VIVEKANANDA COLLEGE

THAKURPUKUR

KOLKATA-700063

NAAC ACCREDITED GRADE—'A'

TOPIC: COMPARATIVE STUDY OF AORTIC ARCHES

COURSE TITLE: COMPARATIVE ANATOMY OF VERTEBRATES

PAPER: CC8 (ZOOA-CC4-8-TH)

UNIT: 4

SEMESTER: IV

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NAME OF THE DEPARTMENT: DEPARTMENT OF ZOOLOGY.

Comparative anatomy of Aortic Arches in vertebrates

The arterial systems of various adult vertebrates appear to be different in arrangement. But a study of development reveals that all are built upon the same fundamental plan. The fundamental plan includes six pairs of aortic arches present only in the embryonic condition in all vertebrates.

Embryonic aortic arches:

During the embryonic stages:

- The anterior end of the ventral aorta divides into 6 (Six) pairs of aortic arches develop in most gnathostomes and are named according to the name of the visceral clefts.
- These aoric arches moves to the dorsolateral side and fuse to form dorso-lateral aorta on the respective sides.
- The two dorso-lateral aorta fuse at the posterior end to form a common dorsal aorta. aorta
- These are designated by roman numerals.
- The first aortic arch named **Mandibular,** proceeds upwards on either side of the pharynx.
- The second aortic arch becomes **Hyoid** arch.
- The third, fourth, fifth & sixth are called branchial arches.
- Each of the aortic arches lies anterior to the visceral cleft bearing the corresponding number.

Although the manner in which the dorsal aorta branches is fairly uniform throughout, the vertebrate series, the aortic arches undergo profound modifications in different forms, the changes being similar in members of given class.

Blood pumped anteriorly from heart

Aorta

aortic arches

Paired dorsal aorta

Anteriorly to head posteriorly to single dorsal aorta

M**odification of aortic arches in different vertebrates:**

The number of aortic arches is different in different adult vertebrates but they built on the same fundamental plan in embryonic life.The differences in number of aortic arches are due to the complexity of heart circulation in the mode of living from aquatic to terrestrial respiration.

There is a progressive reduction of aortic arches in the vertebrate series during evolution.

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Aortic arches in primitive vertebrates:

Branchiostoma sp.(Amphioxus)

1. Heart is sometimes called the ventral aorta is a single contractile vesse lying ventral to the gill region.
2. The afferent branchial arteries arses as lateral branches of the ventral aorta.
3. has about 60 pairs of aortic arches.

In Cyclostomes:

1. the ventral aorta leaves the heart as a single median vessel for some distance and then bifurcates. The number of aortic arches given off depends on the species and the number of gill pouches.
2. In Lampreys 7 pairs of gill pouches present. The ventral aorta leaves the heart and bifurcates at the level of the 4^{th} gill pouch.
3. 4 Afferent branchial arteries arises from each of the paired anterior extensions and 4 pairs are given off by the unpaired portion.
4. Each vessel arises at the level of the inter-branchial septum and divides almost immediately to supply the gill lamellae on either side of the septum.
5. Efferent branchial artery corresponding the afferent vessels collects the blood from the gill lamellae. They join single median dorsal aorta. The anterior end of this vessel is paired for a short distance, but the two portions come together again to form a **cephalic circle**.

[NOTE:

Aortic arches in fishes:

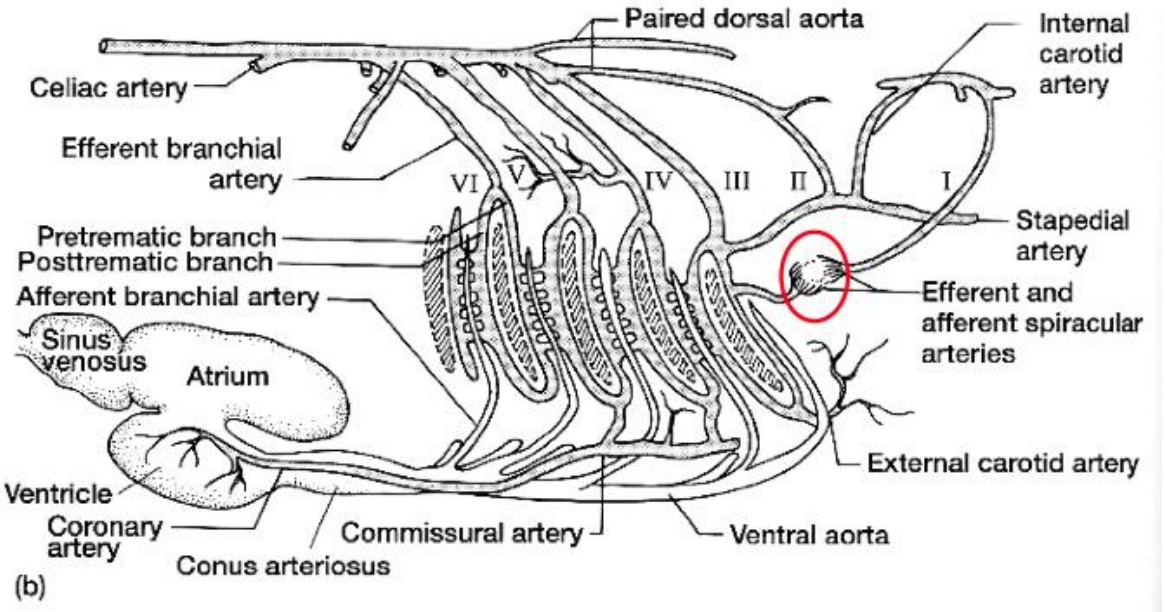
In general there is a reduction in the number within the superclass as the evolutionary scale is ascended. The greatest number is found in some primitive sharks in which number is directly related to the number of gill pouhes.

Soon after branching from the ventral aorta, the aortic arches divide into capillary beds within the gills. The section of the aortic arch delivering blood to the gills is the afferent artery, and the dorsal section carrying it away is the efferent artery. The capillary beds between them partially or completely encircle the gills and empty first into the collecting loop, which joins the efferent artery.

In Elasmobranchs:

1. The primitive elasmobranches, *Heptanchus* has only 7 pairs of aortic arches, where as Selachins has only 6 pairs of aortic arches.
2. In most sharks, *Scoliodon,* have 5 pairs of functional aortic arches; the first pair is reduced or disappears or replaced by the non-functional gills.The first pharyngeal slit becomes reduced but not lost, forming the small **spiracle.** During embryonic development, the ventral section of the first aortic arch, which is ordinarily expected to supply the first pharyngeal slit, does not appear. Instead, a vascular sprout from **the adjacent collector loop grows to the spiracle**, feeding a small capillary bed in its wall. This vessel constitutes **the afferent spiracular artery**. The dorsal section of the first arch forms the **efferent spiracular artery**, which drains this small capillary bed
3. The remaining aortic arches (II–VI) form small sprouts halfway along their lengths. These merge and cross connect as the collecting loops serving the vascular capillary beds within the gills that form adjacent to the enlarged pharyngeal slits.
4. The anterior and posterior halves of each collecting loop are its **pretrematic and posttrematic branches**, respectively. Although the external carotid artery arises embryologically from the anterior end of the ventral aorta, it becomes associated with the collecting loop, to carry oxygenated blood to the lower jaw. The internal carotid

artery supplying the brain receives oxygenated blood from the first fully functional collecting loop (pharyngeal slit II) via the efferent branchial artery (II).



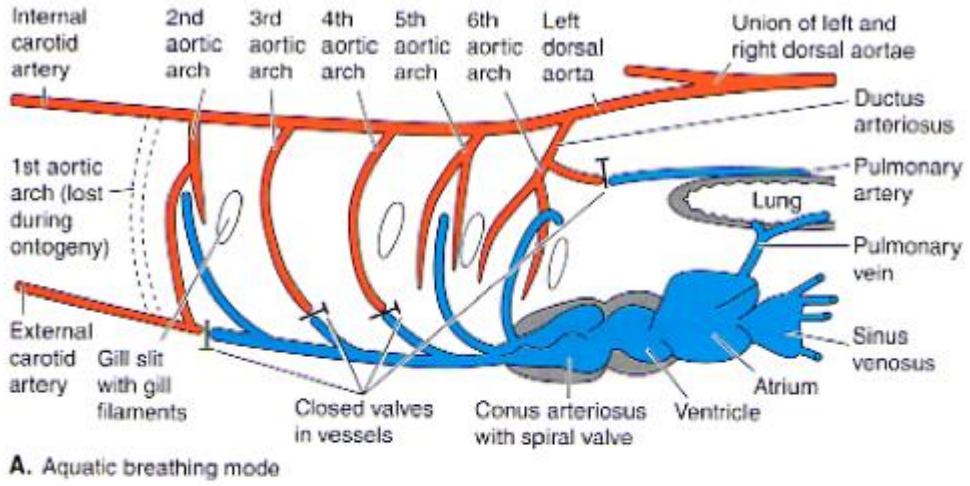
In Teleosts:

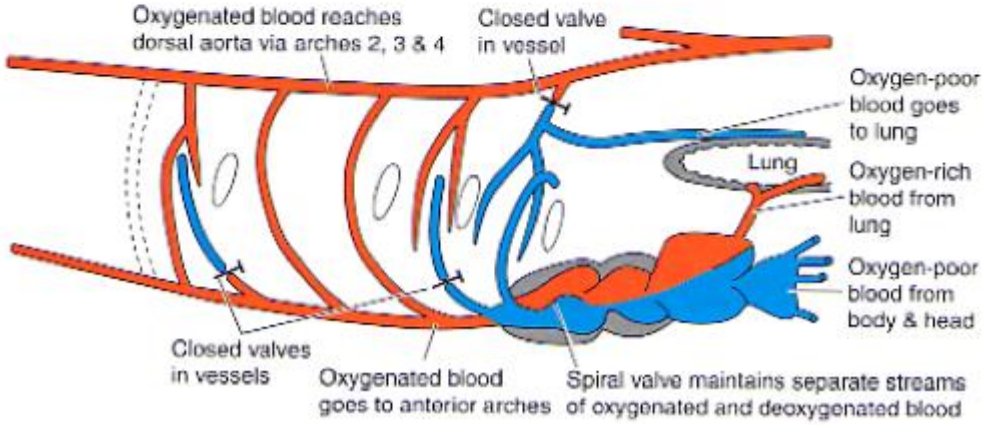
a. In Actinopterygians:

1. There are four pairs of aortic arches. First pair (mandibular) and second pair (hyoidean) are lost, only four pairs (III to VI) persist as branchial arteries. Four pairs afferent branchial arteries arise from the ventral aorta. They supply deoxygenated blood to the gills for aeration.

b. In Dipnoans

1. In most fishes with supplementary air breathing organs , the oxygenated blood departing from the organs enter the general venous circulation boosting the overall oxygen level of the blood returning to the heart. However in lungfishes, the blood leaving the highly vascularised lungs directly renters the heart via a separate pulmonary vein. Lungfishes are the only fishes with a separate pulmonary circulation to and from the lungs.
2. In lungfishes, as in other bony fishes, the first pharyngeal slit is reduced to a spiracle that has no respiratory function. Its associated aortic arch (I) is reduced as well.
3. In the Australian lungfish, *Neoceratodus*, the remaining five pharyngeal slits open to fully functional gills supplied by four aortic arches (III–VI).
4. In the African lungfish, *Protopterus*, the functional gills are reduced further. The third and fourth gills are absent entirely, but their aortic arches (III–IV) persist.
5. In all lungfishes, the efferent vessel of the most posterior aortic arch (VI) gives rise to the pulmonary artery but maintains its connection to the dorsal aorta via the short **ductus arteriosus**. [if blood low in oxygen in the ventral aorta flows along its presumed route through arches II, V, and VI, it passes through the capillary beds of the gills, is replenished with oxygen, and enters the dorsal aorta as oxygenated blood.]
6. But in the African lungfish, blood low in oxygen in the ventral aorta seems to have an alternative route through arches III and IV, which lack gills. Theoretically, blood could reach the dorsal aorta unaltered, still lacking oxygen.
   n most teleosts or bony fishes, the first and second aortic arches are tend to disappear & thus only third, fourth, fifth &sixth pairs of aortic arches remain functional.





Aortic arches in amphibians:

In amphibians, the first two aortic arches (I &II) disappears early in the development. The aortic arches donot break up into afferent and efferent portions since in higher forms internal gill lamellae doesn't develop. The pattern in the remaining arches differ between larvae and the metamorphosed adult.

a. In Urodel Amphibians:

Larval forms:

1. The III, IV and V arches bear gills .
2. The last (VI) aortic arch sprouts the pulmonary artery to the developing lungs.
3. In most of the salamandars, the external gills are lost following the larva's transformation to the adult.

Adult:

1. The short radix of the dorsal aorta between the II and the IV is termed as carotid duct or **ductus caroticus** which is lost after metamorphosis.
2. The Vth arch may persist in a very reduced form.
3. The final VIth aortic arch also joins the dorsal aorta, its last short section forming the **ductus arteriosus** and gives off pulmonary artery divides into small branches to the floor of mouth, oesophagus and pharynx.

b. In Anuran Amphibians:

larval forms:

1. Anuran larva have external gills that reside on the last four aortic arches (III, IV, V and VI)

Adult:

1. At metamorphosis, these gills are lost along with the Ductus caroticus which was present initially.
2. Vth aortic arch is lost.
3. III, IV and VI that persists expand to supply blood to the head, body and pulmonary circuits respectively.
4. The last aortic arch loses its connection with the dorsal aorta as the ductus arteriosus disappears.

