
Working Group Report

Living anatomy of the atrioventricular junctions

A guide to electrophysiological mapping

A Consensus Statement from the Cardiac Nomenclature Study Group, Working Group of Arrhythmias, European Society of Cardiology, and the Task Force on Cardiac Nomenclature from NASPE

Current nomenclature for atrioventricular junctions derives from a surgically distorted view, placing the valvar rings and the triangle of Koch in a single plane with antero-posterior and right-left lateral coordinates. Within this convention, the aorta is considered to occupy an anterior position, while the mouth of the coronary sinus is shown as being posterior. While this nomenclature has served its purpose for the description and treatment of arrhythmias dependent on accessory pathways and atrioventricular nodal re-entry, it is less than satisfactory for the description of atrial and ventricular mapping. To correct these deficiencies, a consensus document has been prepared by

experts from the Working Group of Arrhythmias of the European Society of Cardiology, and the North American Society of Pacing and Electrophysiology. It proposes a new, anatomically sound, nomenclature that will be applicable to all chambers of the heart. In this report, we discuss its value as regards the description of the atrioventricular junctions, establishing the principles of this new nomenclature.

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Key Words: Anatomical nomenclature, atrioventricular junctions, triangle of Koch, atrial mapping, accessory pathway ablation.

Introduction

The introduction of catheter ablation has revolutionized the approach to treatment of arrhythmias. In the 1970s, surgery was a very effective means of curing the Wolff–Parkinson–White syndrome^[1,2]. The accessory pathways responsible for preexcitation and tachycardias were identified by mapping^[3], and their structure confirmed by pathological observations^[4,5]. The atrioventricular junctions, defined as the atrioventricular rings and surrounding structures, and including Koch's triangle and the atrioventricular conduction tissues, were described in great detail. The nomenclature developed at that time, however, depicted the position of the atrioventricular rings and the aortic valve in one plane, which was

described on the basis of antero-posterior and right-left lateral coordinates. In this plane, the aortic valve is represented as being anterior to the mouth of the coronary sinus, when in reality it is predominantly superior. Similarly, the coronary sinus itself, which becomes the main landmark in the presumed posterior part of the section, is properly described as being inferior^[6]. Despite the obvious distortion introduced by this nomenclature, it served its purpose of permitting communication between electrophysiologists and surgeons, and was fundamental in the evolution of surgical and catheter ablation in the treatment of Wolff–Parkinson–White syndrome. But as atrioventricular nodal reentrant tachycardia became better known, and also subject to surgical treatment, the same inaccurate nomenclature was applied to Koch's triangle^[7–9]. This resulted in the definition of anterior and posterior approaches to the atrioventricular node, which again are inappropriate descriptions of the true anatomical orientation since, during life, the apex of Koch's triangle points up, and not to the front. In contrast, those who have described the treatment of ventricular tachycardia have used appropriate anatomical coordinates^[10].

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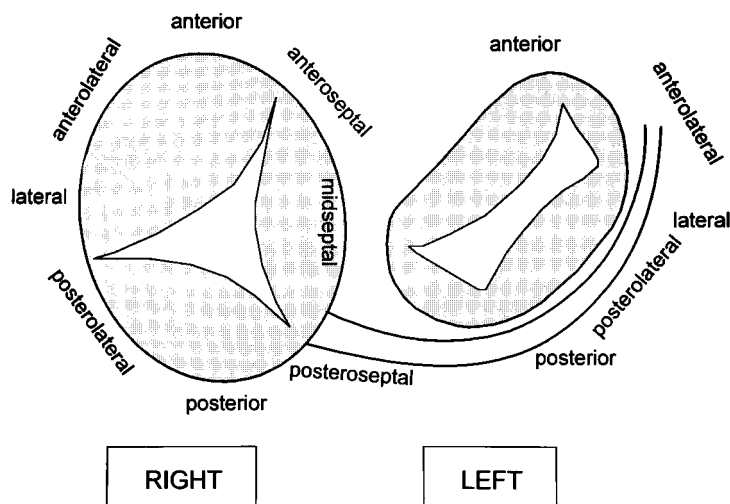


Figure 1 Schematic representation of the atrioventricular junctions in the left anterior oblique projection, showing the anatomically inaccurate nomenclature currently used for the locations of accessory pathways. The aortic valve is not shown. See Figs 2–4 for anatomical orientation and detail.

