REVIEW

Cardiac Anatomy for the Interventional Arrhythmologist: I.Terminology and Fluoroscopic Projections

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Cardiac anatomy is complex and its understanding is essential for the interventional arrhythmologist. The first difficulty is the terminology used to describe the location of sites of mapping and ablation. For many years, electrophysiologists have named these positions following the conventional electrocardiographical vocabulary, or the terminology used by surgeons performing arrhythmic surgery. This traditional nomenclature, however, failed to take note of the crucial principle of considering the location of the heart in the human body as viewed in its erect position. In other words, it had failed to use an attitudinally appropriate terminology. Almost 10 years ago, a new attitudinal nomenclature was proposed for the right and left atrioventricular junctions. In this first of a series of reviews of cardiac anatomy as seen by the interventional arrhythmologist, we discuss the role of attitudinally appropriate terminology, and relate this to the projections used for cardiac fluoroscopy, fluorography, and angiography. Throughout our series of reviews, we will illustrate the value of The Visible Human Slice and Surface Server in facilitating the understanding of the fluoroscopic anatomy. (PACE 2010; 33:497–507)

fluoroscopy*, *ablation*, *mapping*, *anatomy*, *attitudinal nomenclature

Introduction

The establishment of radiofrequency catheter ablation as the mainstay in the treatment of tachycardia in man has renewed the interest in cardiac morphology. The interventional arrhythmologist has drawn attention not only to the gross anatomic details of the heart, but also to some architectural and histological characteristics of various cardiac regions that are relevant to the understanding of the tachycardia substrates, and the potential complications of catheter ablation. Progress in these areas has not ceased. In this review, therefore, the first of a proposed series, we update and expand previous accounts of cardiac anatomy as seen by the arrhythmologist.[1–5]

Some 10 years ago, members of the *Working Group of Arrhythmias of the European Society of Cardiology*, and of the *Task Force on Cardiac Nomenclature from North American Society of Pacing and Electrophysiology,* established a new, attitudinally oriented nomenclature aimed at correcting previous terminological errors when referring to the positions of electrode–catheters at the atrioventricular (AV) junctions during fluoroscopically guided mapping and ablation procedures.[6] We will follow this nomenclature, but clarify some misnomers and conceptual errors concerning the basic cardiac anatomy.

In this review, and in those that will complete the series on Cardiac Anatomy for the Interventional Arrhythmologist, we use *The Visible Human Slice and Surface Server*, extensively. This is an open-access, Web-based software developed by Hersch and co-workers from the Geneva Hospitals and WDS Technologies SA using data sets of the *Visible Human Male and Female Project* of the *National Library of Medicine*, USA.[7,8] The data sets originate from two human bodies donated to science, one from a male and the other from a female. These bodies were frozen and sectioned axially at intervals of 1 mm for the male body and 0.33 mm for the female. This material was digitized and can be obtained from the *National Library of Medicine* of the USA.[8] *The Visible Human Slice and Surface Server* is available at a Web-server, and any

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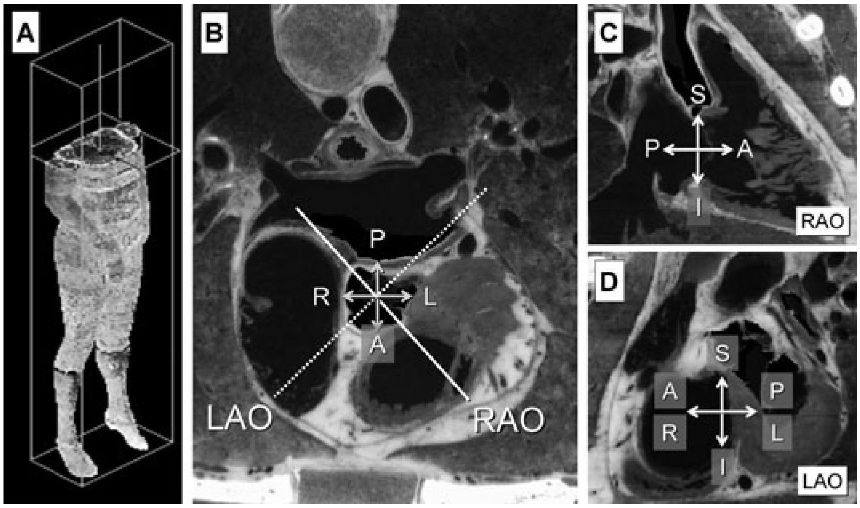

Figure 1. *The Visible Human Project® was aimed at creating a digital image data set of a human male and female cadaver. The Visible Man is a set of digital images from the body of a 39-year-old man, Joseph Paul Jernigan, who donated his body to science after being convicted of murder and sentenced to death. He was executed by lethal injection in Texas in 1993. The Visible Man data were made available in 1994. The Visible Woman data are from a 59-year-old woman who died of natural causes. These data were made available in December 1995. For both the male and female, images of the body were first obtained using magnetic resonance (MR) and computed tomography (CT) scan imaging techniques. The bodies were then embedded in gelatine, frozen, and sliced cross-wise into transverse slices that were 1-mm wide for the male, and 0.33 mm for the female. The entire data set is about 14 gigabyte (GB) for the male and 39 GB for the female, but only 13 GB of the female data are currently in use. Panels A and B show how The Visible Human Slice and Surface Server enables us to obtain axial slices. Panels C and D illustrate how right and left anterior oblique (RAO, LAO) slices can be obtained along the axes shown in panel B. Axial slices cannot be obtained with fluoroscopy but are customary with multislice CT and cardiac MR imaging studies. Axial sections of the heart enable us to define what is anterior (A), posterior (P), right (R), and left (L). In the RAO projection (panel C) we can define what is anterior, posterior, superior (S), and inferior (I), In the LAO projection we can determine what is superior and inferior, anterior and posterior, and right and left (panel D).*

registered client can obtain slices with the desired orientation from these bodies (Fig. 1).[7]

