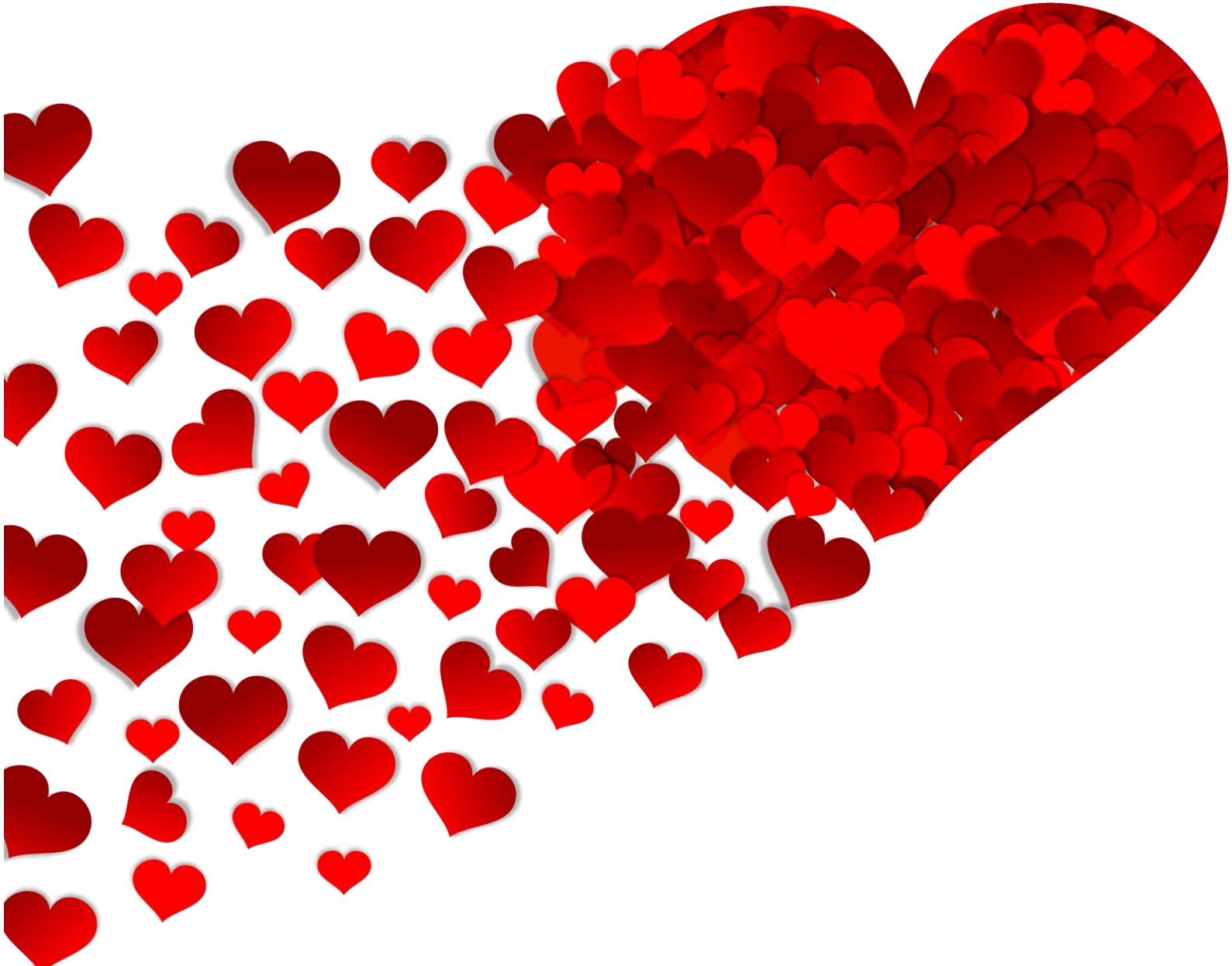
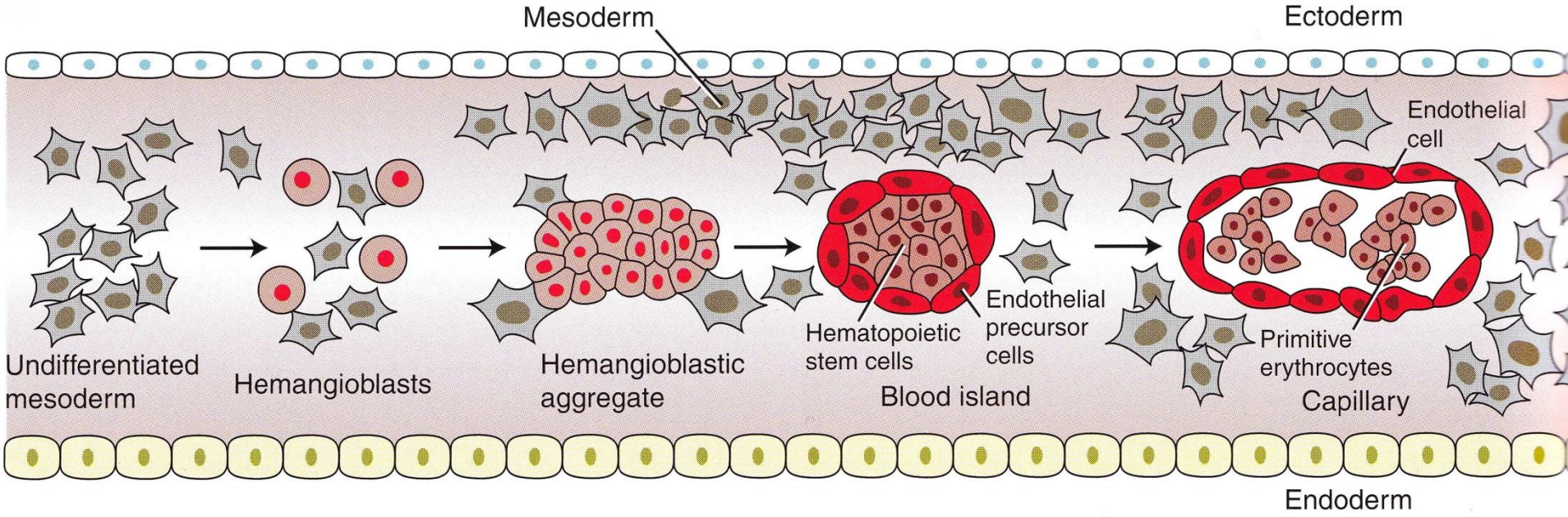
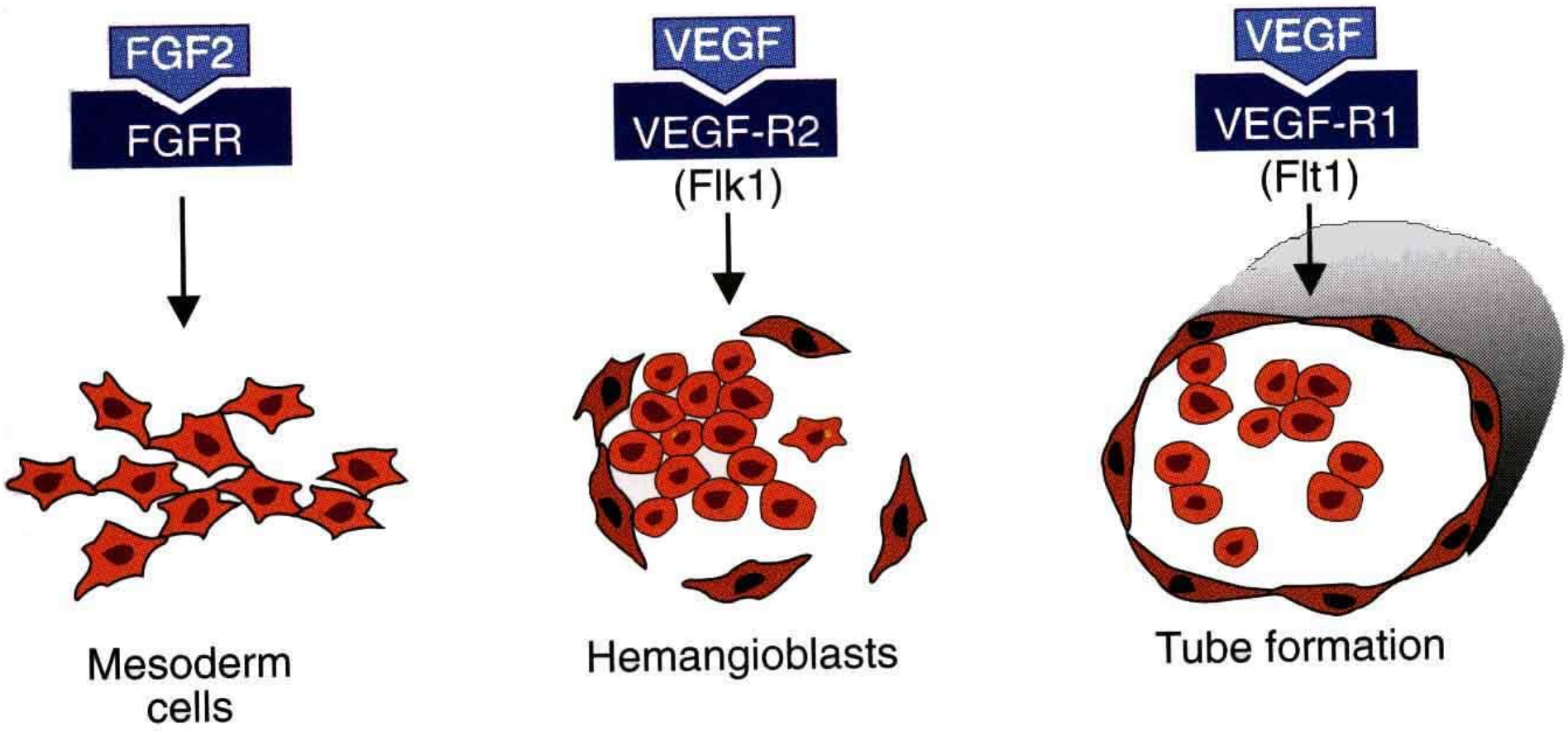
Vývoj srdce