Such discrepancies now achieve greater importance since, with the development of catheter ablation, treatment of accessory pathways and nodal tachycardia has largely become the province of the electrophysiologist, but with the retention of surgical nomenclature^[11–15]. Since the electrophysiologist must navigate around the heart under fluoroscopic control, with the heart viewed as in the setting of the anatomical position of the patient, the terms used by the surgeon, and adopted by electrophysiologists, no longer relate accurately to the location of the heart in the body.

While the target of ablation was the substrate for abnormal atrioventricular conduction, the success of the procedures disguised the need for anatomically correct terminology, since the operators learnt to guide their catheters around the atrioventricular rings irrespective of the accuracy of the words used for description. Current extension of ablative procedures to treat atrial^[16–19] and ventricular arrhythmias^[20–22] now makes it advisable to use terms which not only describe the atrioventricular rings and the adjacent chambers accurately, but also, at the same time, make it possible to describe them correctly in reference to the anatomical position.

As a solution to this problem, the Working Group of Arrhythmias of the European Society of Cardiology and the North American Society of Pacing and Electrophysiology have convened panels of experts to work together to provide an anatomically accurate nomenclature. This document reviewing the anatomical position and nomenclature of the atrioventricular junctions is the first result of this joint effort. We have chosen the term *AV Junctions* to include the atrioventricular rings and the more complex septal and paraseptal areas containing the atrioventricular conduction structures, as well as many atrioventricular accessory connections. Once the true anatomical coordinates are applied to the

atrioventricular junctions the anatomical location of all cardiac structures should become easy to describe. However, the authors recognize the need to extend this effort in the near future to the even more complex anatomy of atria and ventricles.

The root of the problem

Descriptions of the locations of the accessory connections responsible for the Wolff–Parkinson–White syndrome are currently made relative to the atrioventricular

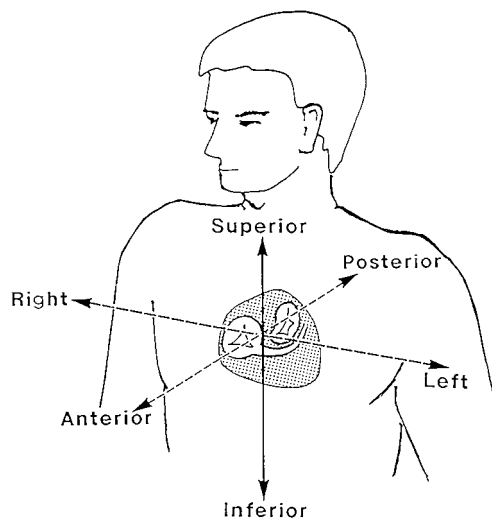


Figure 2 Schematic representation of the atrioventricular junctions within the heart and the body in the left anterior oblique projection. The correct anatomical coordinates are shown. Note the discrepancy with current nomenclature shown in Fig. 1.