IIIrd Aortic Arch

- The IIIrd aortic arch together with the anterior portion of the radix of the dorsal aorta forms the **Internal carotid artery.**
- the ventral aorta after the IIIrd, bifurcates anteriorly and forms the **External carotid artery.**
- The portion of the ventral aorta from which the external and the internal carotid arches originate is known as the **Common Carotid Artery.**

What is carotid body?

The carotid body is a small cluster of sensory cells associated with capillaries, usually located near the point at which the common carotids branch. Its functions are not completely known. Certainly the carotid body plays a role in sensing the gas content or pressure of the blood as well as having some endocrine functions.

Aortic Arches in Reptiles:

Reptiles are fully terrestrial vertebrates in which gills disappear altogether and replaced by lungs. Only three functional arches (third, fourth & sixth) are present. The symmetrical aortic arches of the embryo tend to become asymmetrical in the adult.

1. Aortic arches III, IV, and VI persist in reptiles,
2. In certain lizards the fifth arch may also be retained in reduced form.
3. A remnant of radix btween III and IV may persist in some snakes.
4. The ventral aorta splits to form the bases of three separate arteries leaving the heart:
    - the left aortic arch,
    - the right aortic arch, and
    - the pulmonary trunk.
5. The pulmonary trunk incorporates the bases of the paired sixth arch and their branches as part of the pulmonary arch to the lungs.
6. The base of the left aortic arch, the left aortic arch (IV) itself, and the curved section of the left dorsal aorta into which it continues constitute **the left systemic arch**.
7. **The right systemic arch** includes the same components on the right side of the body: the base of the right aortic arch, the right aortic arch itself, and the arched section of the right dorsal aorta. The two systemic arches unite behind the heart to form the common dorsal aorta.

Aortic arches in birds & mammals:

Birds & mammals are warm-blooded because in both the ventricle is completely divided so that there is no mixing of oxygenated& deoxygenated bloods.

In Birds:

1. The I, II, V and VI aortic arches completely absent.
2. The IV arch and the radix on the left side lose their connection with the dorsal aorta and finally disappear.
3. The ventral aorta splits into 2 portions- a systemic aorta and a pulmonary aorta or trunk.
4. The IV aortic arch from the right side of the ventricle leaves the systemic arch joins the radix, leads to the dorsal aorta proper which supplies blood to the entire body.
5. The pulmonary trunk arising from the right ventricle gives off pulmonary artery which are actually outgrowths of VI aortic arch.in birds the right arch forms the dorsal aorta, whereas the left one becomes the subclavian artery

