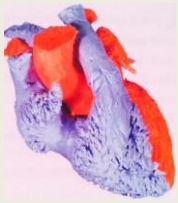


Sequential segmental analysis

Antigone Deri
Consultant Paediatric Cardiologist
Yorkshire Heart Centre

Yorkshire Network Meeting, January 2020

The history of cardiac morphology

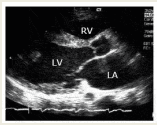
Aristotle (384-322 BC)

The discoverer of the cardiovascular system?

Dr R Van Praagh & Dr S Van Praagh

Dr Maria V dela Cruz

Dr Robert Anderson

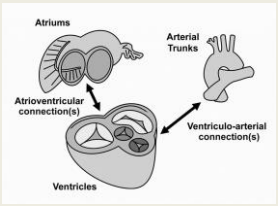


What are we trying to achieve?

- Work out what components of the heart are present
- Work out how they are connected (how blood flows)
- Document associated lesions that might affect the blood flow (stenotic valves, ASD, coarctation of the aorta)
- Use a comprehensive classification scheme of CHD using **clear and consistent nomenclature:**
  - anyone can read the diagnosis and immediately envision the anatomy
  - describe segments and connections in a logical manner
  - template for examination and report

The essence of sequential segmental analysis

- All hearts, normal or abnormal, are built from **3 segments**: the atria, ventricular mass and the arterial trunks
- Also **two connecting segments**:
- The atrio-ventricular (AV) junction: AV valves and AV septum
- The ventriculo-arterial junction (Infundibulum/conus):
  - Circumferential subpulmonary, separating the pulmonary and tricuspid valves.
  - The normal subaortic infundibulum consists only of conal septum

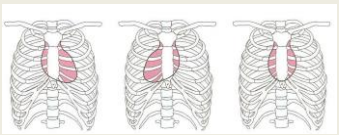


Don't forget to comment on:
The location of the heart, orientation of apex and arrangement of the other organs
Associated malformations

How to assess the morphology of segments?

- The normal heart possesses a right and a left side to each of its 3 segments. Easy in normal hearts (Pulmonary veins connect to LA) … but structures are not always in their expected locations
- Use "morphologically right" and "morphologically left" to describe abnormal structures
- Use the most obvious/constant component of a segment as its defining feature (that is always or almost always present, for example the atrial appendage for the atria)

Cardiac position

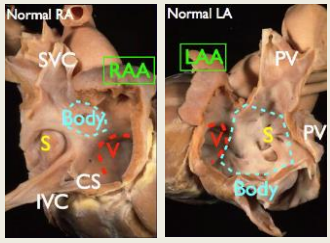


- Where is it in the chest (left, right, middle)?
- Where does its apex point?
- Position and orientation of axis often but **not always** concordant.
- Distinguish between **primary and secondary cardiac malposition** (Scimitar, pneumothorax etc)
- Use of terms 'dextrocardia/mesocardia/levocardia' can be confusing and do not differentiate between primary and secondary cardiac malposition.

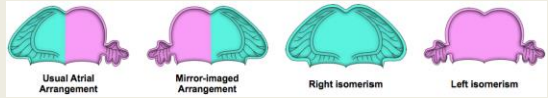
Atrial arrangement

- The first step is to identify the atria according to their morphologic characteristics:

Veins
Vestibule
Body
Septum
Appendage

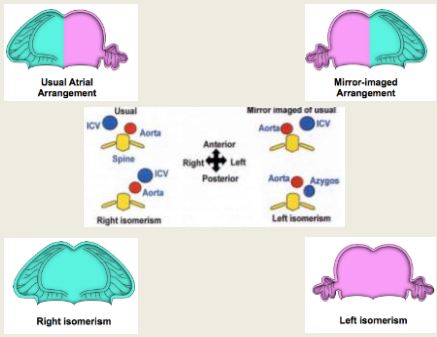


Four types of atrial arrangement

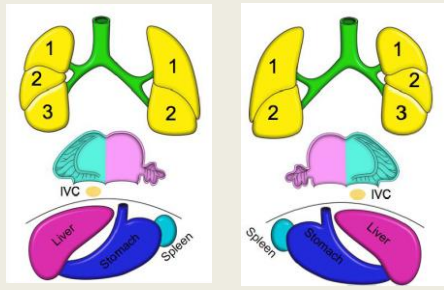


- Right atrial appendage (RAA): broad-based, triangular shape, anterior in relation to the left atrial appendage (LAA). The pectinate muscles extend towards the AV valve annulus and the Eustachian valve
- The LAA is elongated, finger-like. The pectinate muscles are confined to the appendage.
- Imaging of the pectinate muscles in living patients is challenging!
- In practice, we use relative position of the IVC and the aorta (initial subcostal transverse view – 'situs view')