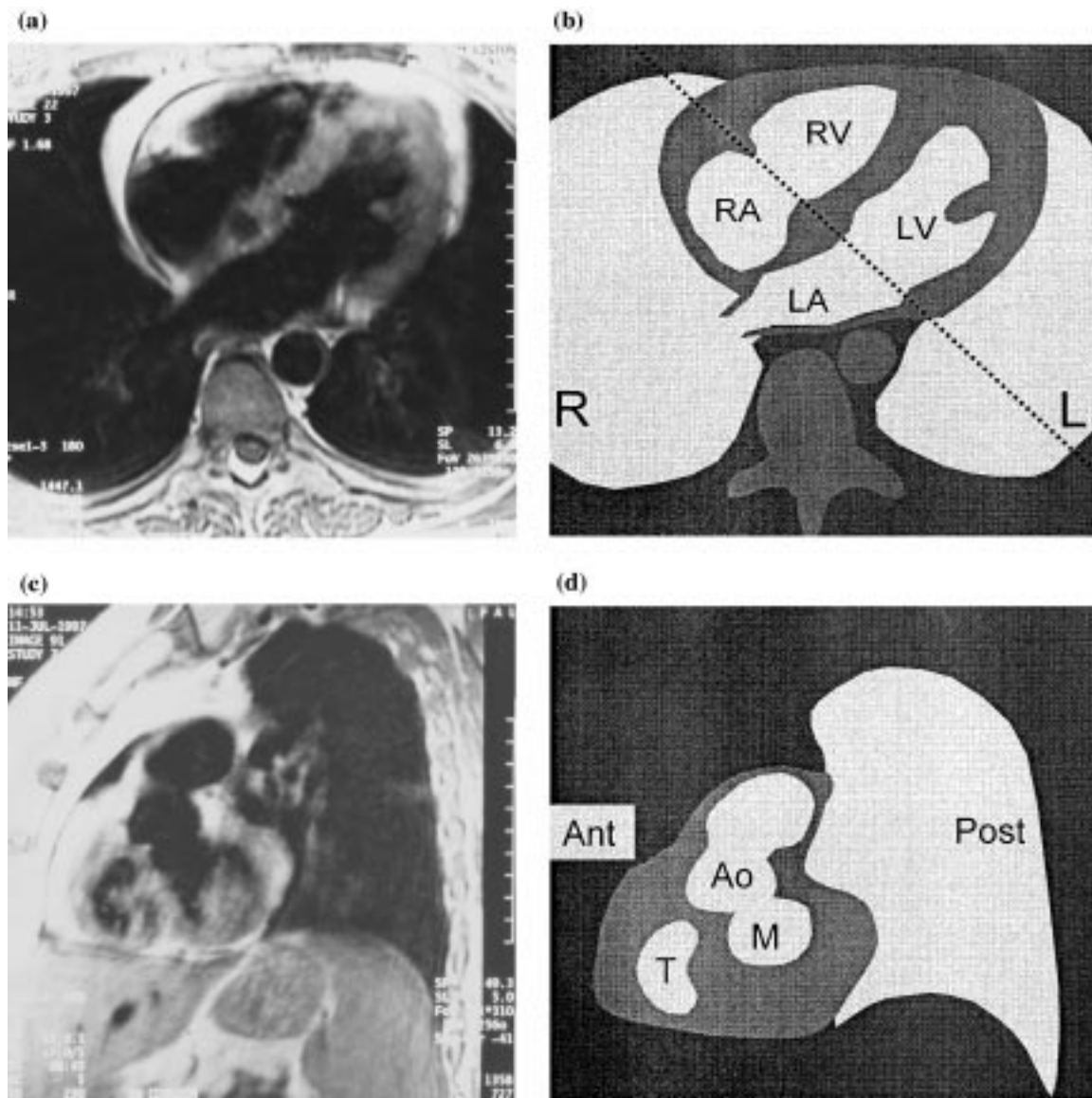


Figure 3 (a) View of the heart, through the mitral and tricuspid planes, atria and ventricles using horizontal magnetic resonance. (b) Schematic reproduction of (a) with appropriate labels. The main direction of the valvar planes, marked by the dotted line in (b), is from the anterior (right) to the posterior (left). L=left, LA=left atrium, LV=left ventricle, R=right, RA=right atrium, RV=right ventricle; (c) oblique sagittal magnetic resonance image of the heart, parallel to the plane of the atrioventricular valves (dotted line in (b)), showing the position of the mitral and tricuspid valvar orifices and the aortic root in the left anterior oblique view, as in Fig. 4; (d) schematic reproduction of (c) with appropriate labels. Ant=anterior, Ao=aortic root, M=mitral valve, Post=posterior, T=tricuspid valve.

junctions, as seen in the left anterior oblique radiographic projection (Fig. 1). The descriptive terms used, however, are anatomically inaccurate. The superior aspect of the heart is described as being anterior, while the anterior and posterior aspects are described as right and left lateral (Fig. 2). Reference to the location of the heart, as seen in the anatomical position (Figs 3 and 4), demonstrates the inaccuracy of this approach. This mismatch between current nomenclature and the true anatomical position engenders major problems in teaching the appropriate movement of catheters in the electrophysi-

ology laboratory, and underscores inaccuracies in correlating the electrocardiographic patterns of preexcitation with the location of accessory muscular atrioventricular connections.

