HEART: INTERNAL EXAMINATION – The Right Atrium
Access to the right atrium is obtained by cutting on the posterior side of the heart, starting from the inferior vena cava and going up to the superior vena cava.

Inside the right atrium it is possible to observe:

1. **the ORIFICES (or foramina) where the VESSELS (i.e., superior vena cava, inferior vena cava, coronary sinus) drain into the right atrium**

2. **the EUSTACHIAN VALVE** that lies at the junction of the inferior vena cava and right atrium. It is a rudimentary/not functional valve, formed by an incomplete valve leaflet.

3. **the THEBESIAN VALVE**, a semicircular valve leaflet at the orifice of the coronary sinus.
Inside the right atrium it is possible to observe:

4. The **RIGHT ATRIOVENTRICULAR FORAMEN** with the right atrioventricular valve (*tricuspid valve*)

5. the **INTERATRIAL SEPTUM** which divides the right atrium from the left atrium; it shows a depressed structure which is named **FOSSA OVALLIS**

   It is a depression representing the remnant of an *interatrial opening* which had a significant role in fetal circulation

   the **FORAMEN OVALE**
During fetal development, at the level of the interatrial septum, this foramen allows blood flowing between the right and left atria.

Fetal circulation is different from circulation after birth, just think that the lungs do not work and the blood is oxygenated by the placenta.

Actually, the foramen ovale IS NOT A COMPLETE OPENING, otherwise it would hardly close immediately after birth.

It is made up of 2 membranous septa very close to each other, which have 2 holes/openings which are not aligned.

As long as the two septa are separated from each other due to a specific pressure gradient, the blood flows from the right to the left atrium following an "S" path:

- enters the first opening - passes between the 2 septa - exits from the second opening.
At birth, the umbilical cord is clamped and cut, the placenta is detached, and the baby ventilates his lungs for the first time.

The pressure between the right and left atrium changes and the two septa of the foramen join/fuse together.

The foramen ovale closes:

- At the beginning: functional closure given by the pressure variation.
- Over time: fusion of the two sheets with the formation of a complete anatomical septum where the fossa ovalis remains visible.

Diagram of the foramen ovale in a fetal heart. The red arrows show how the blood comes from the inferior vena cava. RA: right atrium; LA: left atrium; RV and LV: right and left ventricles.
Inside the right atrium it is possible to observe:

6. the **atrium proper**, with a rough/irregular surface because of the pectinate muscles

7. the **sinus of venae cavae**, with a smooth wall

The separation between the 2 portions is marked by

- **the terminal crest** (or *crista terminalis*)

A vertical ridge of the inner surface of the right atrium, extending from the superior vena cava to the inferior vena cava — it corresponds to the terminal sulcus found on the external surface of the right atrium
HEART: INTERNAL EXAMINATION – The Right Ventricle
In this image we can observe:
- the right atrium, closed
- the right ventricle, opened

In the image, the sternocostal wall of the heart at the level of the right ventricle has been sectioned.

Two important structures of the right ventricle are identifiable, namely the TWO VALVES:

1) TRICUSPID VALVE
2) PULMONARY VALVE
1) **TRICUSPID VALVE**: valve of the right atrioventricular foramen → it is located between the right atrium and the right ventricle

The portion of the right ventricle that follows the right atrioventricular ostium is the ↓ **INFLOW TRACT OF THE RIGHT VENTRICLE** (it is the part of the right ventricle where the blood enters from the right atrium through the tricuspid valve)
2) PULMONARY VALVE:
it is located at the origin of the pulmonary trunk (which will then divide into right and left pulmonary arteries)

It is located at the exit part of the right ventricle, i.e. the part of the right ventricle that is called **OUTFLOW TRACT OF THE RIGHT VENTRICLE** (it's the part where the blood flows out the heart to enter the pulmonary circulation)
In the right ventricle we can identify:
- an INFLOW TRACT, which immediately follows the right atroventricular foramen and tricuspid valve
- an OUTFLOW TRACT, which leads to the pulmonary valve and the origin of the pulmonary trunk