Four types of atrial arrangement



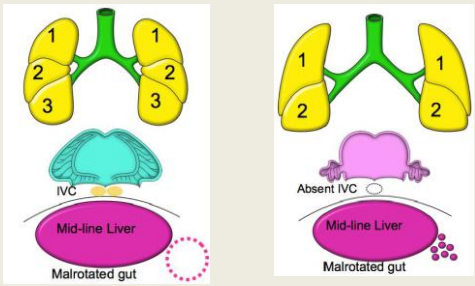
Lateralised body arrangement



Usual

Mirror-imagery

Isomerism



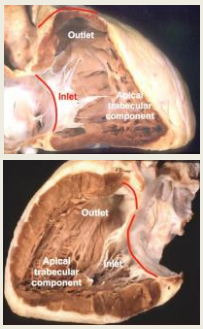
Right Isomerism

Left Isomerism

The ventricles

- 3 components:

Inlet
Outlet
Apical trabecular



Virtually all hearts have 2 ventricles and therefore 2 apical trabecular components but very rarely one can find solitary/indeterminate ventricles

In ventricles with one inlet the best guide to the morphological RV is the tendinous cords attaching the TV to the septum

Ventricular morphology

- **Right ventricle:**

Septal attachments of the tricuspid valve

Off-setting of the tricuspid valve

Coarse trabeculations

Distinct septal surface that includes the septal and moderator band

- **Left ventricle:**

Attachments of the mitral valve to the LV free wall via two distinct papillary muscles

Fine apical trabeculations

Aortic and mitral valves in fibrous continuity

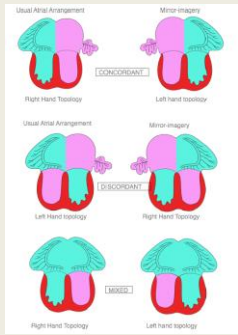
Beware of exceptions: hypertrophied LV, abnormal attachments in common AV valve or straddling MV etc
The most reliable morphologic feature of the LV is its **smooth superior septal surface**.

Atrioventricular alignments and connections

- **Biventricular AV connections** (each atrium connected to its own ventricle):
  - Concordant
  - Discordant
  - Mixed (Ambiguous) (isomerism)
- **Univentricular AV connections:**
  - absent AV connection
  - common AV valve
  - double inlet connections
- **Uniatrial AV connections (uniatrial but biventricular):**
  - absent RAV valve and straddling LAV valve
  - absent LAV valve and straddling RAV valve

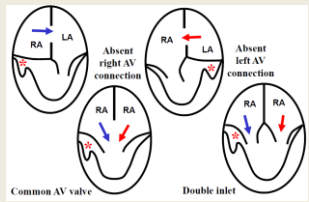
3 forms of biventricular AV connections

- Each atrium connects to each own ventricle

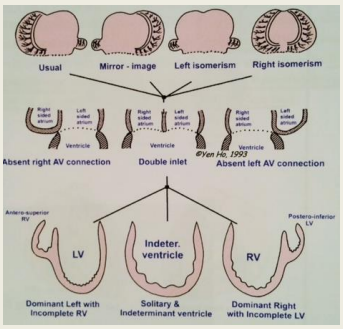


Univentricular AV connections

- Absent AV connection (right/left):
  Tricuspid/Mitral atresia
- Common AV valve, with single ventricle
- Double inlet ventricle:
  connections of both AV valves to the same ventricle



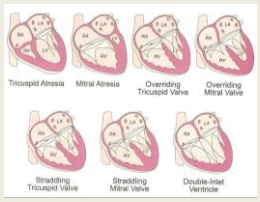
Univentricular AV connections



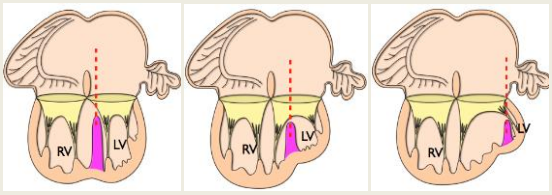
Arrangement of the AV valves

- = morphology of the AV valves that guard the overall AV junction

-two patent valves
-one patent and one imperforate valve,
-a common valve or
-straddling/overriding valves



Overriding valves-the 50% rule



Overriding MV

<50% override
=concordant
(biventricular)

Overriding and straddling MV

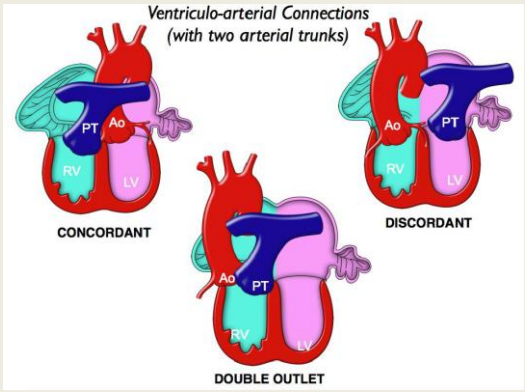
<50% override
=concordant
(biventricular)