The fluoroscopic screen presents the thorax in an upright image, even if the patient is recumbent. This facilitates recognition of anatomical positions by showing superior structures in the upper part of the screen, such as the superior caval vein, and inferior ones in the lower part, such as the inferior caval vein. Oblique and lateral views give no problems in defining

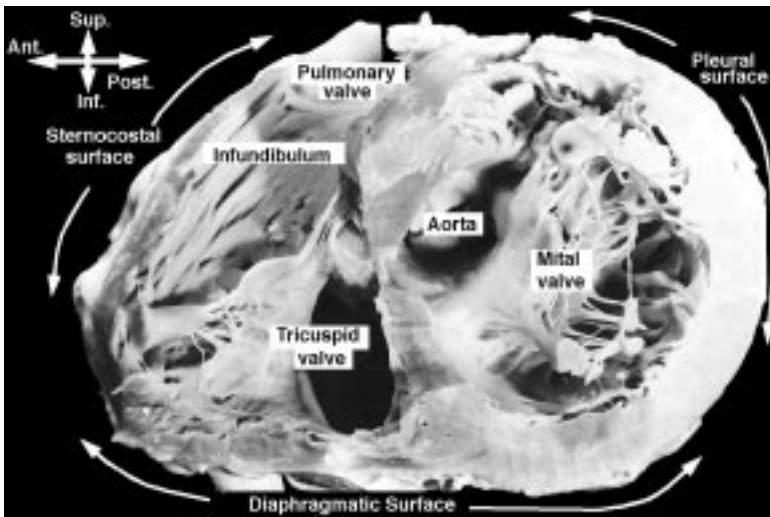


Figure 4 Photograph of the ventricular aspect of the atrioventricular junctions. The ventricles have been cut away parallel to the atrioventricular junctions, and the image is placed in the same anatomical position as that of Fig. 3(c) and (d). The aortic root is interposed between the superior aspects of the mitral and tricuspid valvar orifices. Anatomical axes are shown, and the segments of the atrioventricular junctions are labelled according to their appropriate anatomical position.

antero-posterior directions, because the spine and the sternum are clearly recognizable as reference markers. According to current nomenclature, nonetheless, the trainee in electrophysiology is taught to move the catheter 'anteriorly' from the inferior caval vein to reach the His bundle, even though the catheter is seen to move upwards on the screen during this manoeuvre. Similarly, the trainee is taught to move the catheter 'posteriorly' from the superior caval vein to reach the mouth of the coronary sinus, when in reality the catheter is seen to move down.

The obvious distortion of logical thinking provoked by this nomenclature is well portrayed in left anterior oblique or lateral fluoroscopic views. In these projections, the position of the His bundle and mouth of the coronary sinus are approximately equidistant from the spine and the sternum (Figs 5–6), but the His bundle itself is superiorly positioned relative to the coronary sinus. Another obvious distortion is the designation of accessory pathways located in the upper margins of the mitral ring as being 'anterior'. In the left anterior oblique view, such pathways can be seen to be close to the spine, and hence in reality to be relatively posterior (Fig. 5). A further example is the designation of those accessory pathways, which insert in the lower part of the parietal tricuspid ring, as 'posterolateral', while these pathways really occupy an inferior and anterior position (Fig. 6). Such distortion would be of relatively little importance if only the atrioventricular junctions had to be mapped. The problems are greatly exacerbated, however, when mapping is extended to include the atria. Current nomenclature prevents any accurate description of the posterior and anterior atrial walls, and makes

impossible the logical understanding and teaching of endocardial mapping (Fig. 7).

Since vectorial analysis of the electrocardiogram is also based on the anatomical position, patterns of preexcitation are similarly difficult to explain logically when current nomenclature is taken literally. Thus, for the beginner, it is unclear why a presumed 'posterior' accessory connection should produce negative delta waves in the inferior leads. When posterior is translated to inferior, then the correlation immediately becomes easy to understand and to teach. The same can be said for 'left lateral' accessory connections producing R waves, or 'right lateral' connections producing negative QRS complexes in right precordial leads V_1 – V_3 . Probably because of this non-anatomical nomenclature, it has been necessary to construct rather complex diagnostic algorithms to provide clinical correlations, and these are often used in preference to intuitive vectorial analysis^[23–26].