The INFLOW and OUTFLOW TRACTS are positioned to form a «V» with:
- the inflow tract directed towards the apex of the heart;
- the outflow tract facing the base of the heart

The inflow tract shows an irregular internal side due to the presence of muscular ridges (myocardium) → TRABECULAE CARNEAE

The outflow part has a smooth internal side
Inside the right ventricle it is possible to identify the **INTERVENTRICULAR SEPTUM** ▼

it is the muscular wall separating the right and left ventricles

It defines a COMPLETE division between the two ventricles
Opened Right Ventricle
Anterior View

- Aorta
- Pericardial reflection
- Transverse pericardial sinus
- Superior vena cava
- Right auricle
- Right atrium
- Parietal band
- Membranous septum
- Anterior cusp of tricuspid valve
- Septal (medial) cusp of tricuspid
- Posterior cusp of tricuspid valve
- Trabeculae carneae
- Chordae tendineae
- Pulmonary trunk
- Right semilunar cusp of pulmonary valve
- Transverse pericardial sinus
- Anterior semilunar cusp of pulmonary valve
- Left semilunar cusp of pulmonary valve
- Conus arteriosus
- Supraventricular crest
- Septal (medial) papillary muscle
- Interventricular septum
- Septal band of septomarginal trabecula
- Moderator band of septomarginal trabecula
- Posterior papillary muscle
- Anterior papillary muscle
TRICUSPID VALVE

It is a CIRCUMFERENTIAL connective structure, made up of dense fibro-connective tissue.

It is described as a FIBROUS RING that delimits the perimeter of the atroventricular orifice.

3 CUSPS are inserted into this fibrous ring:
- ANTERIOR CUSP
- POSTERIOR CUSP
- SEPTAL (or MEDIAL) CUSP

CUSPS = flaps of dense connective tissue that have the ability to move under the action of hemodynamic and muscular forces.

The cusps:
- by moving closer to each other they close the valve = they prevent the reflux of blood from the right ventricle to the right atrium.
- by distancing themselves from each other, they cause the valve to open = they allow the passage of blood from the right atrium to the right ventricle.
In the free margin of the cusps, fibrous cords are inserted, which are called **TENDINOUS CORDS (CHORDAE TENDINEAE)**

The tendinous cords insert on:

a) **the FREE MARGIN/EDGE OF THE VALVE CUSPS** extending even beyond it and inserting on the ventricular side of the cusps (i.e. the side facing the ventricle)  
On the other hand, the atrial side of the cusp is smooth.

b) **PAPILLARY MUSCLES** (n=3, like the cusps) they are digit-shaped muscular projections (= myocardium) that arise from the internal side of the right ventricle and direct towards the cusps. They are:

- the anterior papillary muscle  
- the posterior papillary muscle  
- the medial (or septal) papillary muscle
How the cusps connect with the related papillary muscles?

RATIO 1:2

Each valve cusp is connected by the tendinous cords to 2 papillary muscles

And vice versa...

Each papillary muscle is connected by the tendinous cords to 2 valve cusps

CUSPS
+ TENDINOUS CORDS
+ PAPILLARY MUSCLES
↓
ATRIOVENTRICULAR VALVE COMPLEX
How the cusps connect with the related papillary muscles?

**Example:**

The **ANTERIOR CUSP:**
- is connected by tendinous cords to the anterior papillary muscle
- is connected by tendinous cords to the medial (or septal) papillary muscle

Moreover...

The **MEDIAL PAPILLARY MUSCLE:**
- is connected by tendinous cords to the anterior cusp
- is connected by tendinous cords to the septal or medial cusp
How the cusps connect with the related papillary muscles?

**RATIO 1:2**

This guarantees that, when a problem with a papillary muscle or a group of tendinous cords occurs, there is no total loss of functionality of a valve cusp.