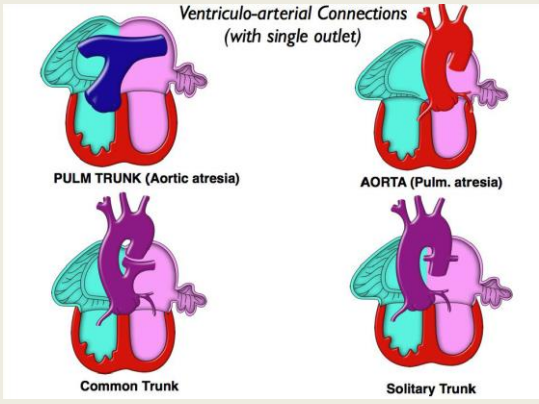
Overriding & straddling MV

>50% override
=discordant
(univentricular)

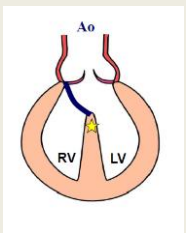
Ventriculo-arterial alignments

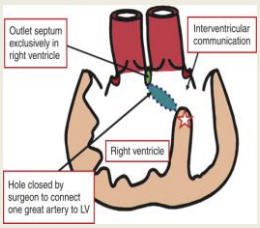
- Describes how the semilunar valves and their respective great vessels align with the underlying ventricles
- Can be concordant, discordant or absent
- Double outlet: both great vessels arise from the same ventricle





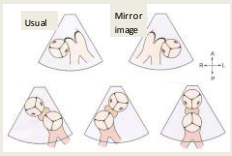
TOF Vs DORV





Relationship between semilunar valves

- **Use simple terms** to describe the Ao/PA position: left, right, anterior, posterior and side-by-side
- **Remember:** these describe only the arterial/valvar relations
- **Describe** the position of the arch and side of the descending aorta (TOF, vascular rings etc)



Associated anomalies

- Finish the evaluation by examining and describing all associated cardiovascular anomalies, segment by segment
- Any abnormal venous connections?
- Any defects? Where? How many?
- Stenosis or regurgitation of the outflow tracts?
- Coarctation?

For the adult echocardiographer…

- If 'things don't seem right', orientation of structures seems abnormal, there is history of CHD, think of a different order:

✓ Begin with the subcostal view to identify IVC, Ao, atrial arrangement, orientation of the heart
✓ Apical views for AV connections and ventricular morphology
✓ Additional view, sweeps, off axis views to identify specific segmental features and connections
✓ We continue segment by segment and use sweeps from one structure to another.
✓ Don't forget suprasternal views!
✓ Call a friend!

Template for CHD echo report

- Heart in left hemithorax, apex to the left
- Usual atrial arrangement, AV and VA concordance
- Pulsatile abdominal aorta
- IVC and single right SVC to right atrium
- 4 pulmonary veins to left atrium
- Intact atrial and ventricular septa
- Competent mitral and tricuspid valves with no stenosis
- No right/left ventricular outflow tract obstruction
- Competent aortic and pulmonary valves
- Trileaflet aortic valve. Usual origin of coronary arteries
- Confluent, unobstructed branch pulmonary arteries
- No PDA
- Unobstucted, left-sided aortic arch with a normal branching pattern
- Good biventricular systolic function

Sequential segmental analysis

- Allows accurate description of all (known) forms of cardiac anomalies
- Uses a systematic approach to identify each segment by its characteristic features and then each connection and any associated anomalies.
- Provides a template for the echocardiographer's study and report in CHD, easy for all to understand

References

- Echocardiography in Pediatric and Congenital Heart Disease: From Fetus to Adult. Wyman Lai, Luc Mertens, Meryl Cohen, Tal Geva, Sept 2009, Wiley-Blackwell
- Paediatric Cardiology
  Robert H. Anderson, MD, Edward J. Baker, MA, MD, FRCP, FRCPCH, Daniel J. Penny, MD, Andrew N. Redington, MD, Michael L. Rigby, MD, and Gil Wernovsky, MD. 3rd edition
- Hands-on Cardiac Morphology Handbook, Yen Ho
- Partners of the Heart-Vivien Thomas and His Work with Alfred Blalock
  Vivien T. Thomas
- Aristotle's "triventricular heart" and the relevant early history of the cardiovascular system
  Van Praagh R, Van Praagh S. Chest. 1983 Oct;84(4):462-8

Thank you!