Heart Anatomy Relevant to VT Ablation

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Introduction:

- The heart has a complicated, spiral organization which is markedly skewed when compared with the planes of the body.
- Terms such as left and right, anterior and posterior, therefore do not always assist the description of cardiac anatomy.
Basic anatomy of the normal heart

With two thirds of the bulk of the heart lying to the left of the midline in the thorax, and the overlapping arrangement of the cardiac chambers, the so-called left and right heart structures do not occupy positions implied by their names.
The “right” chambers are anteriorly located relative to their supposedly left sided counterparts, while the RVOT and the pulmonary trunk pass anterior and leftward to the aorta.

The atrial chambers are positioned superior and to the right relative to their respective ventricular chambers. The left atrium is also the most posteriorly situated cardiac chamber, lying anterior to the tracheal bifurcation.
Right ventricle:

- Its interior is crescentic in cross section & its thickness is about 3-5mm
- It is divided into 2 parts: **Rough inflow & Smooth outflow tract.**
- The walls of the inflow portion have numerous muscular, irregular structures called *(trabeculae carneae).*
- A few trabeculae carneae *(papillary muscles)* have only one end attached to the ventricular surface, while the other end serves as the point of attachment for the chordae tendineae.
The sites of the tricuspid and plumonary valves are widely separated on different plans, the flat cavity of the right ventricle, which is crescentic in its section, splaying out between them.
**Left ventricle:**

It is formed of 2 parts:

1-The outflow tract (the aortic vestibule) is posterior to the infundibulum of the right ventricle, has smooth walls.

2- The trabeculae carneae in the left ventricle are fine and delicate in contrast to those in the right ventricle. The general appearance of the trabeculae with muscular ridges and bridges is similar to that of the right ventricle.
Surface anatomy of the heart

- **Point a**: on lower border of 2nd left cc 4 cm from middle line
- **Point b**: on upper border of 3rd right cc 3 cm from middle line
- **Point c**: on right 6th cc 3 cm from middle line
- **Point d**: on left 5th intercostal space 9 cm from middle line (apex)
Surface anatomy of cardiac valves

- PV → at 3rd left sternocostal junction
- AOV → at 3rd space left sternal border
- TV → at 4th space behind center of sternum
- MV → at 4th left sternocostal junction
In LAO view, the heart is made shorter and rounder. In RAO view, it is longer with the apex extending to the left chest wall.
In RAO the spine which is posterior appears on the left side of the image, in LAO the spine appears at the right. In RAO the beam aligns with the AV valves such that left on the screen is atrial and right is ventricular.
In RAO the right and left atrio-ventricular junctions are superimposed and it is difficult to determine if a catheter (for example the coronary sinus electrode) is on the right or left side of the heart.
In LAO the beam is aligned with the apex to base axis of the heart such that left on the screen is the right heart while right on the screen is the left heart.
Using the LAO view allows recognition of the right and left free walls and the distinction of these zones from the septal area but lacks information about whether a catheter is atrial or ventricular.
Swapping between the two oblique views allows the position of a catheter to be assessed within the geometry of the heart.

RAO → to determine whether the catheter is in atrial, junctional or ventricular.
LAO → to determine whether the catheter is left, septal, or right.

Cardiac anatomy in fluoroscopic projections
Ventricular tachycardia

Idiopathic

Scar related

Normal anatomy

Structurally normal heart
represents 10% of all VTs

Structural heart disease
The most common forms have a focal origin in RVOT or LVOT.
- Up to 70% arise from the RVOT.
- Up to 18% arise from LVOT.
- Up to 12% arise from Purkinje fascicles.
- Other rare sites include mitral annulus, papillary muscles, RV inflow, and epicardial outflows.

The RVOT is bordered by the pulmonary valve above and the superior aspect of the tricuspid apparatus below (both dotted lines). The upper part of the septal wall is the conus arteriosus, bordered below by the supraventricular crest. To the anatomical left of the septomarginal trabeculation, which continues into the moderator band, are the septoparietal trabeculations. These structures have been emphasized in this illustration.
From an electrophysiologist’s perspective, the walls of the RVOT can be divided into four segments; septal, anterior, posterior, and free walls.
CARTO maps in LAO view, showing VT originating from the free wall of RVOT
Since RVOT is an anterior structure, it is more left in LAO view and more right in RAO view.

The inferior margin of the RVOT on fluoroscopy is represented by a line drawn from the superior tricuspid annulus (at the level of the His catheter) to the left cardiac border.
Two leads in the RVOT (septal: S, and free wall: FW). The PA and RAO views were not helpful in determining where the leads are. The LAO view confirms that the lead passes posterior (to the right) into the septum, whereas the other passes anterior (to the left) into the free wall.
Ablation catheter rotation in the Rt heart

Ablation catheter in a cadaver heart introduced from the IVC to RV
Clockwise rotation ➔ anterior then septal rotation of the catheter tip
Ablation catheter rotation in the Rt heart

Counterclockwise rotation → movement of the catheter tip toward the free wall
VT can arise from the pulmonary artery

The myocardial sleeve typically extends circumferentially around the pulmonic valve between and above all 3 cusps
Anatomy of the LVOT
Sinuses of Valsalva

- Aorta, cut open
- Right coronary artery
- Aortic semilunar valve
- Wall of left ventricle (thick)
- Trabeculae carneae
- Left ventricle
VT originating from the LVOT

Subvalvular origin

Superior septum
LV free wall
LV epicardium

Supravalvular origin

LCC
RCC
NCC (rare)
The hinge of the valvular leaflet is attached to the ventricular myocardium well proximal to the anatomic ventriculo-arterial junction.

VT can arise from sinuses of Valsalva.

Ventricle within aortic sinus

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CARTO mapping: supravalvular origin of VT
Non coronary sinus of Valsalva is less likely to be an origin of VT due to lack of adjacent myocardium.

The noncoronary cusp (NCC) of the aortic valve generally is surrounded only by atrial structures, and thus, mapping in the NCC will identify predominately atrial signals that may arise either from the right atrium, left atrium, or the interatrial septum. Therefore, ablation in the NCC is rarely required for ventricular tachycardia, but more often for atrial tachycardias from these regions.
Be guided with anatomy during ablation to avoid complications
Ablation of LVOT near the superior basal interventricular septum may injure the His bundle
Also due to close proximity of His bundle to the lower RVOT, complete heart block was reported during ablation of RVOT tachycardia.

The right phrenic nerve descends in the thorax along the right side of the right brachiocephalic vein and the superior vena cava. It passes in front of the root of the right lung and runs along the right side of the pericardium, which separates the nerve from the right atrium.

It then descends on the right side of the inferior vena cava to the diaphragm. Its terminal branches pass through the caval opening in the diaphragm to supply the central part of the peritoneum on its underaspect.
The left phrenic nerve descends in the thorax along the left side of the left subclavian artery. It crosses the left side of the aortic arch and here crosses the left side of the left vagus nerve. It passes in front of the root of the left lung and then descends over the left surface of the pericardium, which separates the nerve from the left ventricle. On reaching the diaphragm, the terminal branches pierce the muscle and supply the central part of the peritoneum on its underaspect.
Coronary injury

Ablation within the LVOT within 8 mm from coronary ostia may occlude left main or right coronary artery.

Ablation near the mitral annulus or within the CS may injure the left circumflex artery.
Cardiac perforation

Risk of perforation increases with increased contact force of ablation over a relatively thin part of myocardium
Thank you!