VASKULOGENEZE

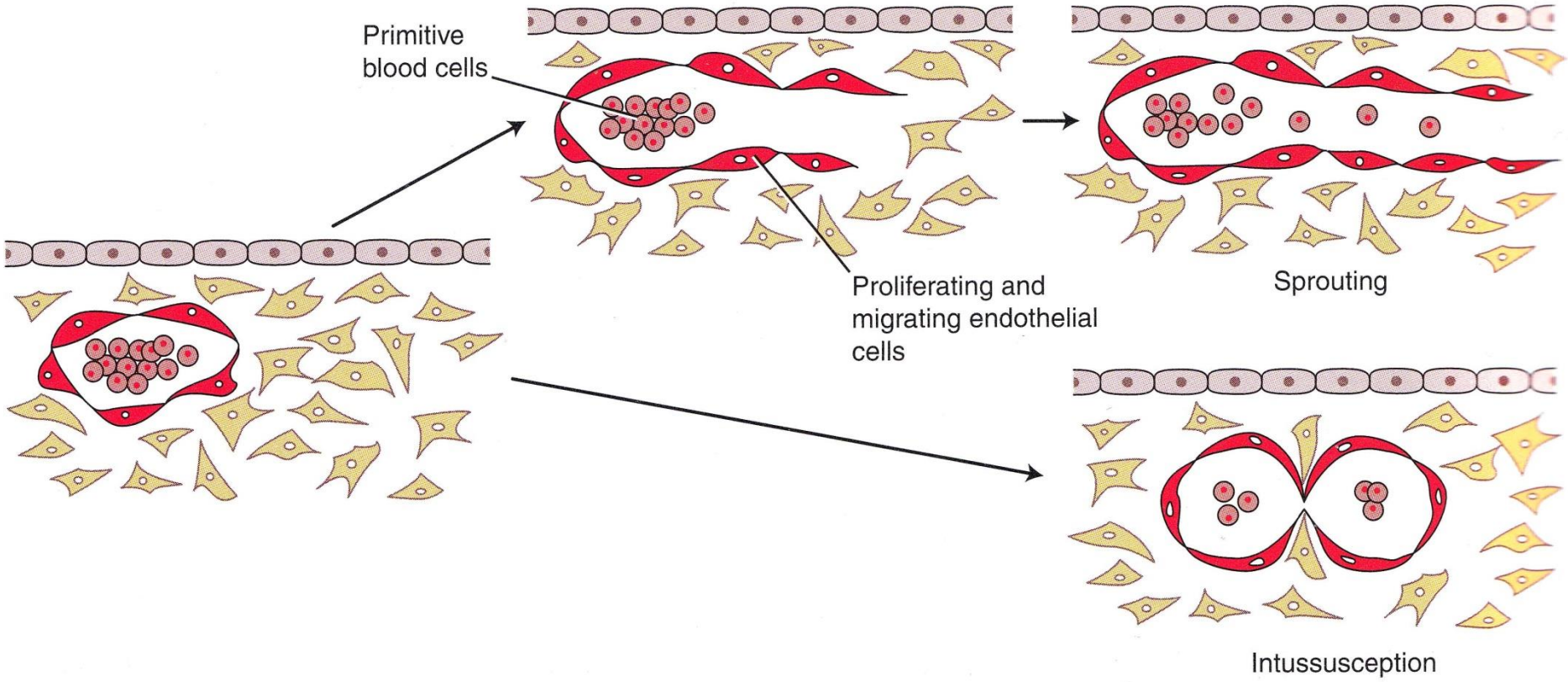


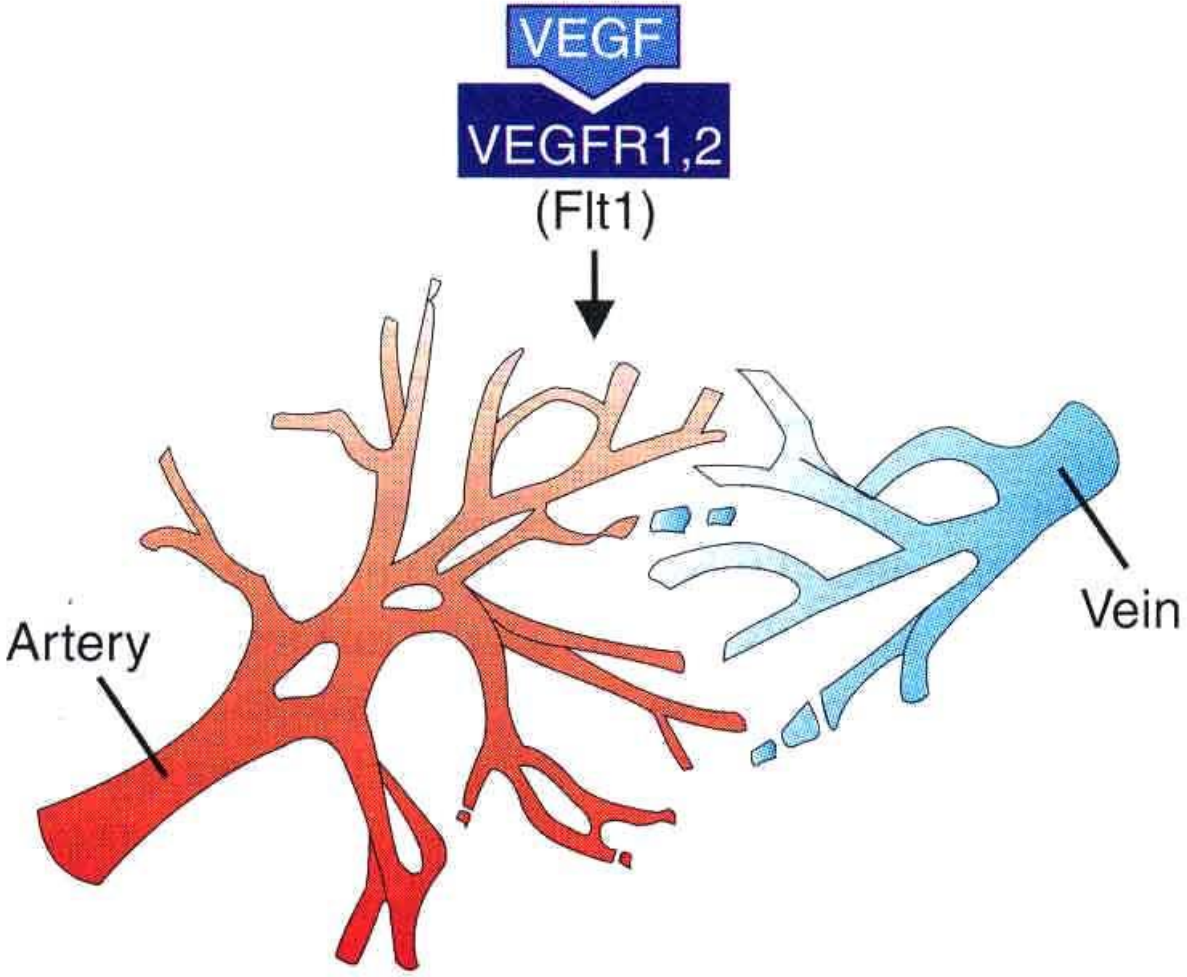
- primární cévní pleteně jsou vytvořeny dějem vaskulogeneze
- vytvořené cévy pučí = angiogeneze (zprostředkované VEGF)
- první krevní ostrůvky v extraembryonálním mezodermu ve stěně žloutkového váčku (**3. týden**) a allantois
- později intramebryonální mezoderm – další oblastí