Basis for an anatomically correct nomenclature

For the purposes of anatomical description^[6], the body is viewed in the upright position and has three orthogonal axes: superior–inferior, posterior–anterior, and right–left (Fig. 2). The same axes are used to describe the electrocardiogram, and also in fluoroscopic projections. The atria are fixed in the thorax by the connection of the pulmonary and caval veins, together with the attachment of the arterial trunks. The position of the ventricles, and hence the atrioventricular junctions, is

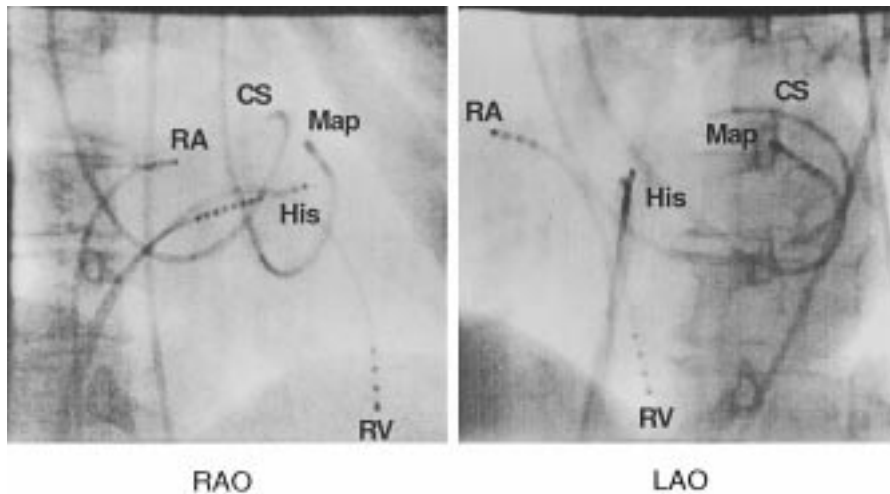


Figure 5 Right anterior (left) and left anterior (right) oblique fluoroscopic views of mapping catheters during ablation of accessory pathways. RA marks the atrial appendage, and CS the coronary sinus. The ablation catheter (Map) is on the superior segment of the mitral ring (see Figs 2–4 for reference) in what is currently known as a ‘left anterior’ position. Note that this position is, in fact, very much posterior, overlying the spine in this view. The His catheter is not anterior, but in a position mid-way between RA and Map. The CS catheter is posterior only in its distal portion, with most of its course being inferior. In the right anterior view of the planes of the mitral and tricuspid valves overlap in such a way as to make it impossible to distinguish antero-posterior directions.

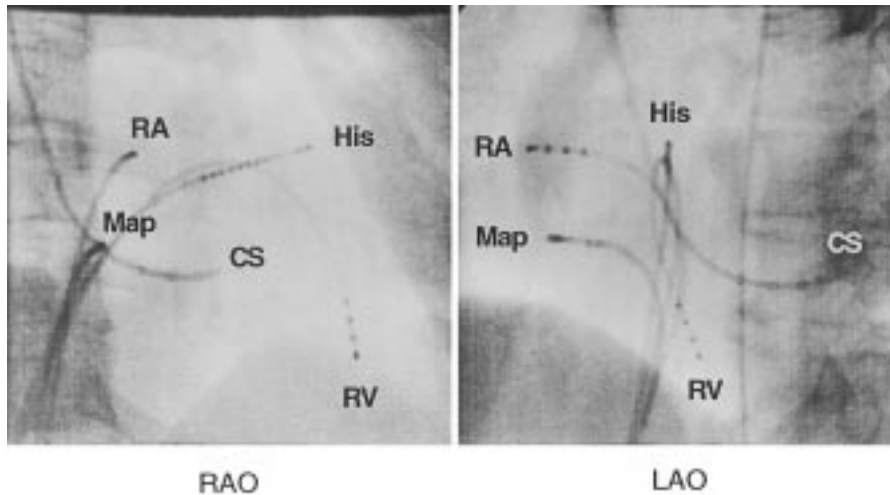


Figure 6 Right anterior (left) and left anterior (right) oblique fluoroscopic views of mapping catheters during ablation of accessory pathways. RA marks the right atrial appendage, and CS the coronary sinus, with the catheter less advanced within the sinus than in Fig. 5. The ablation catheter (Map) is on the infero-anterior segment of the tricuspid ring, in what is currently known as a ‘right posterolateral’ position. The left anterior oblique view confirms that the true anatomical position is inferior and anterior.

more variable. The axis of the ventricles tilts laterally to the left from base to apex, extending anteriorly and slightly inferiorly, with the atrioventricular junctions following the orientation of the ventricles. The junctions, nonetheless, have a relatively constant relation-

ship to the bodily coordinates. It is recognized that the so-called *right* atrium and ventricle are more accurately described as anterior to the *left* atrium and ventricle, respectively, however, we hesitate to challenge this traditional designation at this point.

