1

We are going to start off the day with a review of cardiac anatomy, specifically for 3D echo.

2

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3

These are my disclosures.

4

I am going to rely here on the sophisticated 3D visualization capabilities of our brains.

My goal is to help you memorize and visualize the structure of the heart base in 3-dimensions and to use it to rapidly orient yourself when looking at echo images, specially 3D datasets.

We'll start with a drawing exercise that will help you visualize the position of the all the cusps and leaflets and some key adjacent structures.

Then we'll look at the morphology of the base in 3D and its position in the chest.

Next, using the heart base as an anchor we will build the cardiac chambers and great vessels around it, then add the airway, esophagus and stomach which determine or trans-esophageal windows.

Finally we'll practice using it as a compass to navigate around 3D datasets.

5

Here we have a dissection of the heart base and a schematic diagram which by the end of this talk you will hopefully be able to draw from memory.

We are looking at the base here from the atrial side towards the ventricles, or roughly from the right shoulder looking towards the apex of the heart.

In the middle is the **aortic valve**.

You can see the right and left coronary cusps and the non-coronary sinus of valsalva, closely associated with the **IAS**.

Here is the **right atrium**, the right atrial appendage and the tricuspid valve with its A, P and S leaflets.

You can just see the ostium of the coronary sinus here at the commissure between P and S leaflets.

Here we have the **left atrium**, the mitral valve and the LAA.

Note its relationship to the aortic root and pulmonic valve.

At the top of the image we have the **pulmonic valve**. You can see the A and L cusps here.

6

The heart base corresponds roughly to the so-called fibrous skeleton of the heart, illustrated here.

This structure is clinically significant in that it forms strong anchor points for sutures.

It includes the crown-shaped support structures of the aortic and pulmonic valves, two dense trigones, the lateral and the medial, which also houses the AV-node.

It also extends into often incomplete rings around the mitral and tricuspid valve annuli.

On the right here you see a 3D model of the heart base created from cardiac CT, from the same vantage point.

7

So, let's start to draw. I suggest you grab a pencil and paper and follow along.

The first step involves drawing three circles and jelly bean like so, to represent the valves.

We mark out the centers of the circles.

I have put some orientation makers in scare-quotes to remind us that we are talking about conventional cardiac orientation terms which do not correspond to standard anatomic terms.

So R refers to right heart, L to left heart and so on.

Next we connect the centers of the circles.

8

Now you have landmarks that let you work out the orientation of all the commissures simply by dividng each circle into equal thirds.

9

We are cheating slightly with the TV here by making the next commissure horizontal.

For the mitral valve we draw the commissure down the middle of the bean.

10

Here's another mnemonic you might find either helpful or terrorizing

11

To review, we drew three circles and a bean, marked the centers of the circles and connected them and divided into thirds.

12

From here it's pretty easy to label all the cusps and leaflets.

The PV has …

The AV has …

The TV has …

and the MV has …

Now try to add in the IAS, the L and R AAs and the coronary sinus.

13

And here they are.

I've also added these triangles to represent the trigones.

The medial trigone here contains the AV node.

We have the IAS

the LAA and RAA

The CS draining into the RA at the junction of the S and P leaflets.

Next try to visualize the silhouettes of the right and left ventricles.

14

Here they are.

You see the compact form of the LV and the famous banana or croissant shape of the RV.

These grooves here, much exaggerated, represent the anterior and posterior interventricluar grooves.

The LAD travels down here and the posterior interventricular vein and the PDA run in here.

15

Here is an interactive rendering of the base which you might be helpful as we go through the rest of the talk. We'll also post a link the chat. https://skfb.ly/6LGwF

16

Now we move on to the third dimension.

The images here are created from a cardiac CT.

We have modeled the blood volumes and removed the walls in order to emphasize the underlying structures and relationships.

This patient had normal anatomy, but he had undergone a coronary bypass.

If you look closely your can see part of a mobilized LIMA and some vein grafts coming off the ascending aorta.

17

Here we **anterior and L lateral views of the base in the chest.**

The red and blue lines mark the **long axes of the AV and PV**.

You'll notice that unlike our flat schematic the PV and AV axes form a roughly **60 degree angle**.

The AV is positioned **directly behind the sternum,** which is marked by the sternal wires here.

18

Here is a posterior view including esophagus.

19

The **aortic axis** goes from the right shoulder to the apex.

The **pulmonic axis** is in the mid-saggital plane and goes from the lower C-spine to the xiphoid process.

Notice also that the planes of the **MV and TV are basically vertical**.

20

Now we add the chambers and vessels around the base.

Here is the left heart blood pool ...

21

You can see the aortic root ...

22

Here is the right heart blood pool.

We have the SVC, IVC and coronary sinus draining into the right atrium.

The IVC is unfortunately truncated here in the model.

You can see the right atrial appendage

The RV's free wall and septal walls and its triangular shape

23

Here are the left and right combined with the airway, esophagus and stomach.

You can see the where the trachea and LMSB create blind spots.

24

Here is the same model in static images from all four sides.

25

From the point of the view the echo probe in the ME position this is what the base looks like.

Notice the proximity of the mitral and aortic valves and the relative distance of the TV and PV.

26

And here is a view from the stomach.

Which one is the mitral valve?

27

One of the powers 3D echo gives us is the ability to spin the image around regardless of were we acquired it from.

Our goal is to visualize the base embedded in any 3D dataset that has enough surrounding context.

28

So lets practice with some 3D datasets.

29

Here is a full volume of image of the heart base in our standard position, which matches our schematic.

So you have the AV in the middle, the MV and TV here and in the distance there the PV.

Try to visualize the 3D base embedded in there.

30

Like this.

31

Here is a standard short axis view of an aortic valve that happens to be bicuspid.

Again try to visualize the base embedded in the rendering and identify the structures with question marks.

32

Here is the base. This is the RAA and that is the MV, specifically the PMVL.

33

Here is another one. What is the marked structure in the far end (not in the middle)?

34

It's the RVOT!

35

Here is another one with vintage rendering.

36

I have just superimposed the images here but I am trying to show the base actually embedded in the rendered volume.

37

Another MV image. Again try to visualize the base embedded in the image.

38

Here it is in matching position... Just slide it over

39

And you have this

40

In the last few minutes we'll quickly review some of the standard presentations the valves based on the two related ASE guidelines from 2013 and 2012.

These will be covered in more details in the upcoming talks.

41

The en-face short-axis presentation of the aortic valve matches our 2D aortic valve short axis.

Here you can see the schematic and the base orientated to match the standard presentation, with the RCC at the bottom.

42

The MV en-face view has the AV at 12 O'clock.

43

Here is a slight variation

44

...

45

The atrial view of the tricuspid valve is presented with the IAS at the bottom. Here are the schematic and the 3D model in corresponding positions.

46

And finally, the rarely imaged pulmonic valve, displayed en-face with the anterior cusp at the top. Unfortunately the image used in the guidelines does not quite match.

47

And that bring us to the end.

To summarize we learned how to draw a schematic of the heart base; how to visualize the shape of the base in 3D; its position in the chest; how to connect it to the cardiac chambers and vessels; and finally some examples of how we can use it to orient ourselves when looking at 3D data sets.

48

Thank you!