Traditional Nomenclature for the AV Junctions

So as to name the positions of electrode–catheters within the heart, and to refer to the walls of the cardiac chambers, clinical electrophysiologists during the 20th century used a nomenclature combining traditional electrocardiographic terms with the terminology introduced during the late 1970s and the 1980s to locate accessory pathways in the surgically exposed heart.[9–15] Electrophysiologists involved in intraoperative cardiac mapping, and surgeons performing ablation of accessory pathways and the substrates for AV nodal reciprocating tachycardia, distinguished several components of the right and left AV grooves. Thus, in the tricuspid valvar orifice, the so-called anteroseptal region was considered to extend from the central fibrous body to the epicardial reflection of the most superior area of the right ventricle, this being the extension of the supraventricular crest into the free wall of the ventricle (Fig. 2A). The right-sided free wall was considered to extend from the boundaries of the anteroseptal region to the inferior hinge of the septal leaflet of the tricuspid valve. The supraventricular crest itself is the musculature in the roof of the right ventricle interposed between the leaflets of the tricuspid and pulmonary valves. The so-called posteroseptal region included the pyramidal space, interposed between the central fibrous body and the hinges of the facing leaflets of the mitral and tricuspid valves, to the epicardial confluence of the right and left ventricles in the posteroinferior AV groove. The left-sided free-wall region comprised the arc of the left AV groove from the point of continuity between the leaflets of the aortic and mitral valves to the ventricular septum (Fig. 2). The right-sided free-wall was further subdivided into a right anterior,

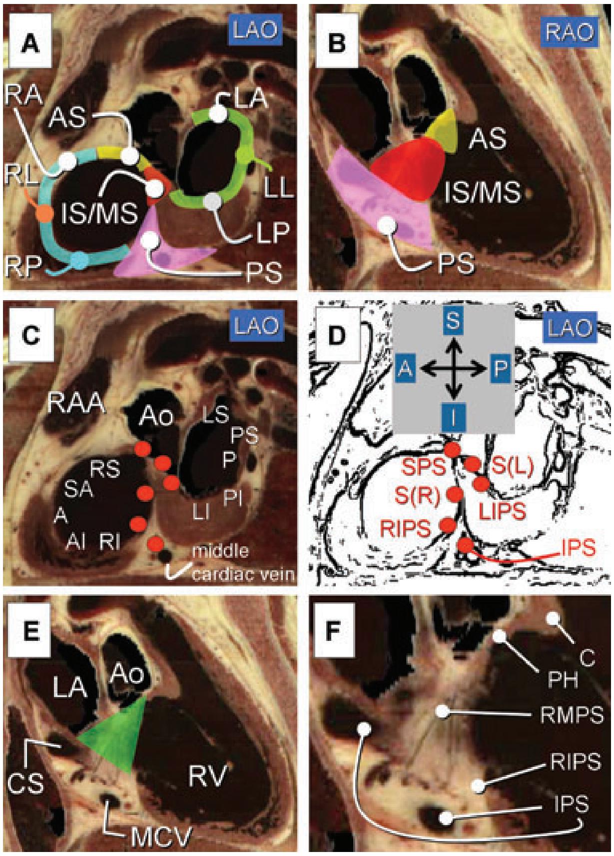

Figure 2. *Anatomical slices of a male heart from The Visible Human Slice and Surface Server.[7] Traditional terminology is shown in panels A and B, and current attitudinal nomenclature in panels C and D. Panels A and B show a LAO and a RAO section of the heart, respectively. Traditional terminology distinguished the regions of the AV junctions as being anteroseptal (yellow), right free-wall (cyan), posteroseptal (pink), intermediate septal (IS) or midseptal (MS) (red), and left free-wall (green). The free-wall regions were subdivided by electrophysiologists into various areas, shown as RA = right anterior; RL = right lateral; RP = right posterior; LP = left posterior; LL = left lateral; LA = left anterior. In panels C and D, we show the names proposed on attitudinal bases. Panel C: RS = right superior; SA = superoanterior; A = anterior; AI = anteroinferior; RI = right inferior; LI = left inferior; PI = posteroinferior; P = posterior; PS = posterosuperior; LS = left superior; RAA = right atrial appendage; Ao = aorta. Panel D: septal and paraseptal locations. SPS = superior paraseptal; IPS = inferior paraseptal; S(R) = septal at the right side of the heart; S(L) = septal at the left side of he heart; RIPS = right inferior paraseptal; LIPS = left inferior paraseptal; IPS = inferior paraseptal. Panel E shows the triangle of Koch (green) in a RAO section of the heart. Panel F is an enlarged view of this region illustrating the location of paraseptal accessory pathways. The superior paraseptal region harbors two types of bypass tracts: cristal (C) and para-Hisian (PH). The so-called septal region of the new nomenclature is paraseptal rather than septal, and harbors the accessory pathways approached from the triangle of Koch (right mid-paraseptal [RMPS]) and those ablated from the immediately subaortic ventricular septum that can be termed left mid-paraseptal (not illustrated in this figure). Among the inferior paraseptal accessory pathways, we should distinguish the right inferior paraseptal (RIPS), the inferior paraseptal (IPS), and the left inferior paraseptal (LIPS). The location of the latter type of bypass tract is shown in panel D. The IPS location includes accessory pathways that are approached from the coronary sinus (CS) and the middle cardiac vein (MCV) (panels E and F). Note that the triangle of Koch is an atrioventricular (AV) sandwich containing fibro-fatty tissue, the AV node and its extensions, atrial and transitional myocytes, and, more deeply, the summit of the ventricular septum. Panels E and F have been obtained in a RAO projection at the level of the fibro-fatty tissue of the triangle of Koch so that the atrial myocardium would be immediately above this slice, and the ventricular septum immediately behind it. The pyramidal space is not septal, but consists of the inferoposterior epicardial fat containing the CS and its tributaries. This fibro-fatty tissue penetrates between the buttocks of both ventricles toward the central fibrous body.*

right lateral, and right posterior areas, while the left free-wall was also segmented into left posterior, left lateral, and left anterior territories. This subclassification for the right and left free-wall regions was less important for the surgeon than for the clinical electrophysiologist, because the surgical approach to ablation of accessory pathways inserting to the right or left free-walls did not depend on the exact location of the bypass tract within the tricuspid or mitral AV junctions.[16,17]

