Morphology of right atrial appendage for permanent atrial pacing and risk of iatrogenic perforation of the aorta by active fixation lead

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BACKGROUND Permanent atrial pacing usually involves lead placement in the right atrial appendage (RAA). Anatomical studies addressing features predisposing to complications are scanty.

OBJECTIVE To assess the morphology of RAA in the perspective of pacing, including the morphology of tenia sagittalis (TS) and the spatial relationship with the aorta.

METHODS The gross anatomy of the RAA has been analyzed in a consecutive series of 100 hearts following a case of iatrogenic perforation of the aorta by active fixation lead located in the RAA. Transmural RAA sections were taken from 40 hearts to assess the wall thickness at the level of pectinate muscles (PMs) and of inter-PMs spaces and the distance between adjacent PMs.

RESULTS The TS was present in 90% of cases (single trunk, 76%; double trunk, 13%; and triple trunk, 1%), demarcating the proximal antral RAA region (facing the adjacent aorta) from the distal saccular RAA region (facing the pulmonary infundibulum). The RAA free wall in the inter-PMs spaces is usually paper-thin and translucent. Histomorphometric analysis reveals that the RAA wall mean thickness was 1.38 ± 0.05 mm (range 0.64–4.25 mm) at the level of PMs and 0.39 ± 0.23 mm (range 0.09–1.05 mm) at the level of inter-PMs spaces. The mean distance between adjacent PMs was 0.88 ± 0.99 mm (range 0.04–4.12 mm).

CONCLUSION In 90% of hearts, a well-defined TS separates the distal saccular from the proximal antral RAA, the latter being closely adjacent to the ascending aorta. The paper-thin wall between PMs is potentially at risk of perforation, and aortic injury could occur when active fixation leads are anchored in the antral RAA, as demonstrated in an iatrogenic fatal case.

KEYWORDS Aortic perforation; Anatomy; Pacing; Pathology; Right atrium

ABBREVIATIONS **PMs** = pectinate muscles; **RAA** = right atrial appendage; **TS** = tenia sagittalis

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Introduction

The right atrial structures involved in lead positioning are the right atrial appendage (RAA) and, less frequently, the right atrial septum. The former structure is close to both right and left ventricle outlets and the supravalvular tract of the pulmonary artery and aorta. During pacemaker implantation, lead positioning in the RAA is achieved because of the J shape of the lead, either as an intrinsic feature of the lead (pre–J-shaped) or obtained by inserting a J-shaped stylet into a straight lead (post–J-shaped). When a screw-in technology is used, the lead is actively anchored in the atrial appendage wall because of its "screw-in" tip. Considering the particular routing made by the atrial lead to reach the RAA, obtained from the above superior vena cava (after left or right subclavian or cephalic vein cannulation), the lead anchorage and its resulting stability are striking issues for permanent pacing. The lower risk of perforation (passive pre–J-shaped systems) compared with a more reliable stability (screw-in systems) has been addressed in previous studies.[1–5] We herein document the iatrogenic perforation of the ascending aorta by a pacing active fixation lead located in the RAA. This rare adverse event prompted us to review a consecutive series of 100 human hearts and to examine the available technologies for permanent atrial pacing in order to understand the anatomical factors predisposing to such complication.

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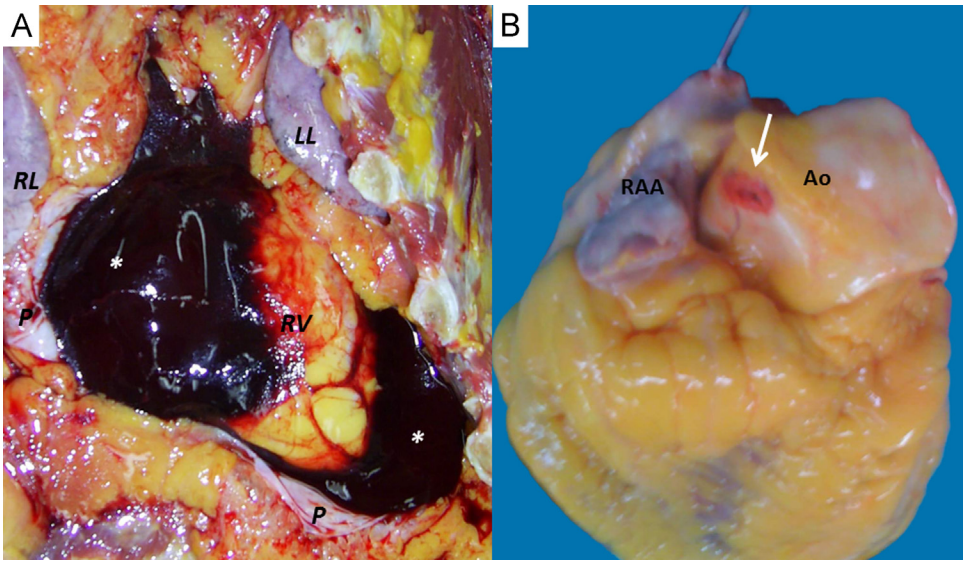