VASKULOGENEZE

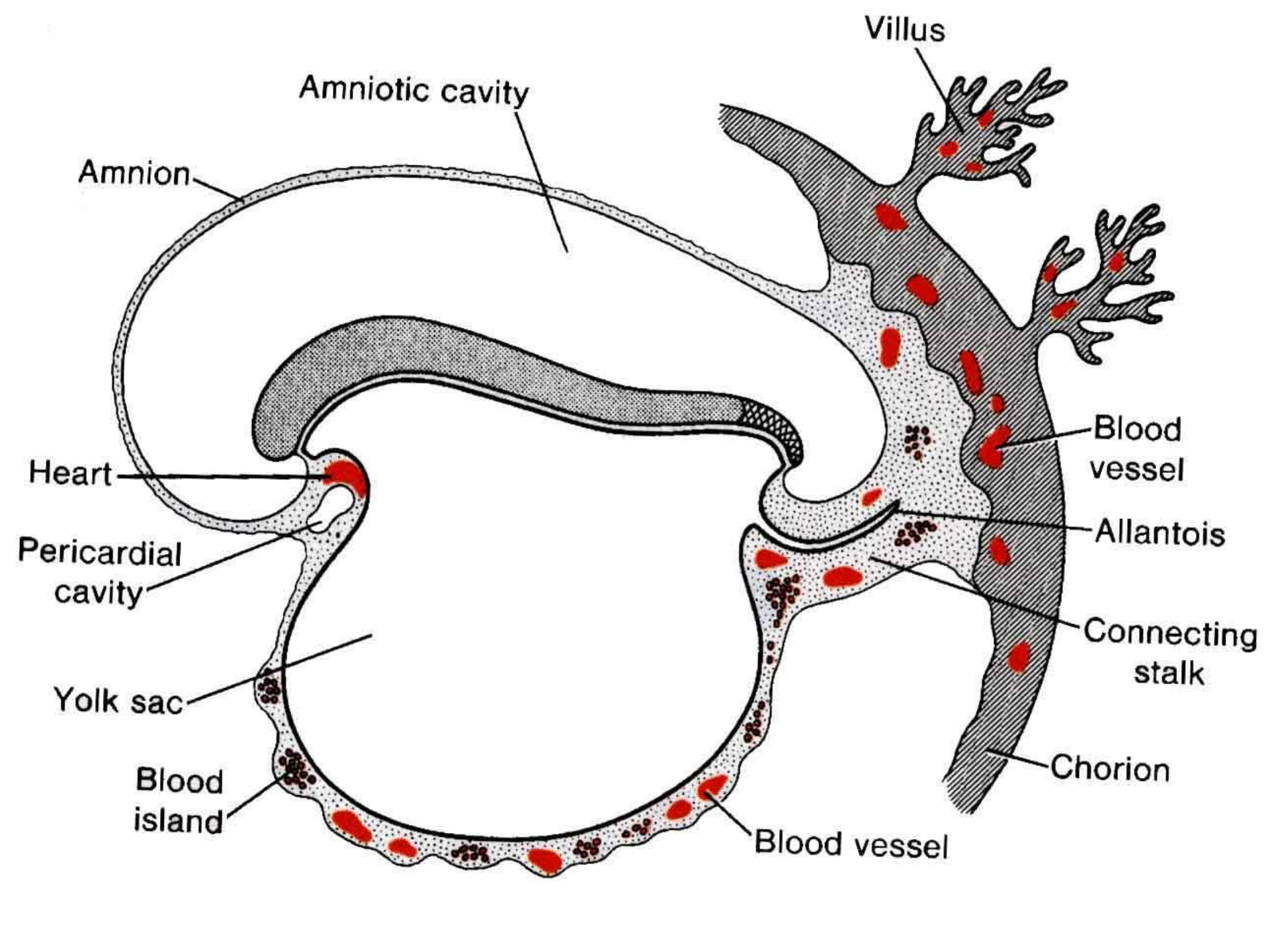
ANGIOGENEZE

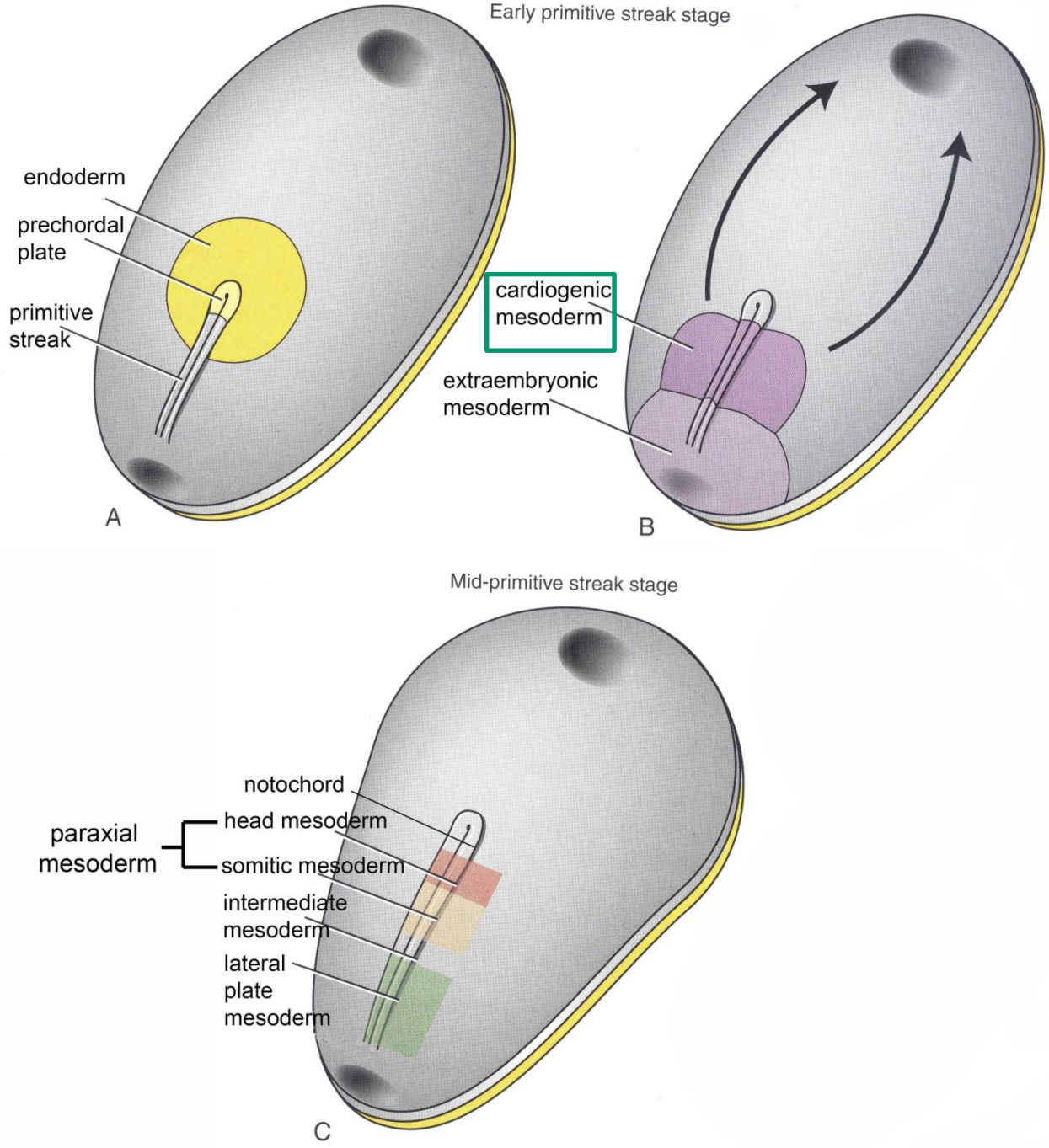




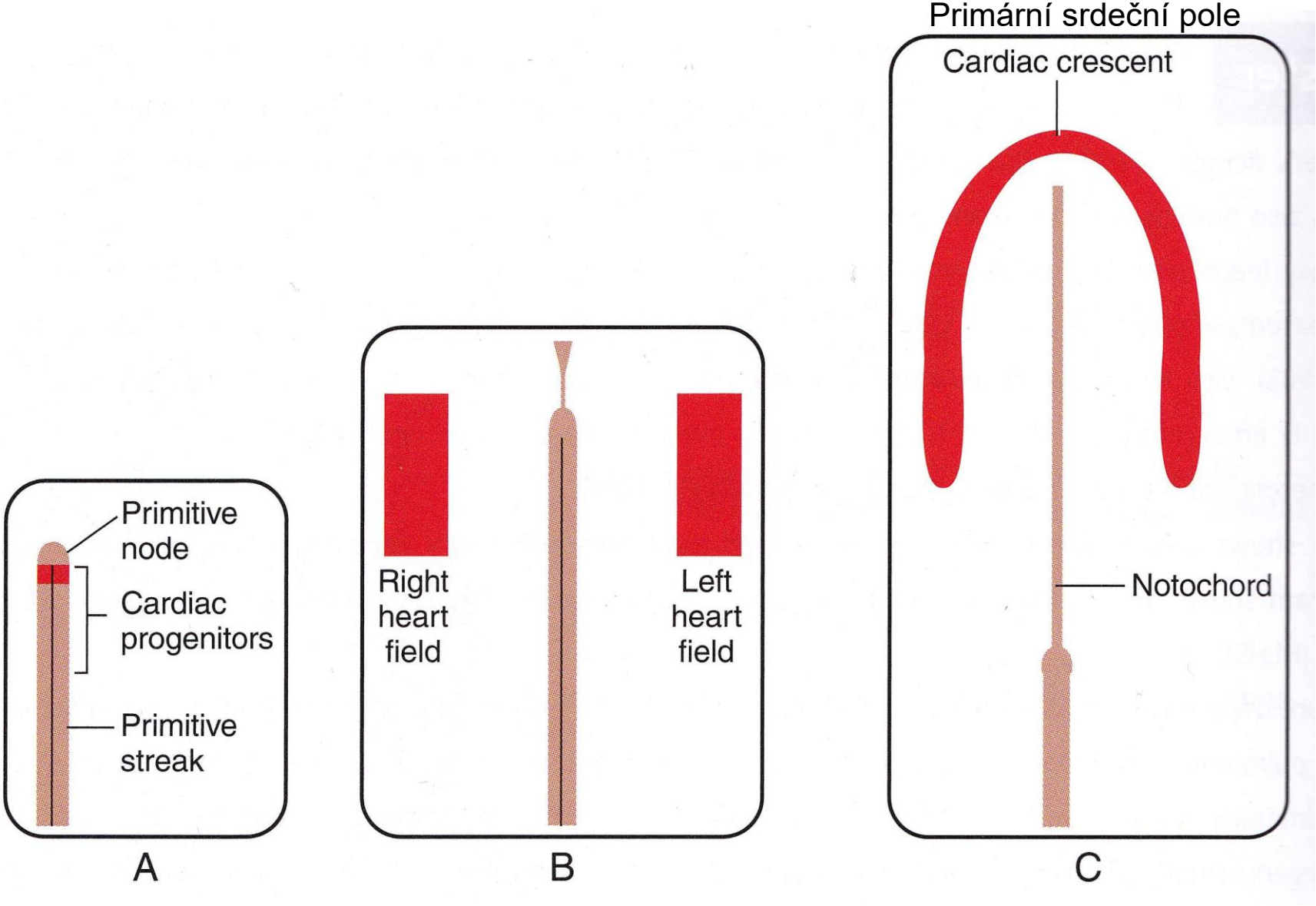
ANGIOGENEZE

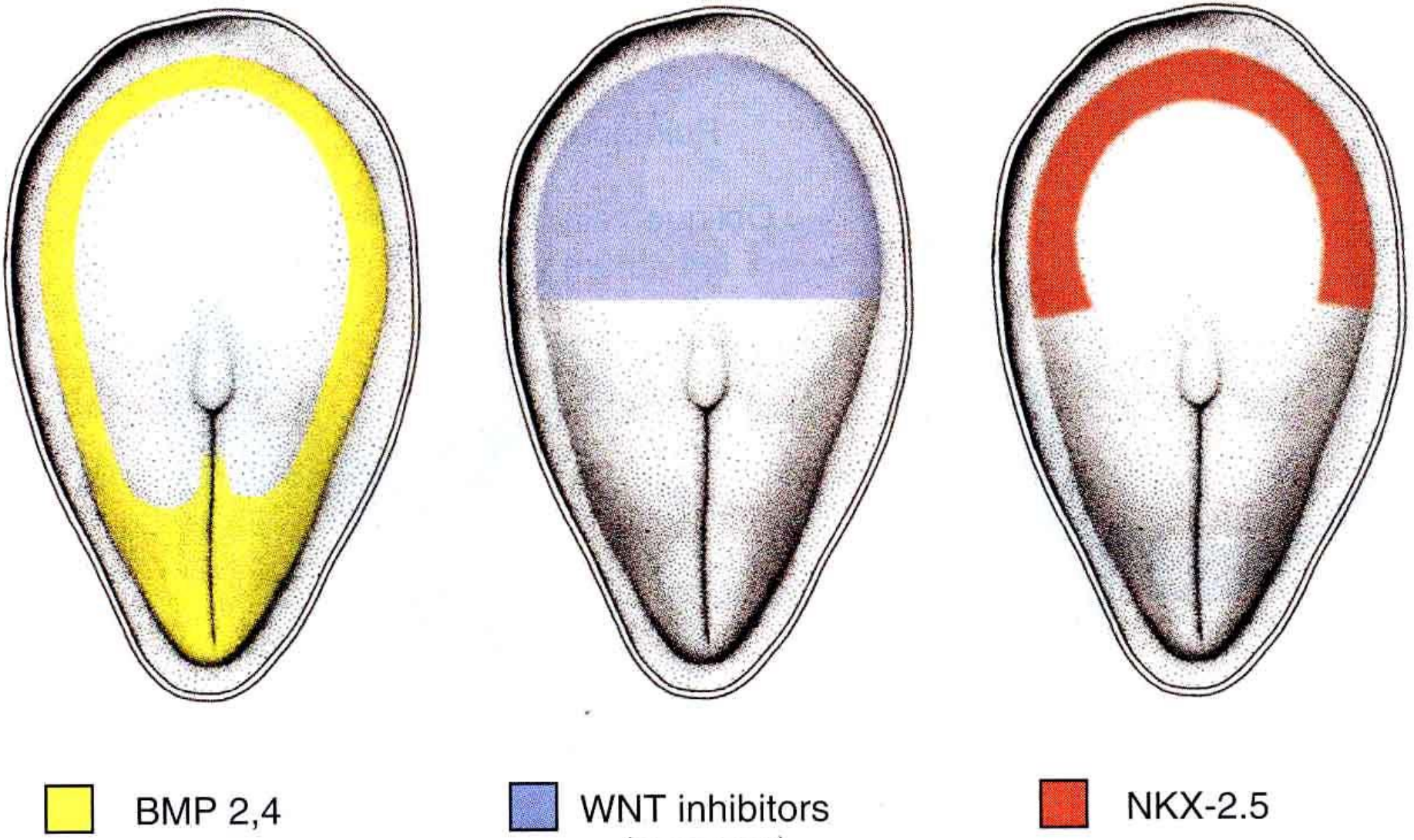
dále také
TGFβ
PDGF


Villus
Amniotic cavity
Amnion
Blood vessel
Heart
Allantois
Pericardial cavity
Connecting stalk
Yolk sac
Chorion
Blood island
Blood vessel


Early primitive streak stage
endoderm
prechordal plate
primitive streak
A
cardiogenic mesoderm
extraembryonic mesoderm
B
Mid-primitive streak stage
notochord
paraxial mesoderm
head mesoderm
somitic mesoderm
intermediate mesoderm
lateral plate mesoderm
C

Primární srdeční pole





entoderm,
laterální mesoderm

(Crescent, Cerberus)
entoderm

Vývoj srdce

1. primordia (cor tubulare duplex) den18-22
2. srdeční trubice (cor tubulare simplex) den 21-24
3. srdeční klička (cor sigmoideum) den 23-28
4. embryonální srdce den 27-56

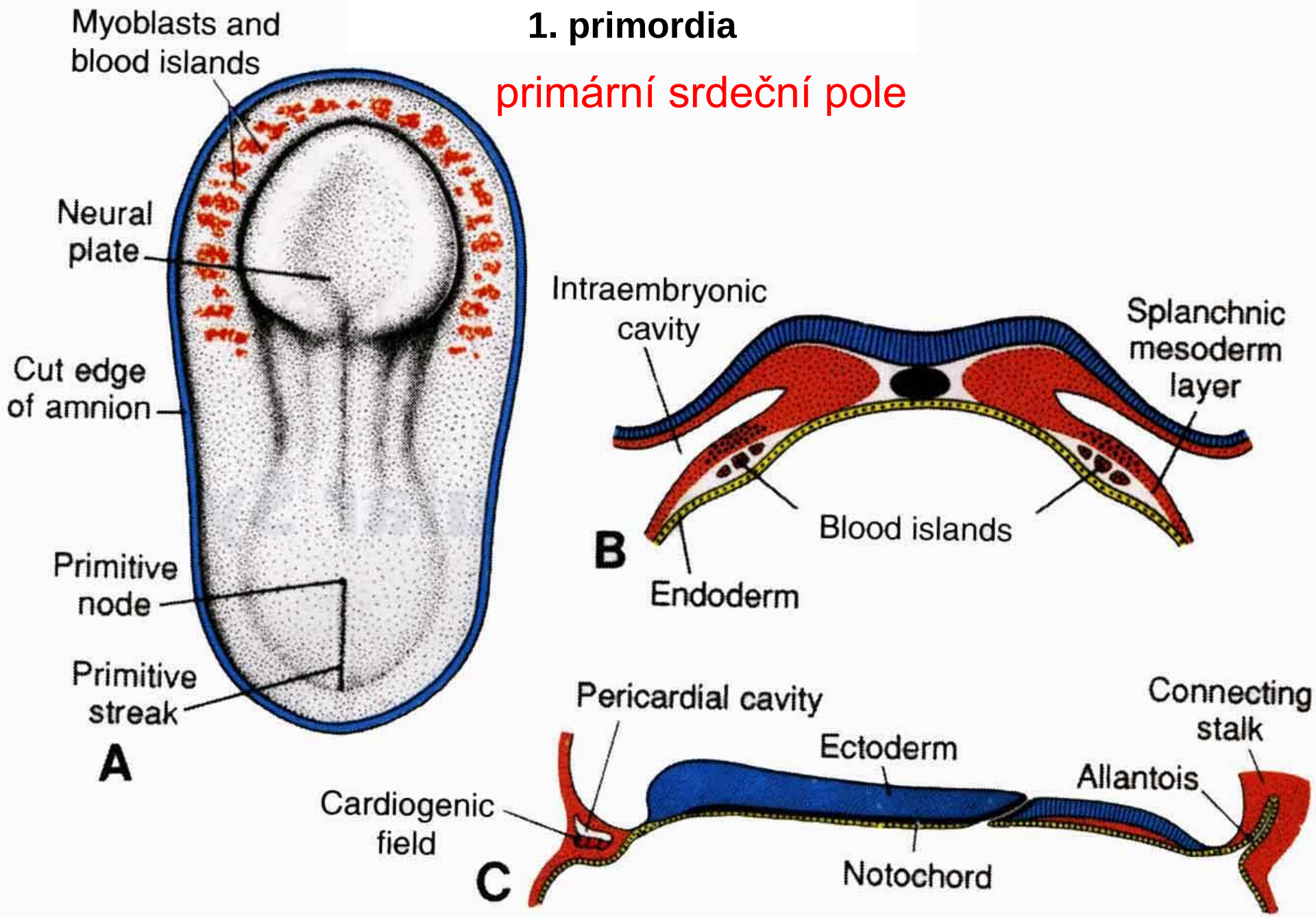
(septace den 27-37)