During the days of Wolff-Parkinson-White (WPW) surgery, John Gallagher, while at Duke University, found accessory pathways whose anterograde exit was in the so-called anteroseptal region, but with the retrograde breakthrough close to the coronary sinus, as for purported posteroseptal pathways. Details of these accessory pathways, named intermediate septal, were presented at the Scientific Sessions of the American Heart Association of 1986, albeit never published, to the best of our knowledge, as a full paper.[18] Epstein and colleagues, from Birmingham, Alabama, nonetheless subsequently reported on four patients with WPW syndrome subjected to surgical ablation, and classified the accessory pathways as being intermediate septal. In three cases, the pathway was localized in the middle of the triangle of Koch, while in the fourth patient it was found at its superior apex, in the peri-Hisian region.[19] Prior to that, Jackman et al., from Oklahoma, in the brief era of direct current (DC)-shock ablation, had differentiated a variety of alleged posteroseptal bypass tracts, finding their putative accessory pathway potentials in the triangle of Koch, behind the His bundle, and anterior to the mouth of the coronary sinus.[20] These accessory pathways were termed midseptal, and it has been that term which has subsequently proved most popular[21–23] (Fig. 2).

It was Gerard Guiraudon, in an abstract that again, as far as we know, was never published as a full paper, who then introduced the concept of para-Hisian accessory pathways.[24] Subsequently to this, Haissaguerre et al. characterized these para-Hisian pathways as entities discrete from the so-called anteroseptal bypass tracts, noting that the atrial and ventricular insertions of para-Hisian pathways were associated with the recording of a large His bundle potential of greater than 0.1 mV. Anteroseptal bypass tracts differed from para-Hisian pathways in that at the site of ablation the His bundle potentials are recorded with a lower amplitude, and their atrial or ventricular insertions are away from the region of the His bundle.[25]

More recently, Kuck and his colleagues, from Hamburg, have described left-sided midseptal accessory pathways, albeit the offered characterization was far from complete.[26] Several studies have shown how the conventional 12-lead electrocardiogram (ECG) can serve to identify the location of the ventricular insertion of the accessory pathway along the right and left AV rings, as well in the so-called anteroseptal, para-Hisian, midseptal, and posteroseptal regions.[18–26]

Attitudinally Oriented Nomenclature for the AV Junctions

As already stated, the *Working Group of Arrhythmias of the European Society of Cardiology* and the *North American Society of Pacing and Electrophysiology* assembled a panel of experts to propose an attitudinally based nomenclature for the AV junctions.[6] The authors acknowledged the need of extending this effort to the atria and ventricles. The term attitudinal, however, was not used in their document. Instead, the panel of experts referred to an "anatomically correct" nomenclature. Because any reference to structures within the human body should be described relative to the subject as seen in an upright position, we use the term attitudinally oriented nomenclature, as suggested by McAlpine in 1995.[27]

The Right and Left AV Grooves

Axial sections of the heart define without ambiguity what is anterior and what is posterior. They show that, in the transverse plane, the AV junction supporting the leaflets of the tricuspid valve has a posterior-to-anterior orientation when assessed from its medial segments to the lateral ones (Fig. 3). When viewed longitudinally, the right AV junction has a superior to inferior orientation. This means that positions that, in the traditional nomenclature, were considered as anterior are, in fact, superior. Those previously referred to as being right lateral are truly right and anterior (Figs. 2 and 3). The left anterior oblique (LAO) projection enables us to see the tricuspid AV junction almost parallel to our plane of observation. This then permits the definition of five sectors in the right junction, which when considered in attitudinal orientation, are right superior, right superoanterior, right anterior, right anteroinferior, and right inferior (Fig. 2C).

The axial slices also permit us to appreciate that the mitral AV junction, when traced from its most medial component, has an anterior-to-posterior orientation when judged transversally, and a superior-to-inferior course when considered longitudinally. Positions that, in the traditional terminology, were labeled as left lateral are, in fact, posterior (Figs. 2 and 3). The LAO projection is again almost parallel to the plane of the mitral AV junction, and this permits us once more to define five sectors in its free wall. When described attitudinally, they are left inferior, inferoposterior, posterior, posterosuperior, and superior (Fig. 2).

The Complexities of the Septal Region

The septal region is less well defined in the new attitudinally appropriate nomenclature. The ventricular septum, of course, is the muscular wall separating the cavities of the right and the left ventricles. The area initially considered to be anteroseptal, however, does not incorporate any part of this muscular septum. Instead, the sections from the *Visible Human* show that the area is superior and paraseptal (Fig. 2). This designation is correct both regionally and attitudinally. In terms of accessory pathways, however, two discrete types can exist within this broad area. Para-Hisian accessory pathways parallel the bundle of His with their atrial and ventricular insertions close to it (Figs. 2 and 4). These pathways cross the AV junction subendocardially because they are prone to suffer catheter-induced mechanical block without accompanying His bundle block. In addition, it is possible to ablate them with relatively low energy outputs without damaging the bundle of His.[25]