Figure 1 Iatrogenic perforation of the RAA and of the aorta with cardiac tamponade. **A:** Hemopericardium at autopsy. **B:** Seven-millimeter-long tear in the wall of the aortic root (arrow) just in front of the RAA ("kissing lesion"). Asterisks indicate hemopericardium. Ao = aorta; LL = left lung; P = pericardium; RAA = right atrial appendage; RL = right lung; RV = right ventricle.

Methods

Anatomical study

A consecutive series of 100 human hearts, obtained from routine autopsies performed at the Cardiovascular Pathology Unit of the Department of Cardiac, Thoracic and Vascular Sciences of the University of Padua, have been examined to analyze the morphology of RAA, with a particular attention paid to the anatomical variability in the tenia sagittalis (TS), also known as sagittal bundle or septum spurium, in its "entrance" into the RAA, the existence of distinct RAA regions and their relationship with the adjacent great arteries as well as the RAA wall thickness variability. Ten hearts obtained from consecutive patients with atrial pacing studied at autopsy were reviewed to assess the location of the atrial lead in the RAA with respect to the TS. The patient information was de-identified in each human heart.

All hearts were preserved in a formalin solution. Considering the aim of the present analysis, specimens with extensive right atrial surgery were excluded. The RAA is defined as the triangular or trapezoidal part of the right atrium, demarcated by the crista terminalis on the endocardial site from the smooth venous part, also called the right atrial vestibule. All hearts were opened by an incision from the inferior vena cava to the RAA tip, along the lateral wall, to expose the inner RAA and TS. The crista terminalis and anatomical variability of the TS were also digitally stored by means of prespecified specimen-related codes, never including the cadaver anagraphic data.

Morphometric analysis of the RAA was carried out in 40 human hearts from patients aged 15–92 years (mean 65.3 ± 20.2 years; 24 male). Heidenhain trichrome–stained sections were evaluated using commercially available software (Image-Pro Plus version 4.0, Media Cybernetics, Rockville, MD). The thickness of pectinate muscles (PMs) and of inter-PMs spaces and the distance between adjacent PMs were

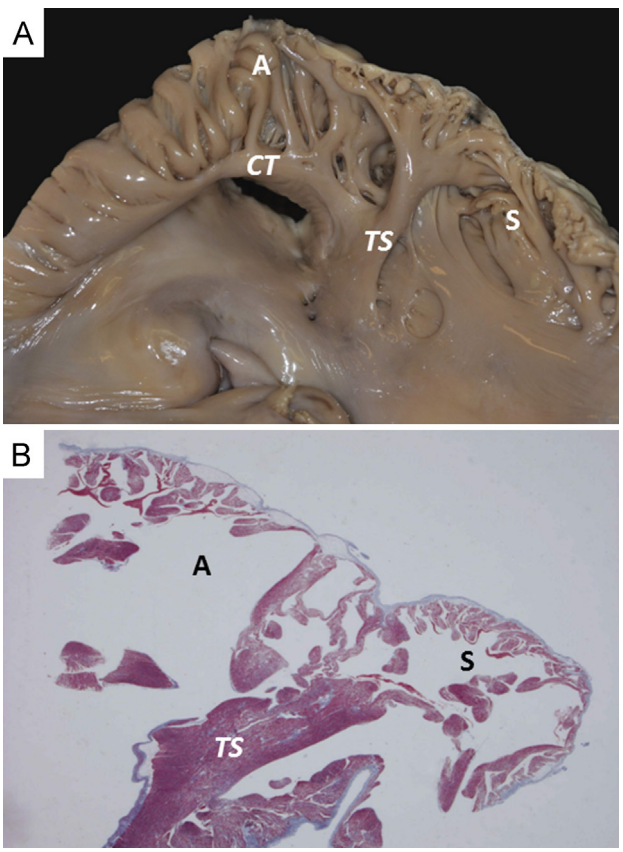

Figure 2 Anatomy and histology of the RAA. **A:** Gross view: a single trunk of TS (the most frequent anatomic variant in our study) clearly separates 2 distinct portions of the RAA, the proximal antral and the distal saccular, beyond the TS. **B:** Histological section including the TS and the antral and saccular portions of the RAA (Heidenhain trichrome stain). A = antral right atrial appendage; CT = crista terminalis; RAA = right atrial appendage; S = saccular right atrial appendage; TS = tenia sagittalis.