5. fetální srdce den 57-narození

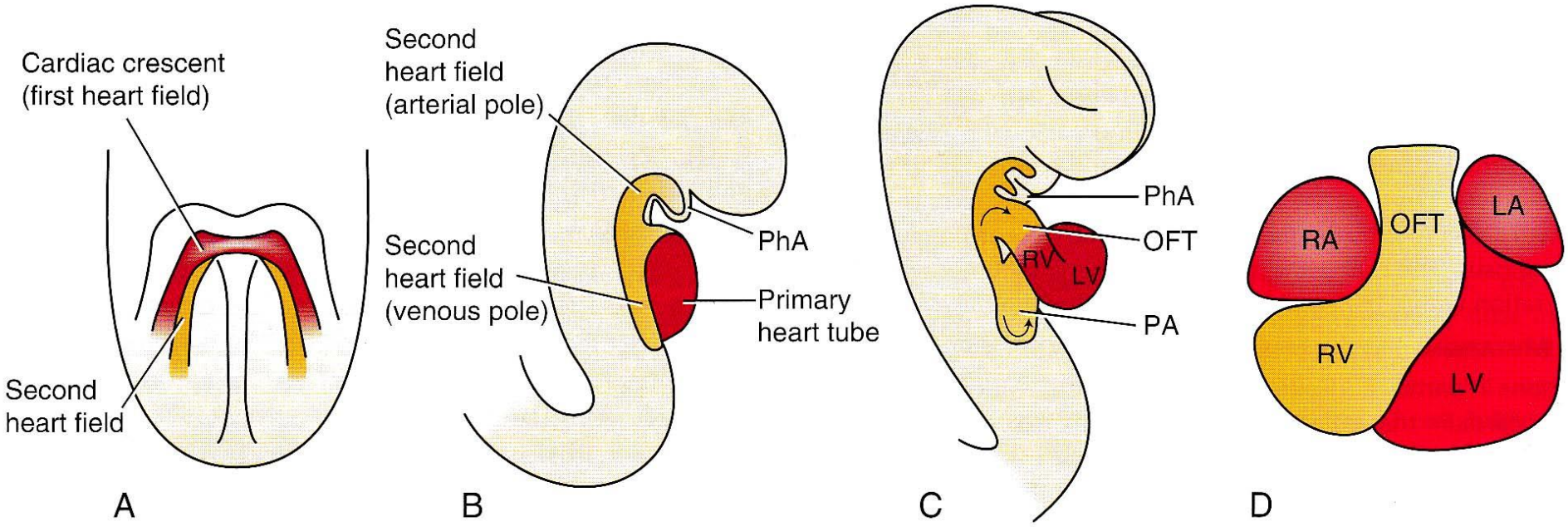
srdeční stahy – 22.-30. den - nekoordinované kontrakce (kyvadlový tok)
30.-32. den - počátek embryochoriového oběhu, frekvence 140-160/min

1. primordia

primární srdeční pole

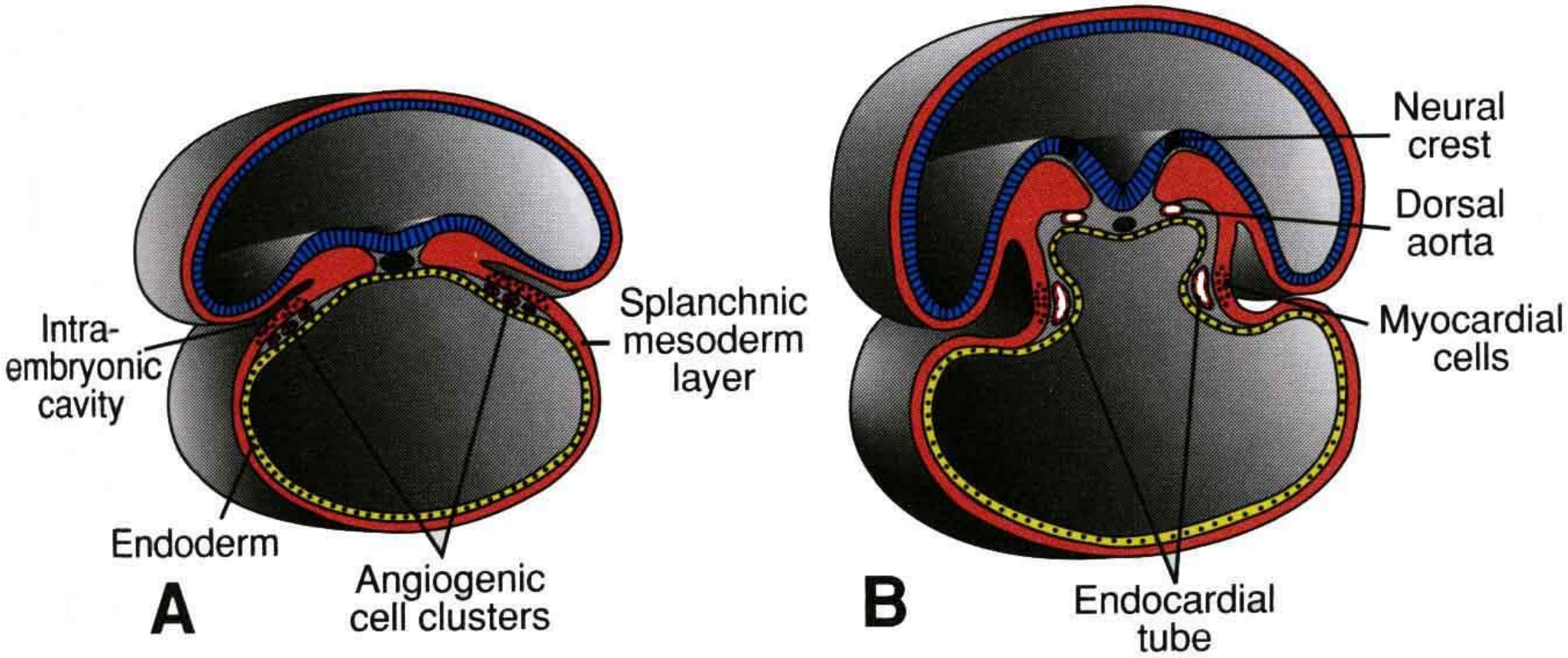


sekundární srdeční pole

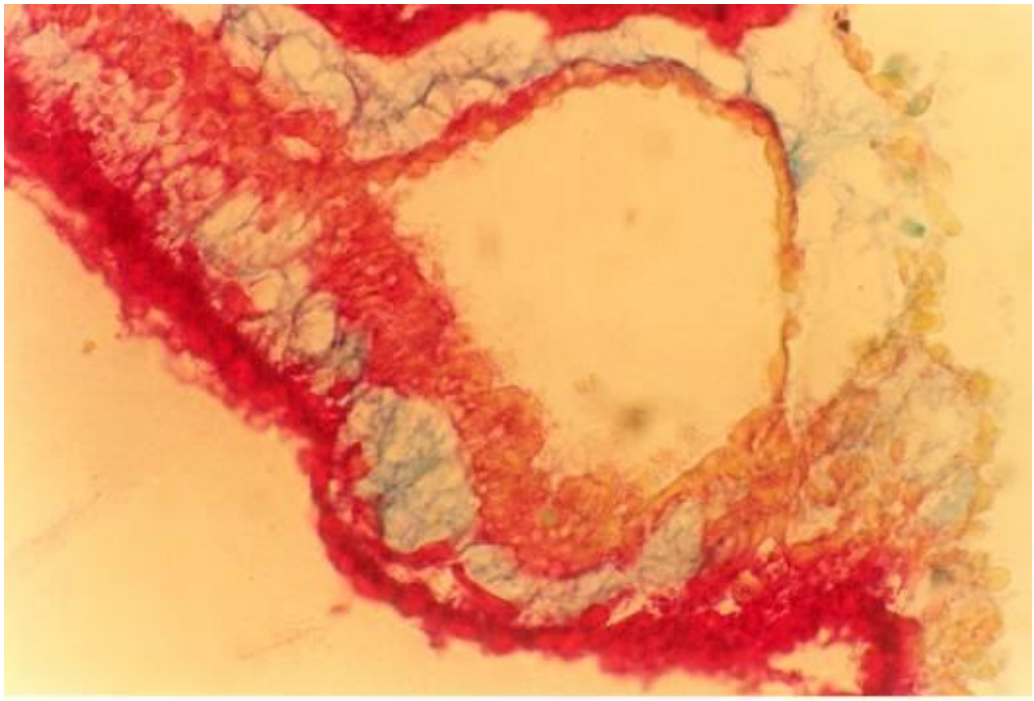


- vzniká později dorzomediálně od primárního srdečního pole
- jeho diferenciace se účastní stejné faktory jako na vzniku primárního srdečního pole (Bmp, inhibitory Wnt)
- podílí se na tvorbě primitivní síně (PA), pravé komory (RV) a výtokového traktu (OFT)

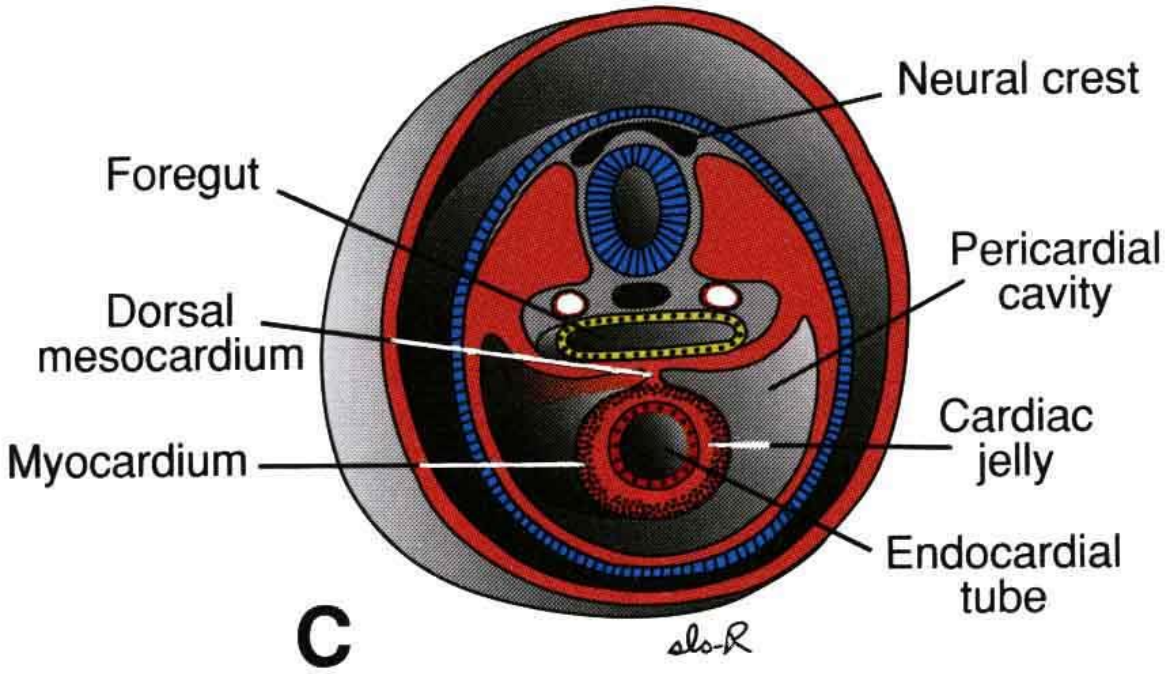
Schoenwolf ,G.C. et al.: Larsen's Human Embryology, Elsevier 2015