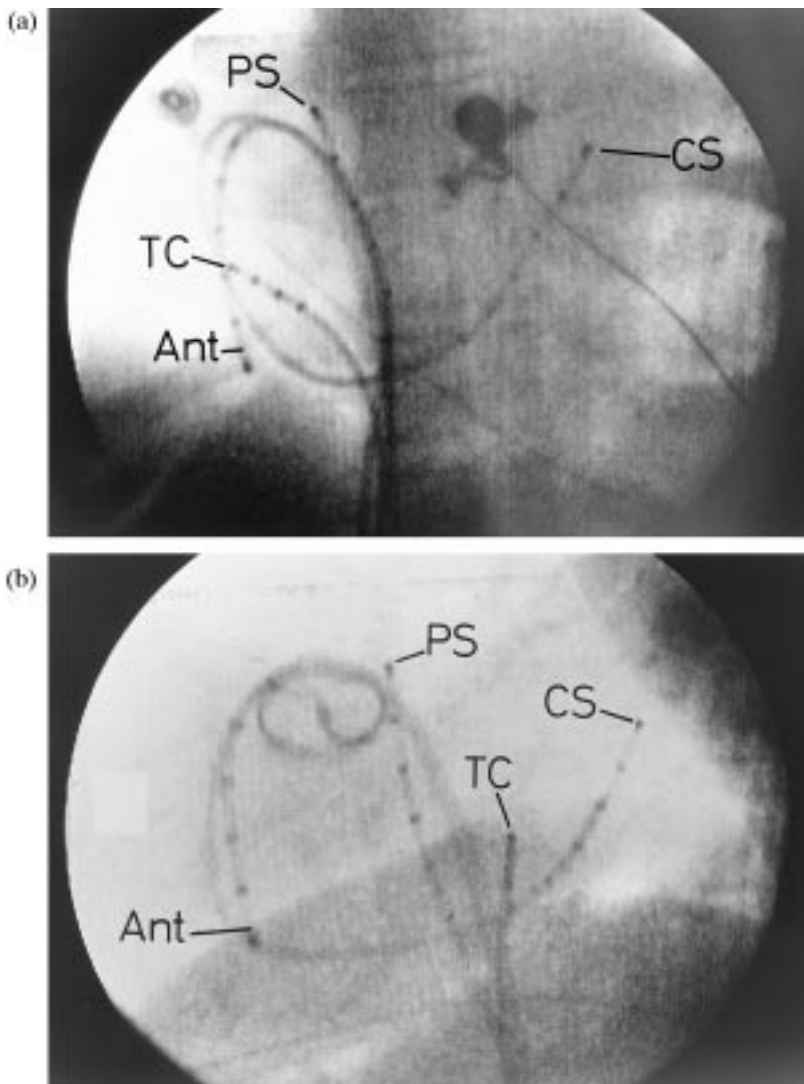


Figure 7 Anteroposterior (a) and left lateral (b) fluoroscopic views of catheters in the anterior right atrium (Ant), the paraseptal right atrium (PS), the coronary sinus (CS) and the low posterolateral right atrium at the level of the terminal crest (TC). Note that this last position is impossible to describe accurately with current terminology, as used for description of the atrioventricular junctions. With current conventions, the position of the tip of the catheter placed against the antero-inferior part of the right atrium would be called 'posterolateral'. An aortic valvar prosthesis marks the superior position of the aortic root. (Modified from: Cosio FG *et al.* Endocardial catheter mapping of atrial arrhythmias. In: Shenasa M, Borggreffe M, Breithardt G, eds. *Cardiac Mapping*. New York: Futura, 1993: 443–59).

Anatomically correct description of catheter positioning

An accurate account of the coordinates of the valvar orifices is provided by the simple expedient of relating appropriately the view obtained in the left anterior oblique projection to the supero-inferior and antero-posterior coordinates of the body. The tricuspid valvar orifice, with its leaflets occupying antero-superior, inferior and septal positions, can then be considered in terms of superior, superior paraseptal, septal, inferior

paraseptal, inferior, antero-inferior, anterior and antero-superior sectors (Fig. 8). Within these coordinates, the central fibrous body and the bundle of His are located in the superior septal region of the tricuspid valvar circumference (Figs 5–7). The mitral and tricuspid rings are adjacent inferiorly, separated in the region of off-setting of the valvar leaflets by an area of overlapping atrioventricular muscular contiguity. The subaortic outflow tract is interposed more superiorly, between the mitral valve and the septum. Using the correct anatomical coordinates, the parietal part of the left atrioventricular