For example, in case of RUPTURE OF THE ANTERIOR PAPILLARY MUSCLE:
- two cusps will work at 50% efficacy
- there will be no completely inefficient cusps

It is preferable to have two cusps working at 50% than one cusp which does not work at all.
DESCRIPTION of the PASSAGE
FROM THE INFLOW TRACT TO THE OUTFLOW TRACT

Several structures contribute to separate the two tracts

SUPRAVENTRICULAR CREST
Muscular structure or muscular ridge (myocardium) that separates the right atrioventricular valve and the pulmonary valve
(this anatomical situation is not found in the left ventricle)

▼

IT'S TO ENSURE VALVE SAFETY!

By KEEPING the 2 valves of the right ventricle apart, the supraventricular crest reduces the risk of transmission of infections from one valve to the other
(this risk is instead greater into the left ventricle)
SUPRA-VENTRICULAR CREST
It continuous with another muscular ridge, called
↓ SEPTOMARGINAL TRABECULA
↓ It is made up of 2 components:

a) SEPTAL BAND, a ridge on the right side of the interventricular septum
The septal band continues with:

b) MODERATOR BAND, a muscular bridge that from the interventricular septum goes to the base of the anterior papillary muscle and is also called «Leonardo da Vinci Moderator band»
The separation between the inflow and the outflow tracts is given by the following structures:

1. **SUPRAVENTRICULAAR CREST**
2. **SEPTOMARGINAL TRABECULA** (septal band + moderator band)
3. **ANTERIOR PAPILLARY MUSCLE**
4. **ANTERIOR CUSP** of the right atroventricular valve
PULMONARY VALVE

In the image you can see the pulmonary valve from the ventricular side.

The PULMONARY VALVE is made up of THREE SEMILUNAR CUSPS → RIGHT SEMILUNAR VALVE

Since the tricuspid valve is open, and the pulmonary valve is closed, the image represents a situation of VENTRICLE DIASTOLE ↓

the blood is entering from the right atrium (which is in atrial systole), therefore the ventricle is in diastole

When the ventricle systole occurs, the atroventricular valve will close and the pulmonary valve will open.
PULMONARY VALVE

- It is made up of THREE SEMILUNAAR CUSPS with the concavity facing towards the pulmonary trunk:
  - right cusp – anterior cusp – left cusp
- Each cusp has its free edges (Tendinous cords and papillary muscles are NOT present)

When the valve closes, the three free edges get close to each other and close the lumen of the origin of the artery.

THE CENTER OF THE ARTERY LUMEN IS THE MOST DIFFICULT POINT TO CLOSE

- this is why at the midpoint of the free edges there are FIBROUS CONNECTIVE NODULES or NODES which allow the closure of the lumen in its central portion
- MORGAGNI NODULES
When the ventricular contraction occurs, the blood is pumped through the pulmonary valve and the cusps distance themselves from each other, approaching the arterial wall and allowing the blood to flow into the pulmonary trunk.

At the end of the ventricle contraction, the cusps return close to each other to close the lumen of the pulmonary trunk.
HEART: INTERNAL EXAMINATION – The Left Atrium
INTERNAL EXAMINATION OF THE HEART
- Left atrium -

Into the left atrium we observe the orifices where the four pulmonary veins open without valves.

*It has a less evident internal division than in the right atrium*

- The walls have mainly a smooth surface
- The portion that corresponds to the left auricle shows muscular ridges similar to those seen on the right atrium.

**Note:** broken line indicates the origin of bicuspid valve.
The interatrial septum can also be recognized in the left atrium.

In this muscular wall there is the residue of the foramen ovale, which however is less evident than on the right atrium.

The septum shows a depression representing the residue of the opening of the foramen ovale at the level of the left atrium.

The posterior portion of the left atrium, between the two pairs of pulmonary veins.
Note: broken line indicates the origin of bicuspid valve
HEART: INTERNAL EXAMINATION – The Left Ventricle
It is possible to identify a left atrioventricular valve complex that regulates the entry of blood from the left atrium to the left ventricle.