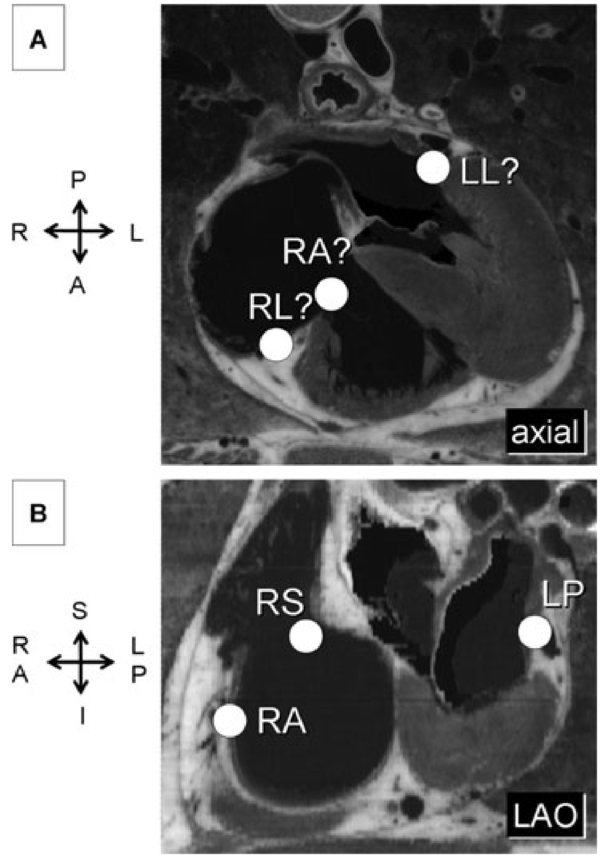

Figure 3. *Limitations of the traditional nomenclature. As shown in panel A presenting an axial section of the heart, the tricuspid and mitral junctions are perpendicular to the plane of the slice. The tricuspid junction, when seen in axial views, runs in a posterior-to-anterior direction from its more medial sector. The mitral junction, from its most medial area, follows an anterior-to-posterior direction in these axial sections. It is clear that what was termed in the past right lateral (RL?) is in fact right anterior, and what termed right anterior (RA?) is indeed right superior. This is more clearly seen in a LAO projection where both AV rings are more or less parallel to the plane of fluoroscopic screen. Considering the tricuspid junction, what was called right anterior (RA, panel A) is in fact right superior (RS, panel B). What was considered right lateral (RL?, panel A) is in fact the most anterior part of the tricuspid ring and should be called right anterior (RA, panel B). The traditional nomenclature erred by considering as lateral those left-sided accessory pathways that were located at the most posterior segment of the mitral annulus (LL?, panel A). The new nomenclature refers to these accessory pathways as left posterior (LP, panel B). Axial sections enable us to determine what is anterior (A) and posterior (P), and also with is right- (R) and left-sided (L). LAO sections as in panel B enable us to determine what is superior (S) and inferior (I), what is anterior (A) and posterior (P), and also what is right- (R) and left-sided (L).*

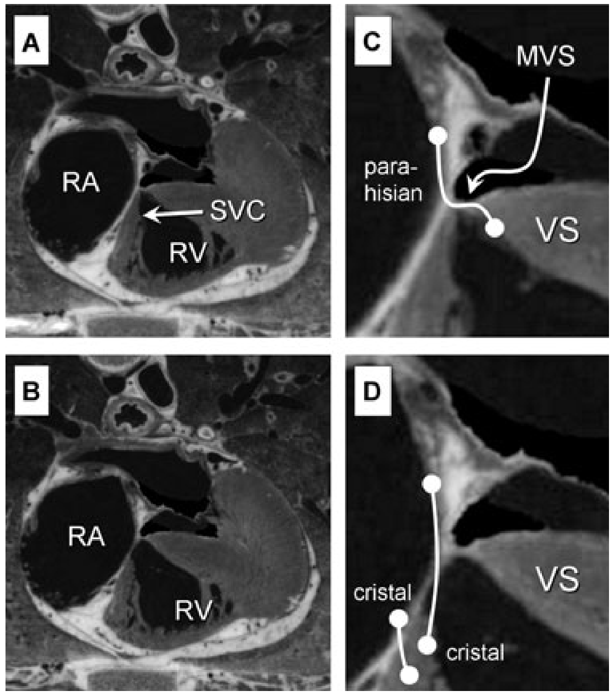

Figure 4. *Axial slices at the most superior level of the summit of the ventricular septum. Slice in panel A was obtained eight pixels more cranially than the slice in panel B. RA = right atrium; RV = right ventricle. SVC = supraventricular crest. Panels C and D are enlarged views of this superior paraseptal area. In panel C we show the possible course of a para-Hisian accessory pathway from the right atrial myocardium close to the region of the bundle of His, to the superior summit of the ventricular septum. While the bundle of His is encased in the membranous ventricular septum (MVS), these para-Hisian pathways run a subendocardial course so that their ablation is possible without inducing AV block. Other types of accessory pathways also considered as superior paraseptal are represented in a theoretical manner in panel D. More cranially, the atrial and ventricular myocardiums at the septal origin of the supraventricular crest can be connected, either from the peri-Hisian atrial myocardium to the crest, or from the crest to the immediately opposite right atrial myocardium.*

The bundle of His itself is the continuation of the compact AV node, becoming the bundle when it penetrates the fibrous tissue of the central fibrous body, this structure itself incorporating the membranous part of the ventricular septum. The second type of accessory pathway initially considered to be anteroseptal is made up of those having one end, usually the atrial one, close to the His bundle, but the other, usually the ventricular, inserting to the superior area of the supraventricular crest, several millimeters apart from the membranous ventricular septum. These pathways are also unequivocally superior and paraseptal in location, being beside or near to, but not at, the septum. Since these pathways need to be differentiated from the para-Hisian ones, we suggest that they be described as cristal bypass tracts (Figs. 2 and 4), since the ventricular insertions are directly related to the supraventricular crest, or the *crista supraventricularis* in the original latin terminology.

