventricular capture. The double headed arrows show the fixed ventriculoatrial conduction time for complexes A, B and C. A, atrial; AEGM, atrial electrograms.

Figure 3. Putative oblique accessory pathway to explain separation between ventricular and atrial electrograms during retrograde conduction in Figure 2. Overlaid on the left anterior oblique (LAO) fluoroscopic projection, the location of the early antegrade ventricular electrograms (V-EGMs) is marked with purple and the location of the retrograde early atrial electrograms (A-EGMs) is marked in green. The zig-zag course (dashed arrow) taken by the wavefront to go from ventricle to the atrium introduces temporal delay due to the longer course and the slowing of conduction on account of wavefront curvature. CS, coronary sinus.