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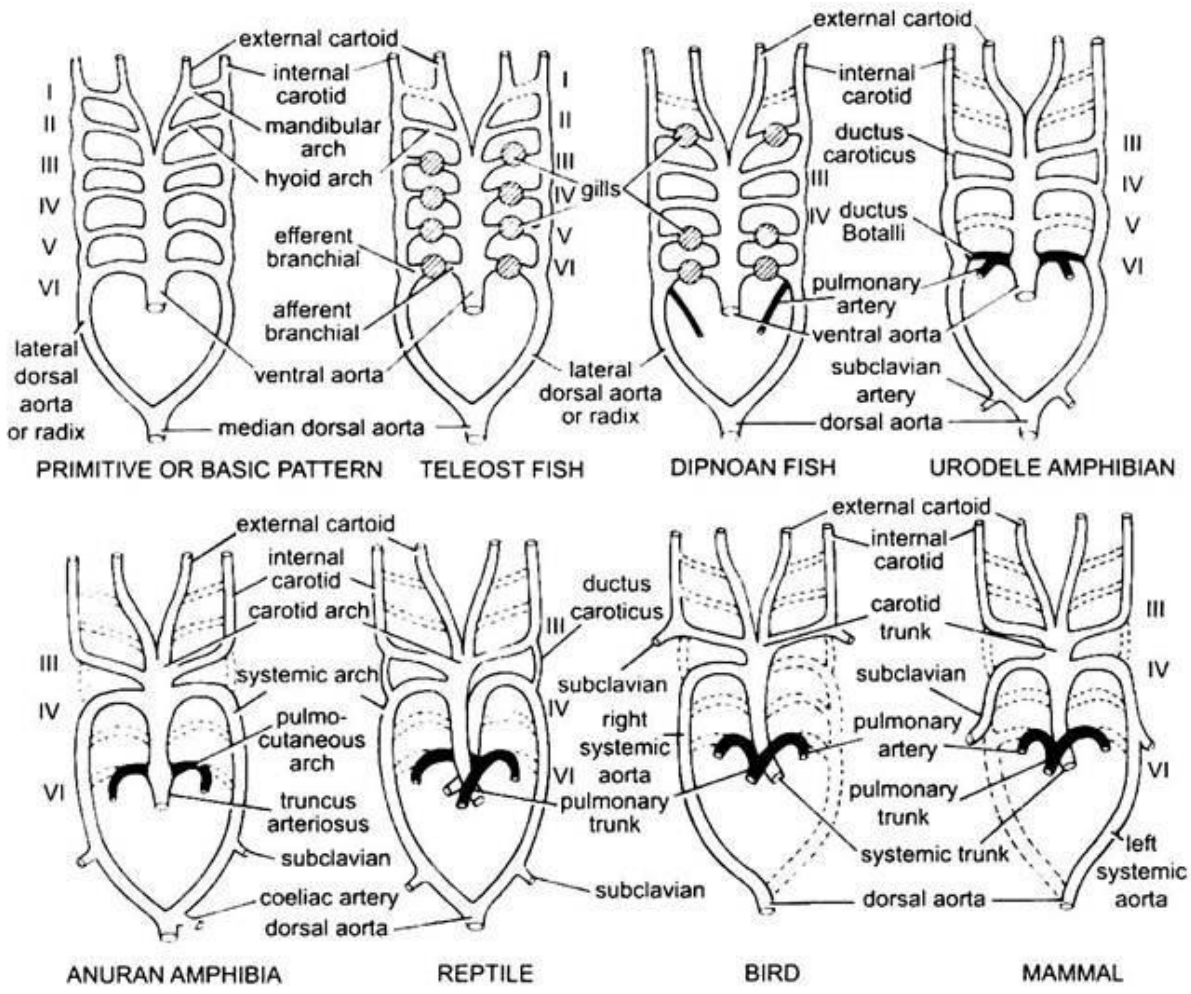
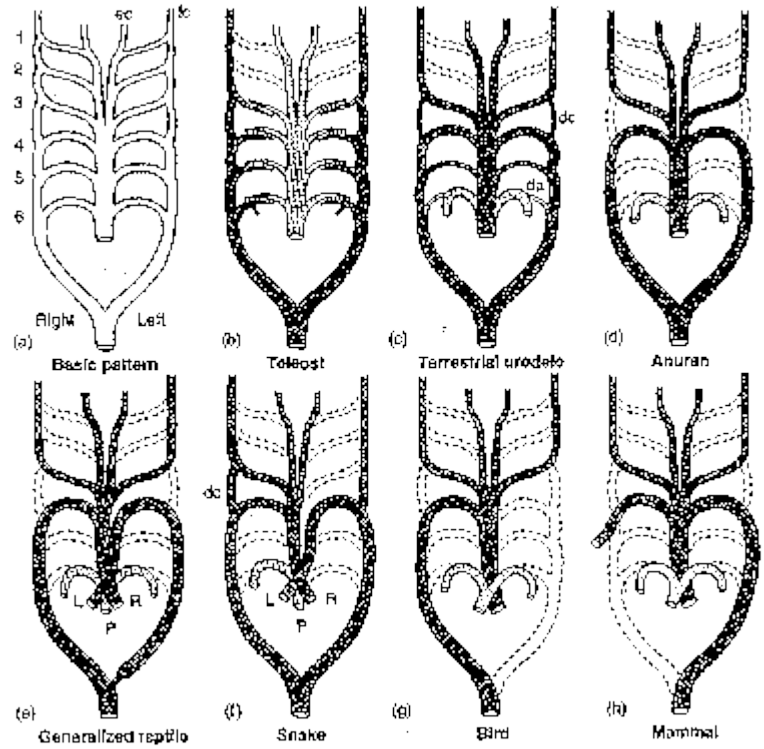


Fig. 45.6. Modification of aortic arches in representative vertebrates.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ic
1
2
3
4
5
6
Right
Left
(a)
Basic pattern
(b)
Teleost
(c)
dc
da
Terrestrial urodele
(d)
Anuran
dc
L
R
P
(e)
Generalized reptile
(f)
Snake
(g)
Bird
(h)
Mammal