The pathways traditionally considered to be midseptal were termed septal in the newly proposed nomenclature (Fig. 2).[6] These bypass tracts are also of two kinds, those that are best approached from the right side of the heart, over the triangle of Koch, and those that are ablated from the immediately subaortic left-sided aspect of the summit of the ventricular septum. The two types of pathways have distinct electrographic expressions.[23] When noting their location within the heart, however, it is immediately apparent that neither the term midseptal, or its equivalent intermediate septal, nor the newer term septal, are anatomically correct. This is not an attitudinal problem, but rather a conceptual one. Both types of pathways extend from the atrial musculature to insert in the crest of the ventricular septum, but throughout their course, they extend within the fibro-fatty tissue that is a continuation of the posteroinferior extracardiac fat pad (Figs. 5 and 6). They are close to, and related with, the ventricular septum, but are nonetheless paraseptal. The right-sided located of these paraseptal accessory pathways are found within the area formed by the surface of the triangle of Koch. An appropriate term that is both descriptive and distinctive is right mid-paraseptal. It would be inappropriate to call them Koch paraseptal accessory pathways, since the apex of the triangle of Koch is itself occupied by para-Hisian and cristal superior paraseptal accessory pathways. The pathways previously distinguished as left-sided and midseptal are appropriately termed left mid-paraseptal. This then serves to differentiate them from left inferior paraseptal accessory pathways, these latter pathways being ablated at more caudal left ventricular sites (Figs. 5 and 6).

The accessory pathways formerly grouped together as being posteroseptal are now called right inferior paraseptal, left inferior paraseptal, and inferior paraseptal (Figs. 2, 5, and 7).[6] The right inferior paraseptal pathways connect the caudal right atrial myocardium with the right ventricular aspect of the ventricular septum, running outside the coronary sinus. The inferior paraseptal accessory pathways are those that are ablated within the coronary sinus or its tributaries, usually the middle cardiac vein (Fig. 8).

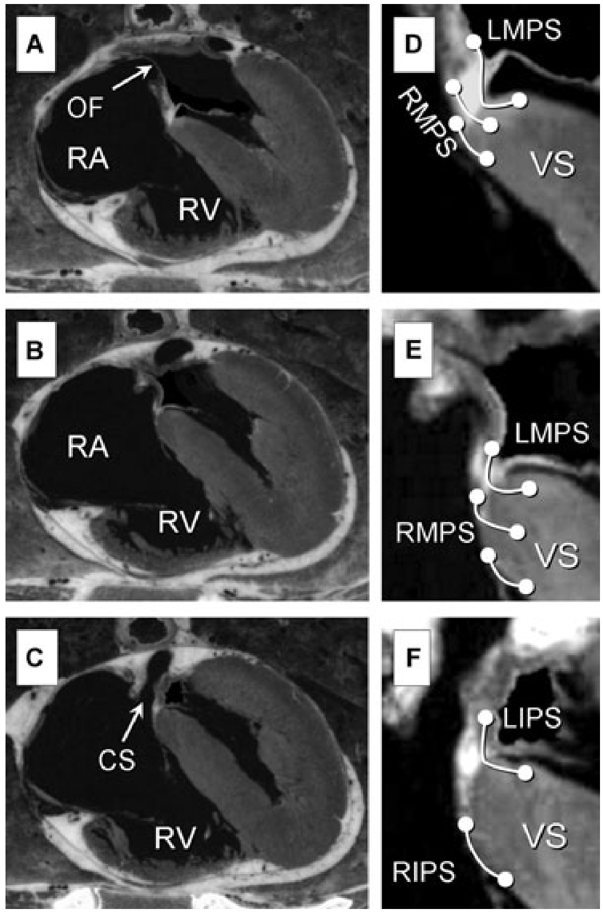

Figure 5. *Successive axial slices obtained from a more cranial (A) to a more caudal (C) position, at three levels: oval fossa (OF) (panel A), the region just above the orifice of the coronary sinus (CS) (panel B), and the ostium of the CS (panel C). Note that the most superior area of the ventricular septum (panel A) is more anterior than the most inferior sector of the ventricular septum at its atrial junction (panel C). Panels D – F are enlarged views at the level of the atrial to ventricular septal junctions of these three levels, to illustrate the potential locations of accessory pathways in these regions. Panel D shows that accessory pathways in this mid-paraseptal area (previously termed midseptal) can connect the left atrial myocardium with the left-sided aspect of the summit of the ventricular septum (left mid-paraseptal, LMPS), or be located at the right side, on the region of the triangle of Koch. The right-sided mid-paraseptal accessory pathways (right mid-paraseptal, RMPS), can connect the atrial myocardium of the triangle of Koch directly with the underlying myocardium of the ventricular septum through the fibro-fatty tissue, or may travel across the tricuspid valve ring toward the right-sided aspect of the ventricular septum. Similar types of accessory pathways at a slightly more caudal level are shown in panel E. Panels C and D illustrate the area of the right and left inferior paraseptal (RIPS, LIPS) accessory pathways.*