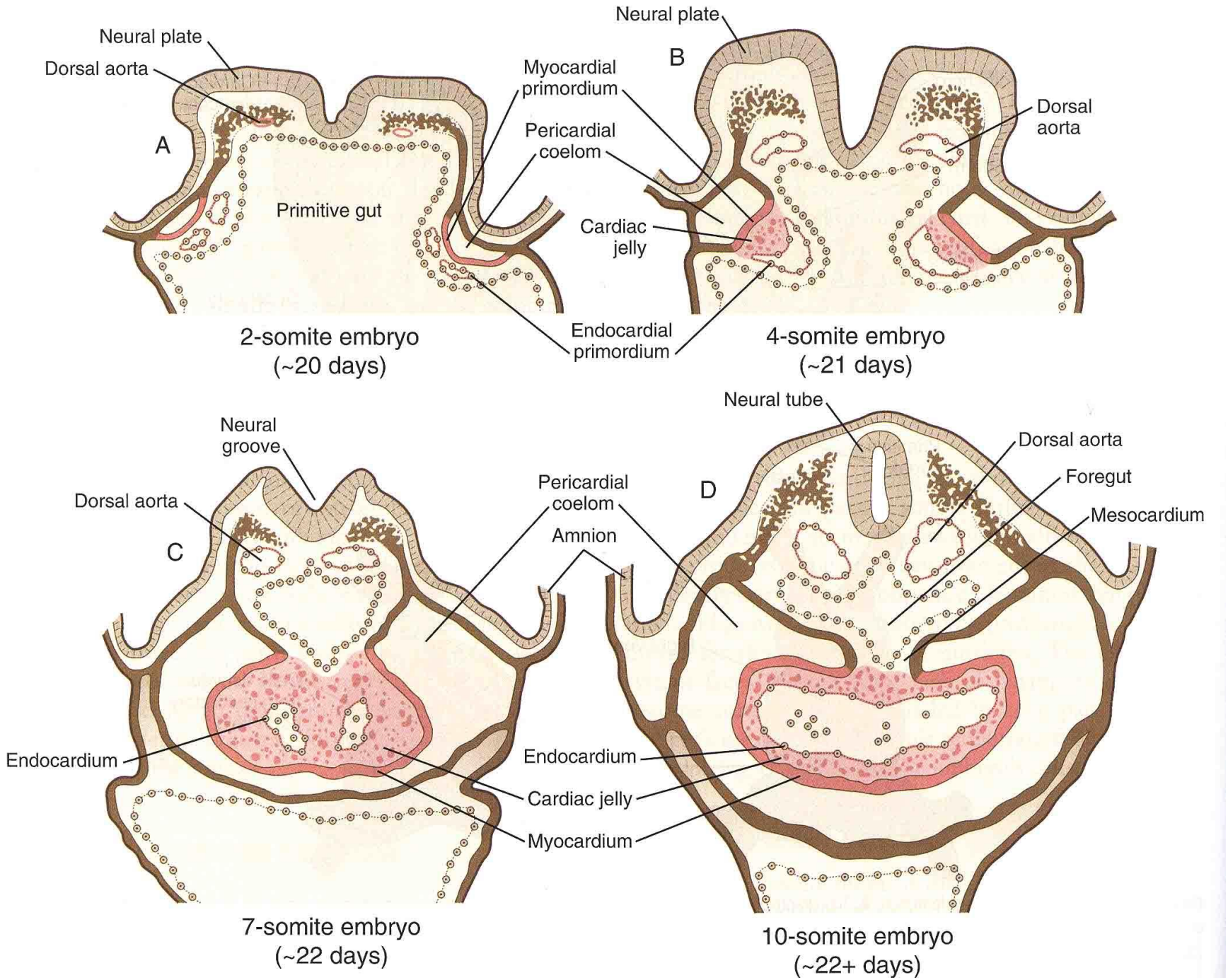
cor tubulare duplex

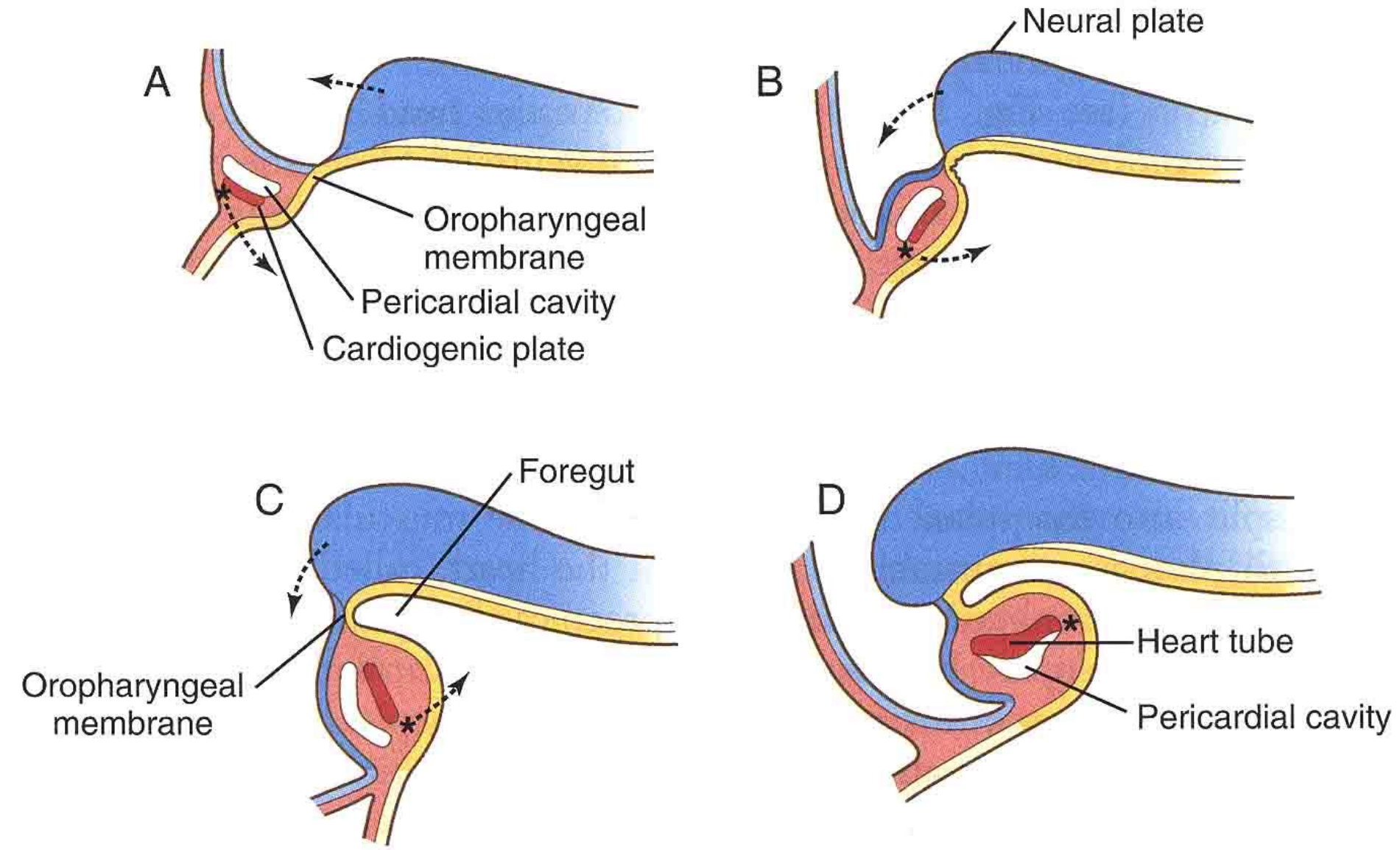


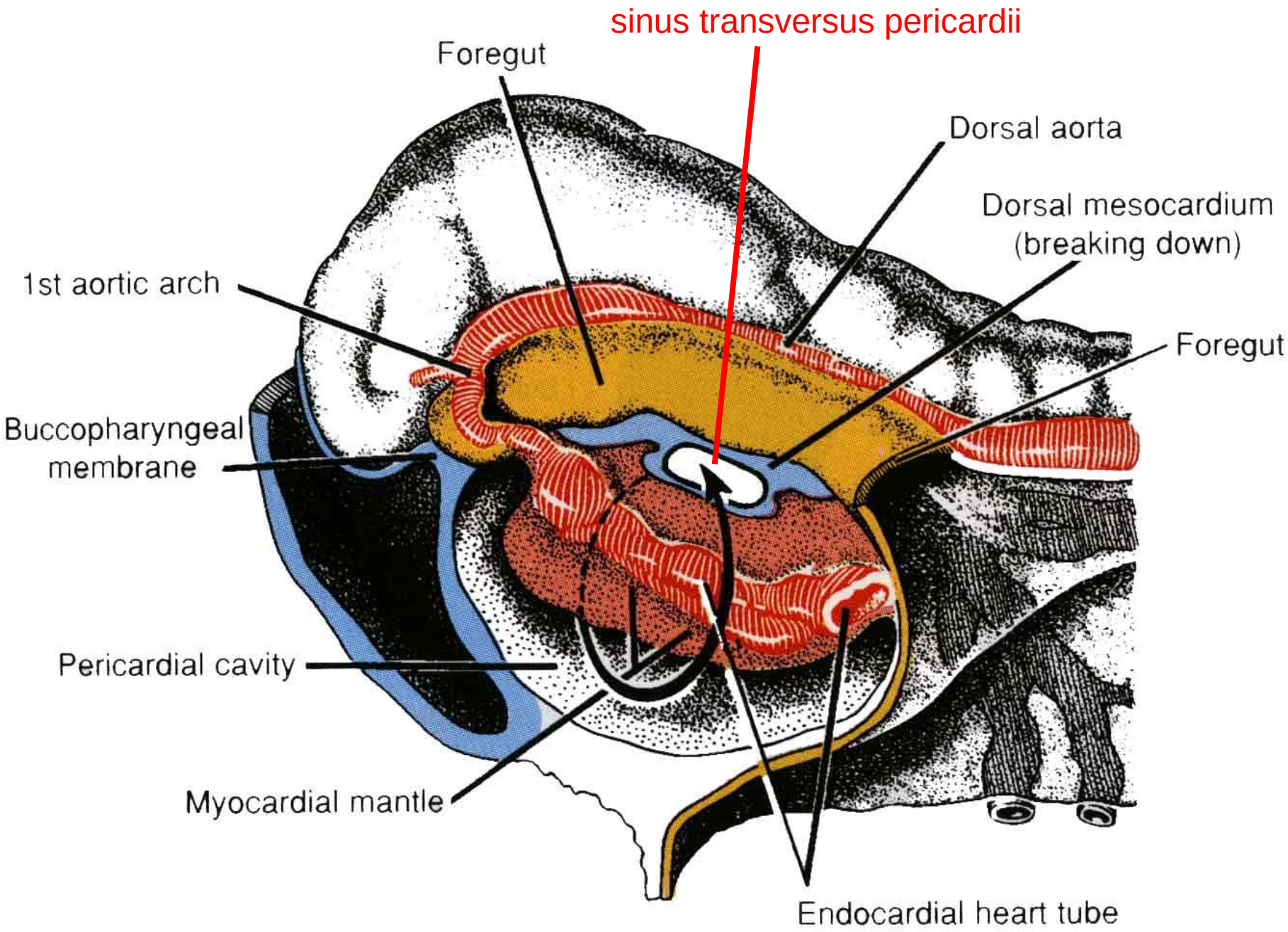
2. srdeční trubice

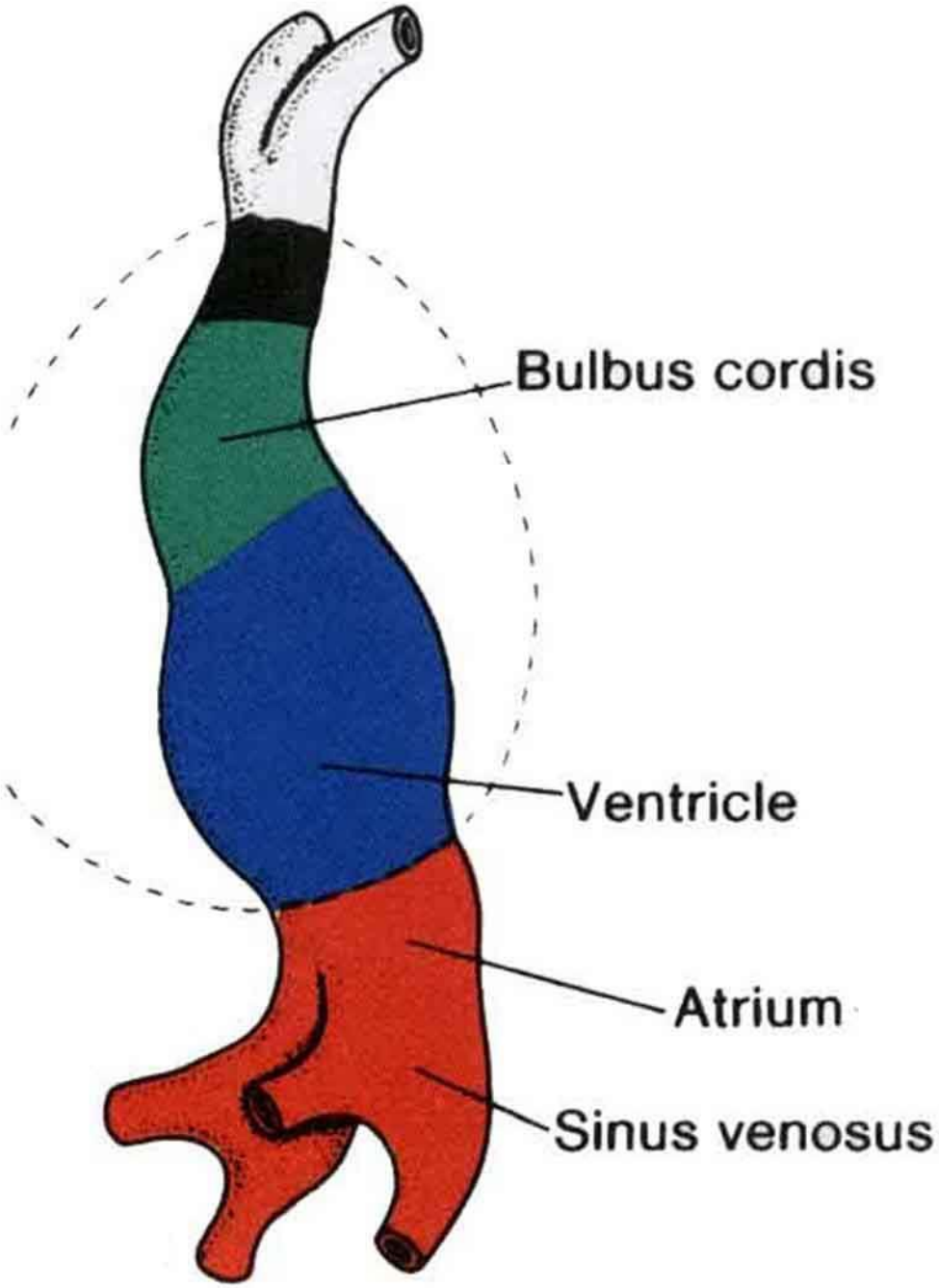


cor tubulare simplex


Neural plate
Dorsal aorta
A
Primitive gut
Myocardial primordium
Pericardial coelom
Endocardial primordium
2-somite embryo
(~20 days)
Neural plate
B
Dorsal aorta
Cardiac jelly
4-somite embryo
(~21 days)
Neural groove
Dorsal aorta
C
Endocardium
Pericardial coelom
Amnion
Cardiac jelly
Myocardium
7-somite embryo
(~22 days)
Neural tube
Dorsal aorta
Foregut
Mesocardium
D
Endocardium
10-somite embryo
(~22+ days)


A
Oropharyngeal membrane
Pericardial cavity
Cardiogenic plate
B
Neural plate
C
Foregut
Oropharyngeal membrane
D
Heart tube
Pericardial cavity