- The INFLOW tract has an irregular surface due to the presence of muscular ridges which are the TRABECULAE CARNEAE.

- Entering from the left atrium through the atrioventricular valve (inflow tract), the blood flows towards the cardiac apex.

- Subsequently, the blood follows a "V" path to return towards the cardiac base, corresponding to the OUTFLOW tract.

- The OUTFLOW tract ends at the origin of the AORTIC VALVE, through which the blood flows into the aorta.
Note: broken line indicates the origin of bicuspid valve
WHICH IS THE DIFFERENCE BETWEEN LEFT AND RIGHT VENTRICLE?

Into the left ventricle:

**LEFT ATRIOVENTRICULAR VALVE**  
and  
**AORTIC VALVE**

▼

Are CLOSE to each other

There is no muscular structures such as the supra-ventricular crest on the right ventricle that separates the fibrous rings of the two valves

(each valve is made up of cusps that fit onto fibrous rings)
The LEFT ATRIOVENTRICULAR VALVE COMPLEX consists of 2 CUSPS (= bicuspid valve):

- **ANTERIOR CUSP**
- **POSTERIOR CUSP**

The cusps are connected by **TENDINOUS CORDS to PAPILLARY MUSCLES**, which are 2 muscles, the ANTERIOR one and the POSTERIOR one.

Also in this case, the connection between papillary muscles is in a 1:2 ratio

The anterior papillary muscle is connected by tendinous cords to both the posterior and anterior cusps, as well as the posterior papillary muscle.

The tendinous cords insert on the free edge (i.e., the portion that is NOT inserted into the fibrous ring of the valve) and extend onto the ventricular surface of the cusps. The internal or atrial surface is smooth.
AORTIC VALVE

In the left ventricle, the OUTFLOW tract:

Shows a smooth appearance
it is not separated from the inflow part by muscular/valve structures
it is characterized by the presence of the AORTIC VALVE

The AORTIC VALVE regulates the exit of blood from the left ventricle

It is a SEMILUNAR VALVE

it consists of 3 semilunar cusps
Right cusp, left cusp and posterior cusp

Each cusp has:
- a free edge
- a nodule/node in the midline of the free edge (= ARANTIUS NODULE)
The AORTIC VALVE is characterized by the presence of the AORTIC SINUSES, also known as SINUSES OF VALSALVA. Aortic sinus is each one of the anatomic dilations of the ascending aorta, which occurs just above the aortic valve. These widenings are between the wall of the aorta and each of the three cusps of the aortic valve.

Within the right and left cusps and the corresponding sinuses of Valsalva - right and left - we distinguish: CORONARY ORIFICES → openings of the two coronary arteries:
1. the right coronary artery, which opens at the level of the right cusp
2. the left coronary artery, which opens at the level of the left cusp

The two coronary arteries are the only two collateral branches of the very first trait of the ascending aorta.
The two valves are close together. Unlike the right atrioventricular valve and semilunar valves!
WHAT IS ANOTHER DIFFERENCE BETWEEN THE RIGHT VENTRICLE AND THE LEFT VENTRICLE?

→ The THICKNESS of the WALL! (That is the thickness of the myocardium)
The image presents a section of the heart through the 4 cardiac chambers.

A comparison can be made between the thickness of:

→ the free wall of the left ventricle (3 times thicker)
→ the free wall of the right ventricle

The interventricular septum also has a thickness similar to that of the free wall of the left ventricle = it is approximately three times the free wall of the right ventricle

Why?
The left ventricle must pump blood into the systemic circulation and so it needs a greater contraction force = a thicker myocardium
Observe that:

→ the free wall of the left ventricle is 3 times thicker than the free wall of the right ventricle

→ the interventricular septum is three times thicker than the free wall of the right ventricle and analogous to the free wall of the left ventricle

→ the left ventricle has a circular profile, while the right ventricle has a semilunar profile

Cross section of the heart through the two ventricles