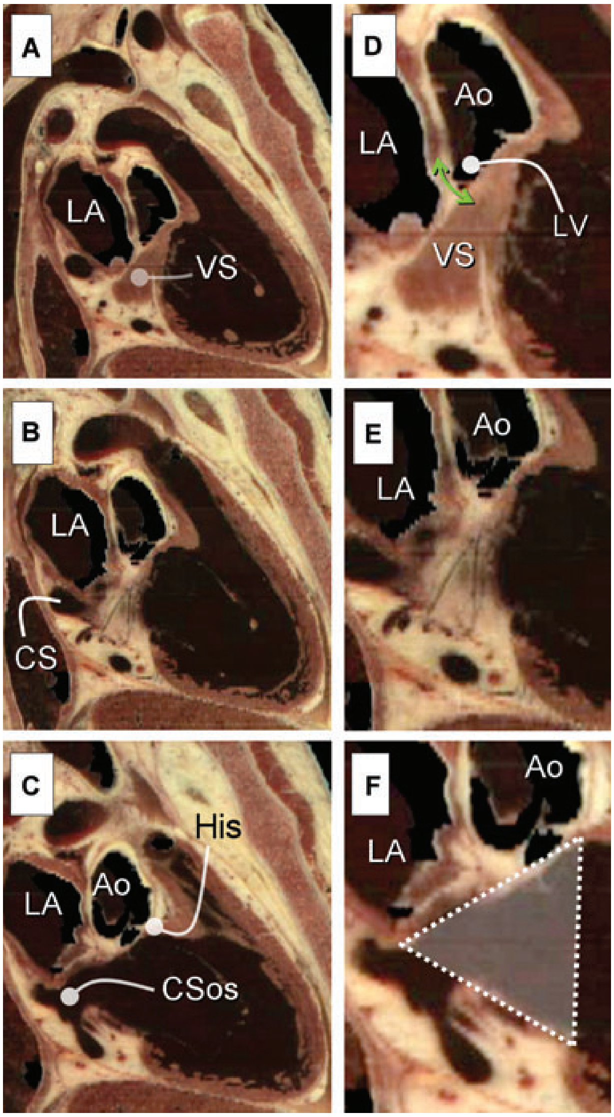

Figure 6. *Panels A–C are three sagittal slices, successively obtained from left to right. Panels D–F are enlarged views from the former three panels to show the paraseptal areas. The slice in panel A is a section at the level of the ventricular septum (VS). The slice in panel B is obtained more to the right, at the level of the fibro-fatty tissue between the ventricular septum and the right atrial myocardium of the triangle of Koch. Finally, panel C is an even more rightward section at the level of ostium of the coronary sinus (CSos). The triangle of Koch is depicted in panel F. In panel D we illustrate the theoretical location of the so-called left-sided mid-paraseptal accessory pathways (double-headed green arrow) connecting the left atrial wall at the level of the interatrial groove (formerly called atrial septum) with the summit of the ventricular septum behind the aorta, and also behind the immediately subaortic left ventricle (LV). The triangle of Koch was called in the past AV septum. This is not a septal structure but the apposition like a sandwich of the right atrial myocardium and the ventricular septal myocardium that in between contains the fibro-fatty tissue that, as shown in panels B and E, is a continuation of the posteroinferior extracardiac fat pad. As shown in panels A and D, the most superior boundary of the ventricular septum is not anterior but has an intermediate location within the thorax.*

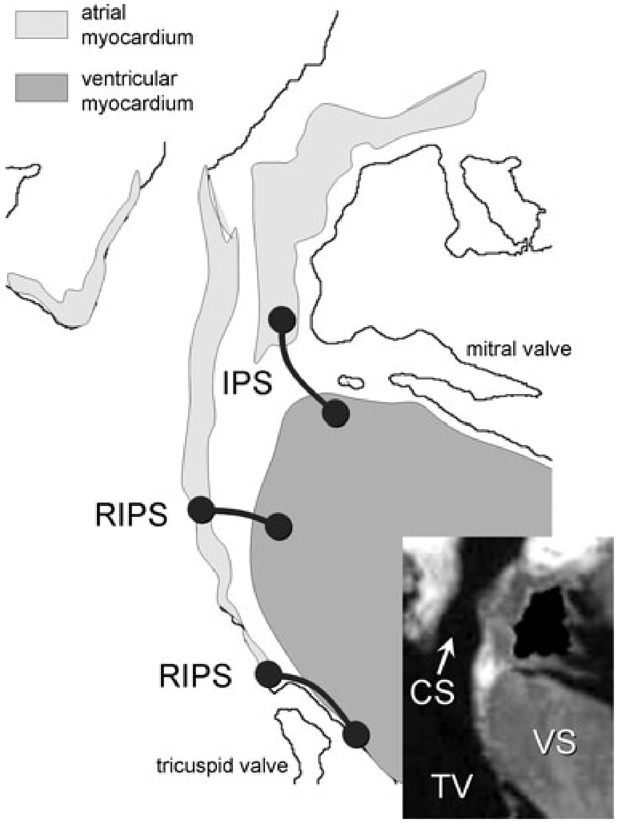

Figure 7. *Right inferior paraseptal (RIPS) accessory pathways are those ablated at the inferior right paraseptal area, outside the coronary sinus. Accessory pathways ablated inside the coronary sinus should be referred to as inferior paraseptal (IPS). Schematic representation of an axial section of the heart at the junction between the ostium of the coronary sinus (CS), the tricuspid valve (TV), and the ventricular septum (VS).*

The above discussion emphasizes the complex nature of the anatomy of the septal region. The most superior boundary of the ventricular septum is not anterior, but has an intermediate location within the thorax (Figs. 6 and 9), behind the cavity of the right ventricle. The right ventricle itself is anterior when considered attitudinally. From its most superior boundary, the septum runs a double course, one directed anteriorly, inferiorly, and to the left, and another, almost vertical,

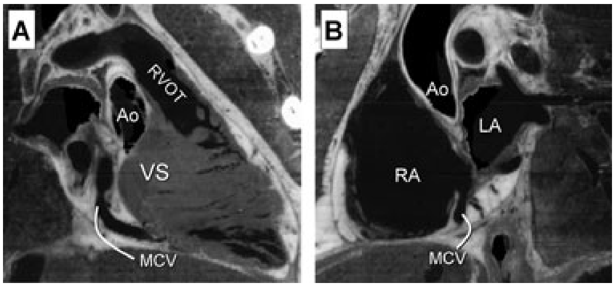

Figure 8. *Middle cardiac vein (MCV) as observed in a RAO and LAO slices of the heart (Panels A and B, respectively). Connections between the middle cardiac vein and the posteroinferior area of the ventricular septum (VS) are known as inferior paraseptal accessory pathways. Abbreviations as in other figures.*

which courses inferiorly and slightly posteriorly (Figs. 9 and 10). The most anterior area of the septum is its apical part, which is anterior, inferior, and left-warded laterally. Always the right ventricle is more anteriorly located than the left (Figs. 9 and 10). This illustrates again the erroneous nature of the concept considering the most superior boundary of the ventricular septum as its