sinus transversus pericardii
Foregut
Dorsal aorta
Dorsal mesocardium
(breaking down)
1st aortic arch
Foregut
Buccopharyngeal
membrane
Pericardial cavity
Myocardial mantle
Endocardial heart tube


Bulbus cordis
Ventricle
Atrium
Sinus venosus

sinus venosus

- atrium - sinus venarum cavarum

- atrium commune

- atrium (odděleno *crista terminalis*) – auricles (ouška)

- ventriculus primitivus
- bulbus cordis

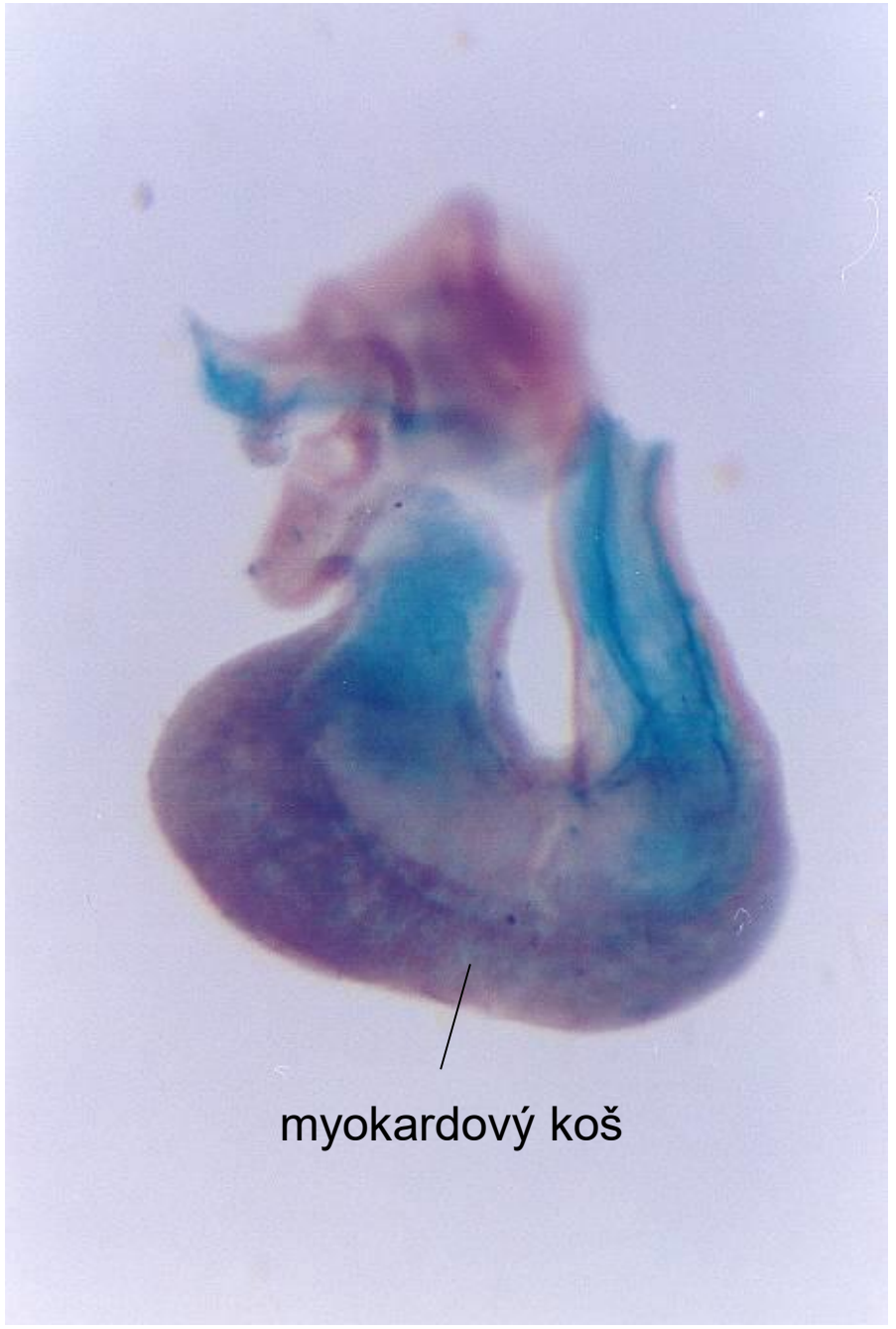
- trabekulární část levé komory
- proximální (ventrikulární) část: trabekulární část pravé komory
- střední část: conus cordis (výtoková oblast obou komor)
- distální část: truncus arteriosus (kořen a proximální číst aorty a trunku)

saccus aorticus

- aorta ascendens, truncus pulmonalis

3. srdeční klička

(cor sigmoideum)