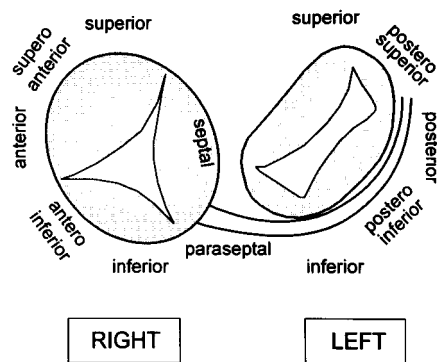


Figure 8 Schematic representation of the atrioventricular junctions in the left anterior oblique view, as shown in Fig. 1. An anatomically correct nomenclature is shown for the different segments of the junctions. The table shows the important differences from the presently accepted nomenclature.

junction, which supports the mural (postero-inferior) leaflet of the mitral valve, can then be described accurately as possessing superior, postero-superior, posterior, postero-inferior and inferior sectors (Fig. 8).

Fluoroscopic guide to mapping the atrioventricular junctions so as to localize accessory pathways

Accessory muscular pathways are mostly localized within the atrioventricular fat pad close to the endocardial aspect of the atrioventricular junctions. Their anatomical classification follows the orientation of the junctions. In the electrophysiological laboratory, assessment of the orientation of the junctions is almost always based on information derived from the fluoroscopic image after the insertion of multiple electrode catheters into the heart.

Since the right and left atrioventricular junctions are superimposed in the anterior–posterior projection, but mostly in right anterior oblique views, precise localization is achieved by using the left anterior oblique view (compare Figs 1, 3 and 5–7). This allows recognition of the right and left free walls, and the distinction of these parietal zones from the septal area. Since the coronary sinus is positioned within the left atrioventricular junction, and drains inferiorly and rightward as it extends to reach its right atrial termination, a multiple electrode catheter inserted within the sinus permits accurate localization of most left-sided accessory pathways, particularly when also manoeuvred into the great cardiac vein. After localizing the accessory pathway, an ablation catheter can be positioned at either the atrial or ventricular aspect of the atrioventricular junction, opposite to the position of the electrodes within the coronary sinus or cardiac vein marking the site of the pathway. Accessory pathways localized in the septal and paraseptal areas are mapped with an electrode catheter

Table 1 Equivalence between current nomenclature and proposed terminology, based on anatomical positions

	Current (attitudinally incorrect)	Proposed (attitudinally correct)
Right	Anterior	Superior
	Antero-lateral	Supero-anterior
	Lateral	Anterior
	Postero-lateral	Infero-anterior
	Posterior	Inferior
Left	Anterior	Superior
	Antero-lateral	Supero-posterior
	Lateral	Posterior
	Postero-lateral	Infero-posterior
	Posterior	Inferior
Septal/paraseptal	Anteroseptal	Superoparaseptal
	Posteroseptal	Inferoparaseptal
	Midseptal	Septal

introduced either from the right or left side, and manoeuvre within a space which is limited superiorly by the His-bundle catheter and inferiorly by the catheter introduced through the mouth of the coronary sinus. Mapping and ablation around the tricuspid junction is usually performed from the atrial aspect, using a catheter which can be moved around the entire junction. Representative examples of catheter positions taken around the right and left junctions, and profiled in right and left anterior oblique views, are shown in Figs 5 and 6. Mapping of the right atrium (Fig. 7) underlines still further the importance of an anatomically correct designation of anterior and posterior positions so as to understand atrial anatomy and related arrhythmias.

Conclusions

By applying anatomically appropriate designations to the sectors of the atrioventricular junctions, as viewed in the fluoroscopic screen, we are able to provide a system of description that is both simple and accurate. Use of the terms proposed will permit the operator to manoeuvre catheters under fluoroscopy in an entirely logical fashion, a facility not provided by existing terminology (Table 1). Understanding patterns of pre-excitation, as seen on the electrocardiogram, should also be facilitated, based on traditional vectorial analysis. The system of description produced will be equally valid in locating the different parts of the atrial and ventricular chambers, and will prove particularly helpful when using the new generations of 'navigational' catheter mapping systems rapidly emerging for treatment of cardiac arrhythmias.

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Appendix

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