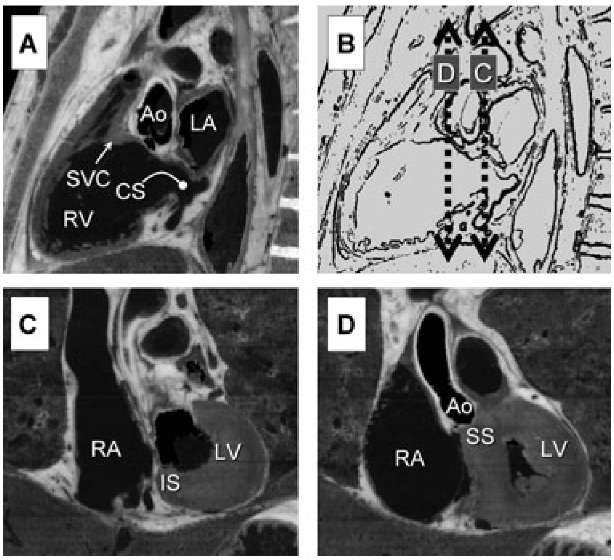

Figure 9. *Panel A: sagittal slice at the level of the ostium of the coronary sinus (CS) and of the supraventricular crest (SVC). Panel B is a schematic representation of the anatomical slice shown in panel A. The dotted vertical arrows indicate the levels at which we have obtained the two frontal sections shown in panels C and D. Panel C: frontal (coronal) slice to show the inferior septum (IS). Panel D: frontal slice at the level of the superior septum (SS). Note that the superior septum is slightly more anterior than the inferior septum.*

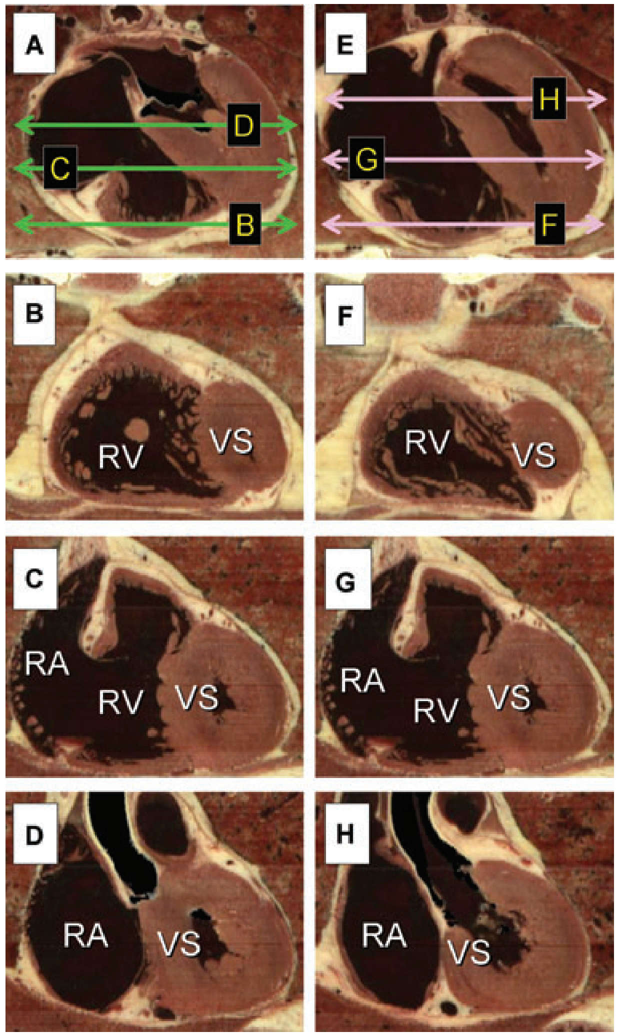

Figure 10. *Panels A and E are two axial slices from The Visible Human Slice and Surface Server obtained at the most superior and inferior boundaries of the ventricular septum, respectively. In both instances we have acquired frontal (coronal) sections from the most anterior retrosternal level (B and F) to the septal most superior limit (D), and most inferior edge (H). Note that the most superior margin of the septum is slightly more anterior than the most inferior septal limit. The coronal slices show that the right ventricle (RV) is always anterior in relation to the most anterior parts of the left ventricle. The ventricular septum (VS) runs anteriorly, to the left, and also inferiorly.*

anteroseptal region. The area of the septum that is closest to the mid-line, this being the sagittal plane at the level of the spine, also runs a course in two directions, superior to inferior, and anterior to posterior (Figs. 9–11). In the past, the most rightward portion of this area was called the muscular AV septum, since the septal right

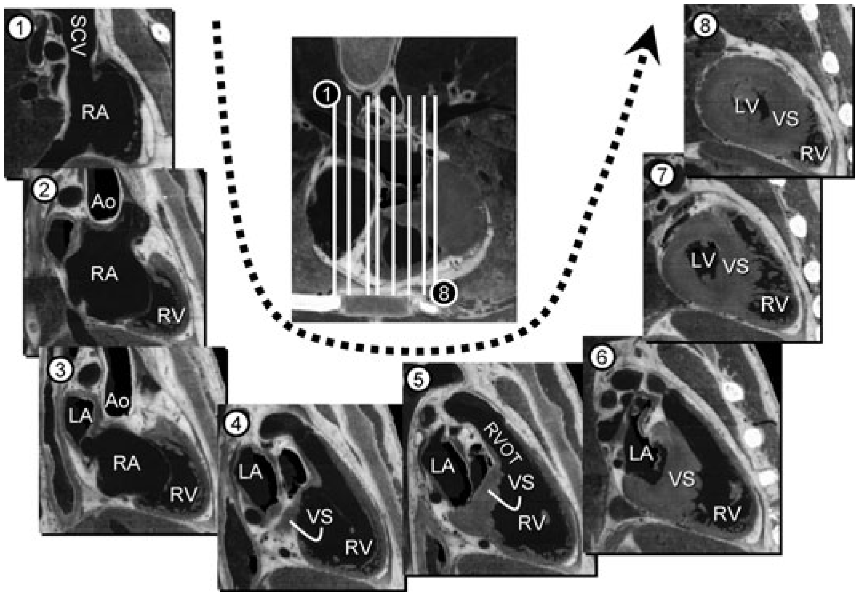

Figure 11. *A series of consecutive sagittal sections of the heart obtained from right to left. The ventricular septum (VS) courses to the left, anteriorly and also inferiorly, but the right ventricle (RV) is always more anteriorly positioned.*