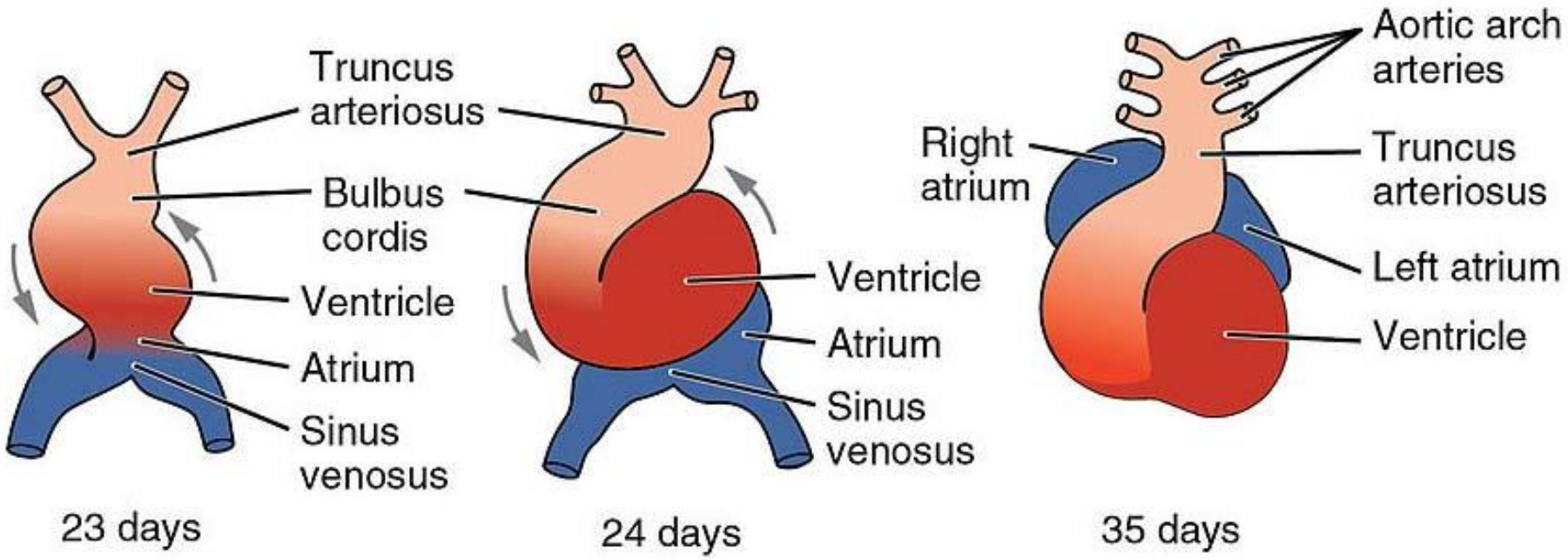


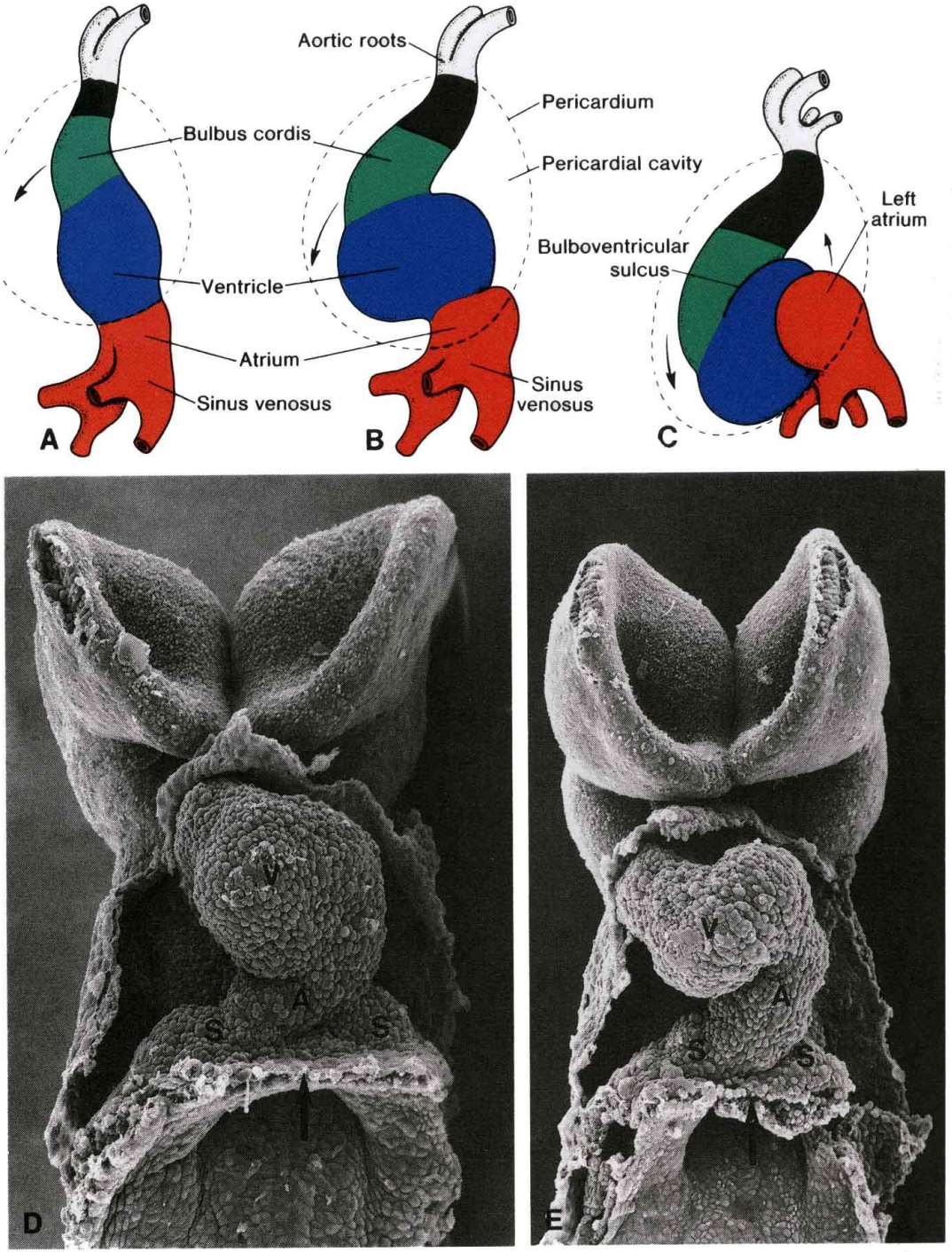
Vznik srdeční kličky

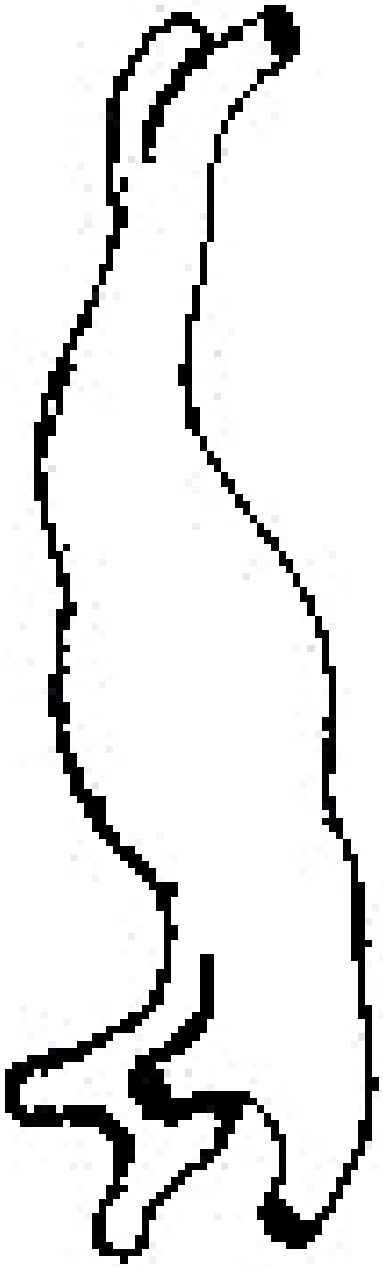
Kraniální část se ohýbá ventrálně, kaudálně, doprava

Kaudální část (atria) dorzálně kraniálně, doleva

do 28.dne

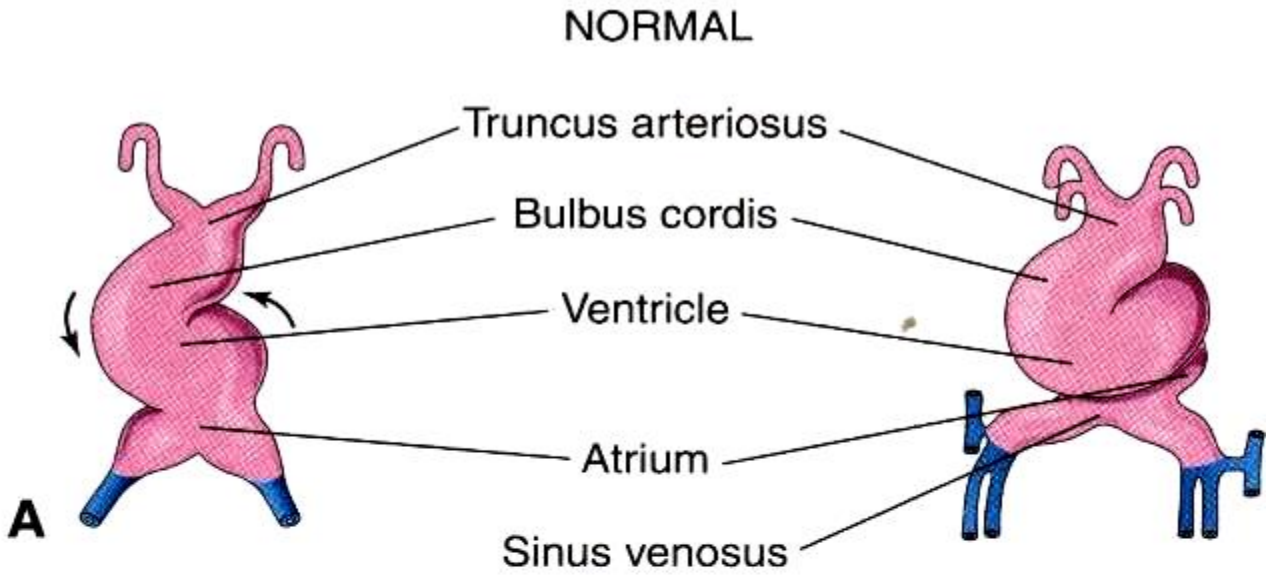


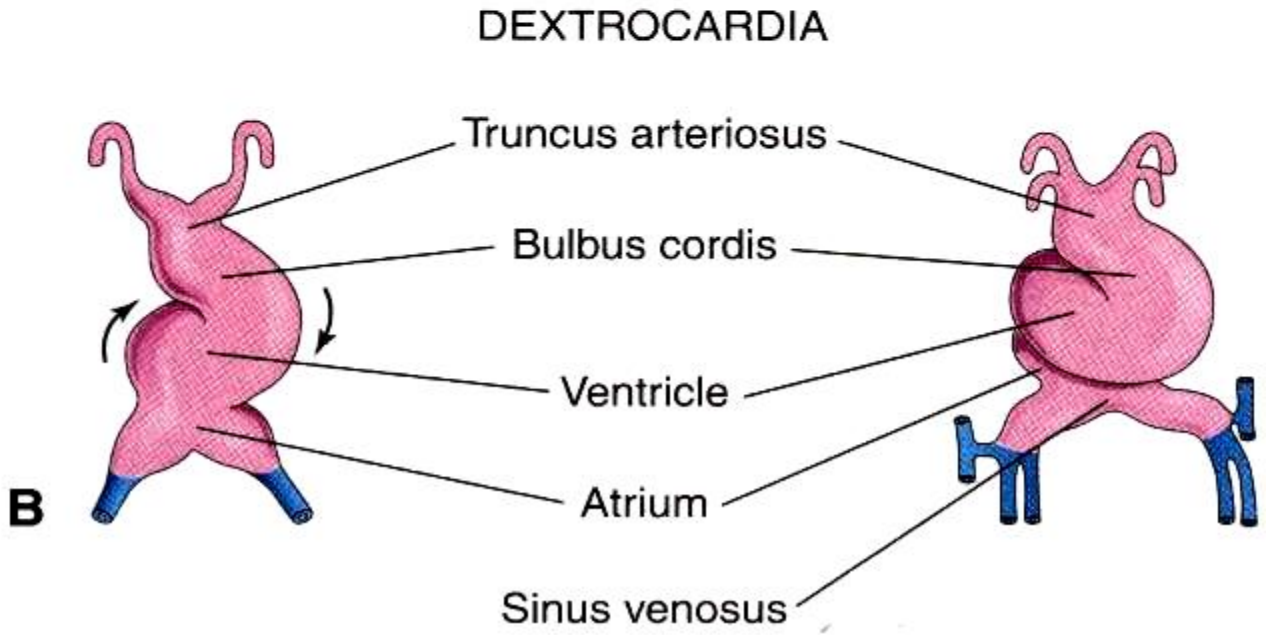

Aortic roots
Pericardium
Bulbus cordis
Pericardial cavity
Left atrium
Bulboventricular sulcus
Ventricle
Atrium
Sinus venosus
Sinus venosus
A
B
C
V
A
S
S
D
V
A
S
S
E