atrium above the hinge of the tricuspid valve was directly related to the summit of the ventricular septum. This area, of course, also contains the so-called triangle of Koch. The area, however, is in reality an AV sandwich, with fibro-fatty tissue interposed between the summit of the ventricular septum and the atrial musculature, which itself contains the AV node and its extensions, atrial and transitional myocytes. To cross from the cavity of the right atrium to the left ventricular chamber, passing through the triangle of Koch, it is necessary to get out of the heart, since the content of the sandwich between the atrial and the ventricular myocardiums is a mass of fibro-fatty tissue belonging to the so-called pyramidal space (Figs. 2 and 6).

Fluoroscopic Projections

The understanding of cardiac anatomy as explored using fluoroscopy is facilitated by *The Visible Human Slice and Surface Server*.[7] This program also helps us to understand the new attitudinally oriented nomenclature of cardiac anatomic landmarks endorsed by the *European Society of Cardiology* and the *North American Society of Pacing and Electrophysiology*.[6] The right atrium is positioned on the right and the left atrium is mainly a posterior structure. Only the tip of the left atrial appendage contributes to the left cardiac silhouette in a frontal fluoroscopic view (Fig. 1). The right ventricle is not a right-sided, but an anterior cavity (Figs. 4 and 5). Even though not attitudinally correct, we recognize the need to continue to use traditional names such as right and left atriums and right and left ventricles, if only for the sake of clarity.

The fluoroscopic examination during catheter–electrode mapping and ablation procedures is performed using the frontal or anteroposterior (AP) projection, and the right and left anterior oblique projections (RAO, LAO). While projections with special angulations are routinely used to improve visualization of various segments of the coronary arteries, such a need has not been made evident for catheter–electrode mapping and ablation. The frontal view is generally used to introduce and position catheters in the right ventricular apex and outflow tract, high right atrium, both inside the tip of right atrial appendage or in the lateral aspect of the right atrium, and in the region of the His bundle. We also use the frontal projection to enter into the left ventricle from a retrograde aortic approach.

Although different laboratories may have their own preferences regarding the rotations selected to obtain the oblique projections, we usually prefer a 45° tilt for both of them, or rotations close to these values. From an attitudinal point of view, the RAO projection defines what is anterior, posterior, superior, and inferior, in cardiac planes that are parallel to the fluoroscopic screen (Fig. 1). This is the case for the interatrial groove, the triangle of Koch, and the muscular ventricular septum (Figs. 1, 2, 8, and 12). The RAO projection

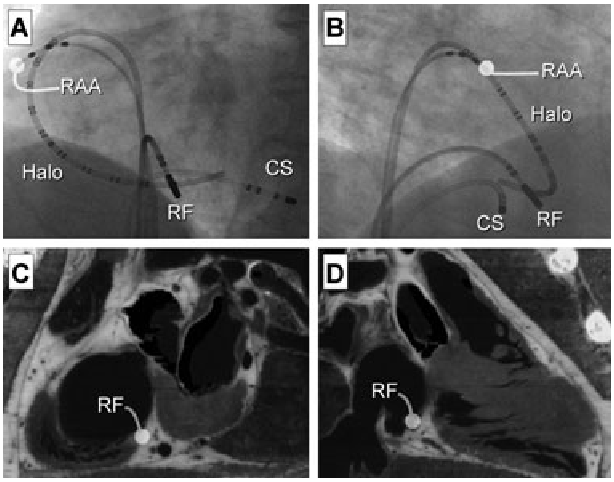

Figure 12. *Ablation of a common, counter clockwise isthmus-dependent atrial flutter at the paraseptal area on the inferior right atrial isthmus. Panels A and B show the location of the ablation catheter (RF) at the site of creation of bidirectional block of the isthmus, as observed in LAO and RAO fluorographic projections. The distal segment of the Halo catheter is placed at the inferior right atrial isthmus. The distal tip of the Halo catheter has entered into the coronary sinus (CS). Panels C and D are LAO, RAO sections of the heart obtained from The Visible Human Slice and Surface Server at the level of the isthmus. The site of ablation is marked in both panels. The precise location of the tip of the ablation catheter requires examining the heart fluoroscopically in both the RAO and LAO projections.*

is used to confirm that the ablation catheter is at the level of the tricuspid valve in the inferior right atrial isthmus in patients with atrial flutter (Fig. 12).

The LAO defines superior, inferior, anterior, and posterior locations, for both the right and left AV grooves, which are almost parallel to the plane of the fluoroscopic screen in this projection (Figs. 1–3, 8, and 12). The LAO is generally used to catheterize the coronary sinus, independently of the venous approach utilized. In patients in whom entering the coronary sinus in the LAO is found difficult, the RAO fluoroscopic projection enables us to identify better the theoretical area where the ostium of this venous structure is expected to be located. The LAO projection is used to establish in which sector of the cavotricuspid or inferior isthmus is the ablation catheter in patients with atrial flutter (Fig. 12). It is difficult to locate with certainty the position of the tip of a given catheter using a single fluoroscopic projection. The use of two orthogonal projections, such as the oblique ones, permits a more accurate location of our exploring electrode within the three dimensions of the heart (Fig. 12). While positioning of the so-called "halo-catheter" is usually accomplished using a LAO projection, the RAO serves finally to ensure that the distal electrodes are at the right inferior cavotricuspid isthmus (Fig. 12). The His bundle catheter can usually be placed at the right spot using a frontal projection, but occasionally a LAO view may help in obtaining a good recording of the His bundle potential.

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