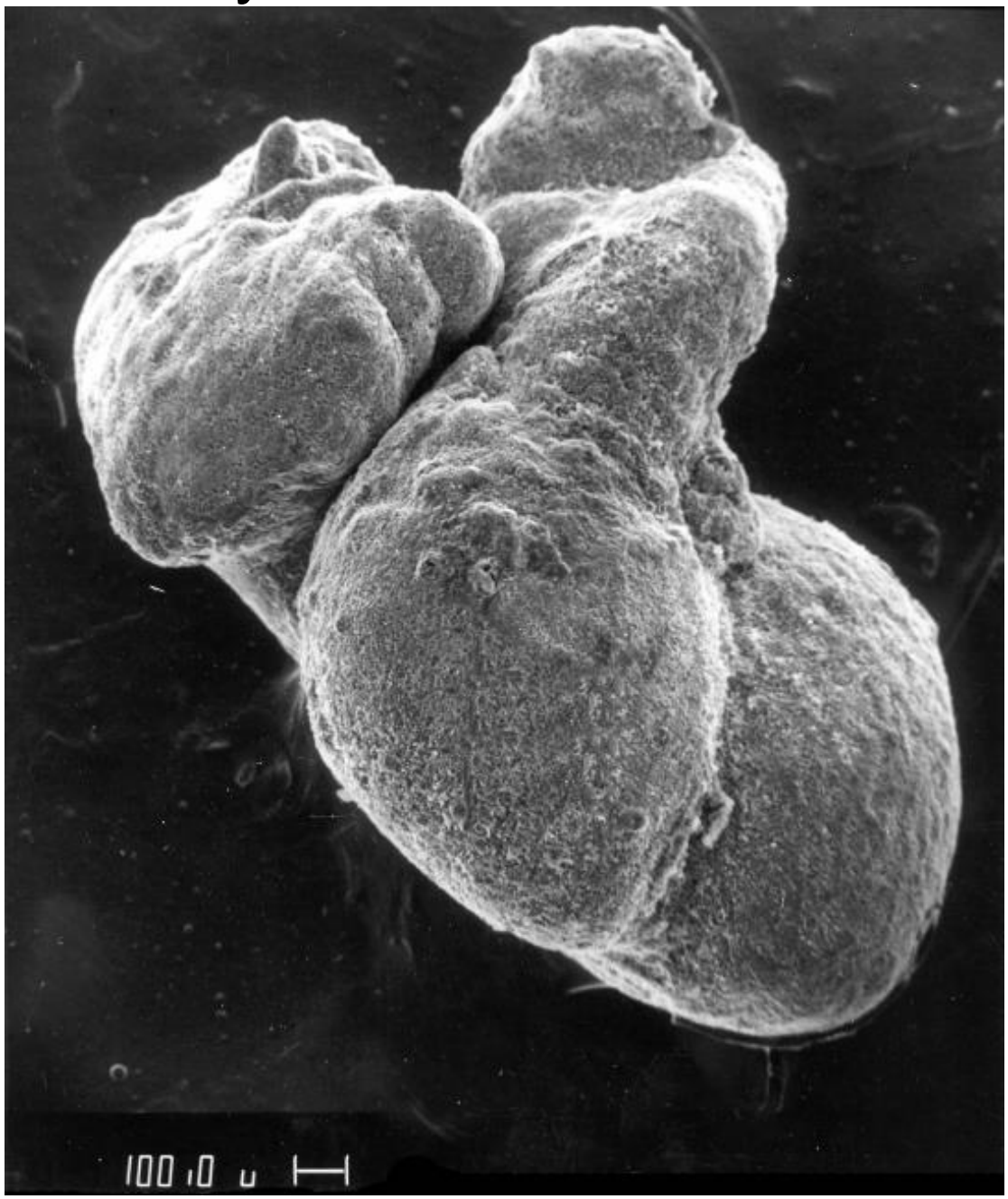
abnormalita u ohýbání

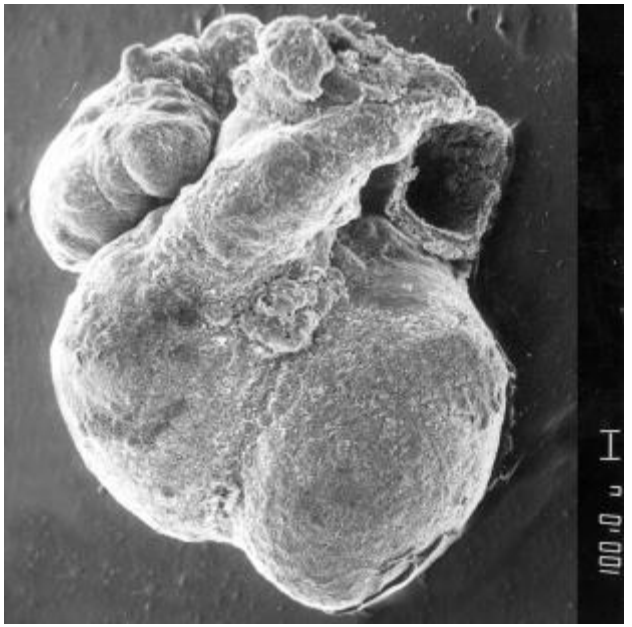
dextrocardia

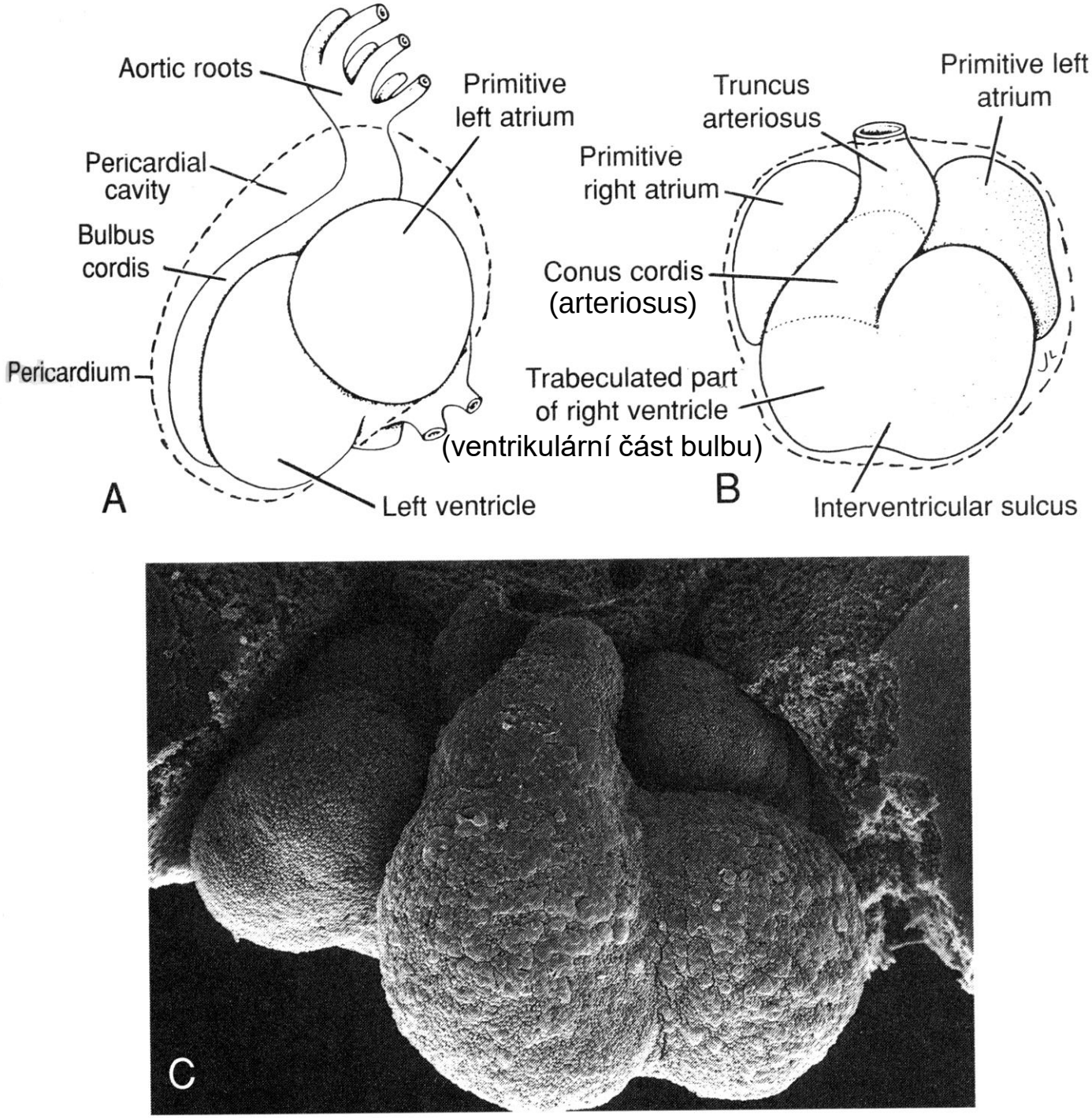


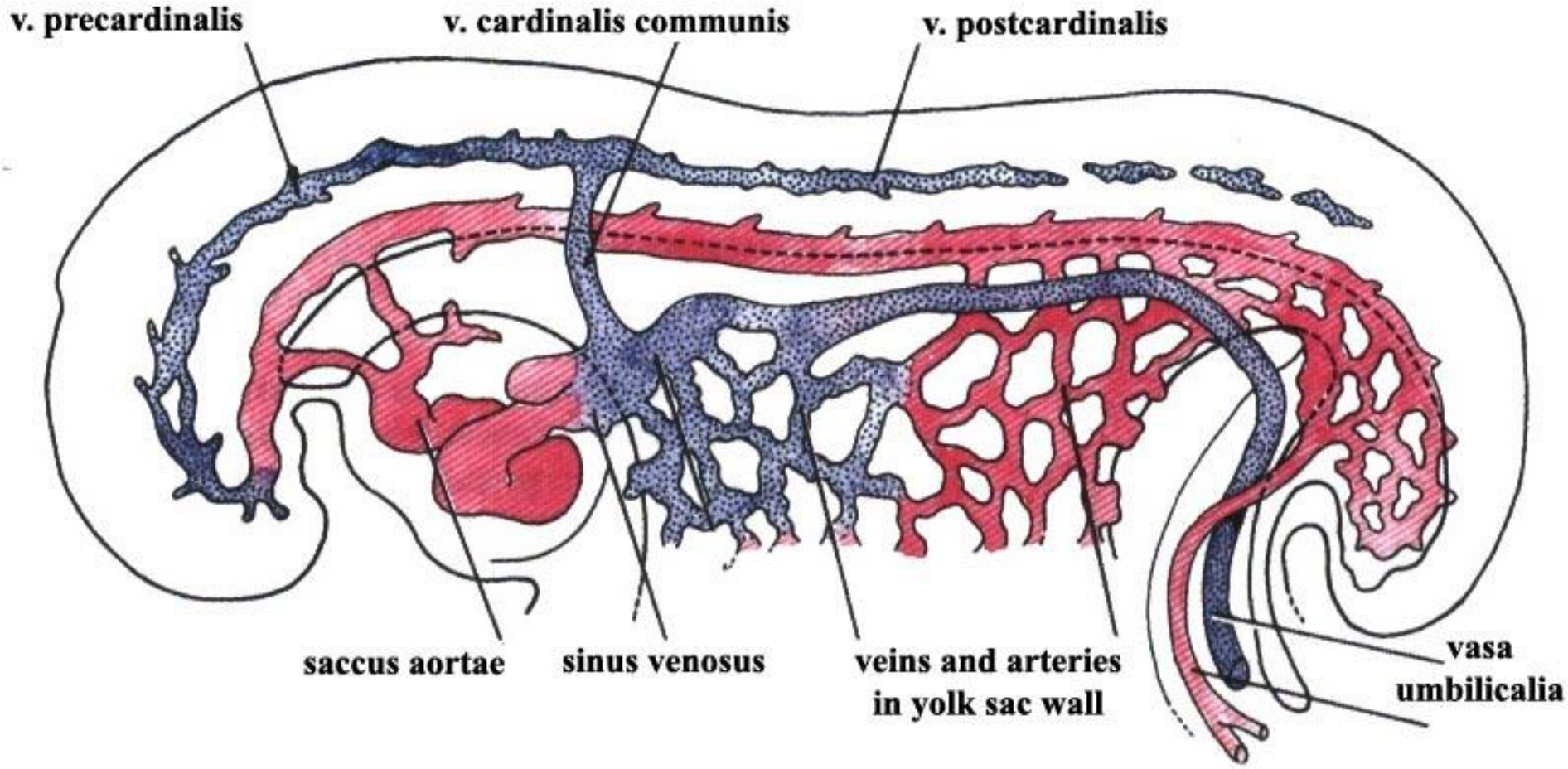


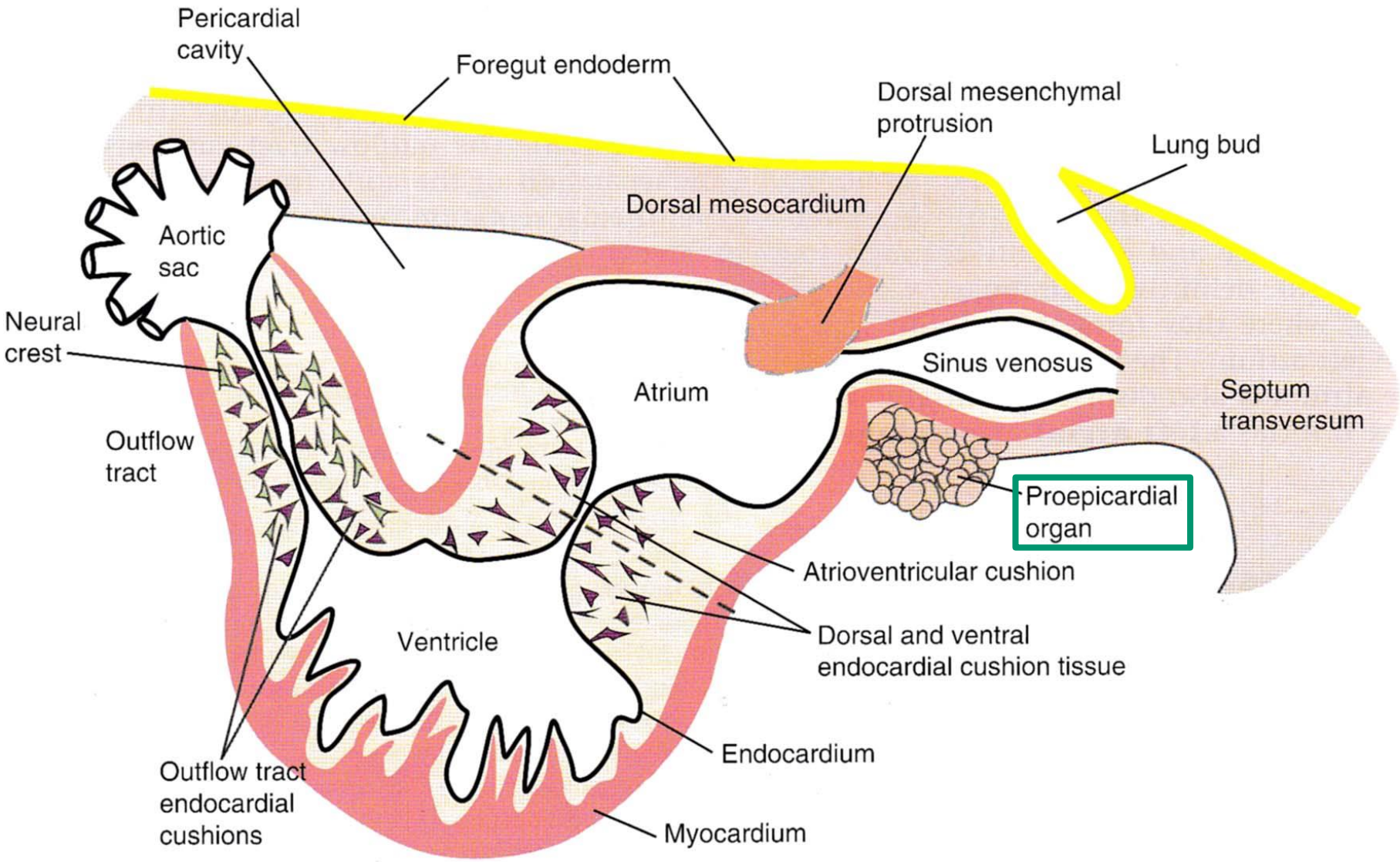
4. embryonální srdce






Aortic roots
Primitive left atrium
Pericardial cavity
Bulbus cordis
Pericardium
Left ventricle
A
Truncus arteriosus
Primitive left atrium
Primitive right atrium
Conus cordis (arteriosus)
Trabeculated part of right ventricle
(ventrikulární část bulbu)
Interventricular sulcus
B
C


v. precardinalis
v. cardinalis communis
v. postcardinalis
saccus aortae
sinus venosus
veins and arteries
in yolk sac wall
vasa
umbilicalia


Pericardial cavity
Foregut endoderm
Dorsal mesenchymal protrusion
Lung bud
Dorsal mesocardium
Aortic sac
Neural crest
Sinus venosus
Atrium
Septum transversum
Outflow tract
Proepicardial organ
Atrioventricular cushion
Dorsal and ventral endocardial cushion tissue
Ventricle
Endocardium
Outflow tract endocardial cushions
Myocardium

SEPTACE
SÍNÍ, KOMOR A VÝTOKOVÉ ČÁSTI SRDCE

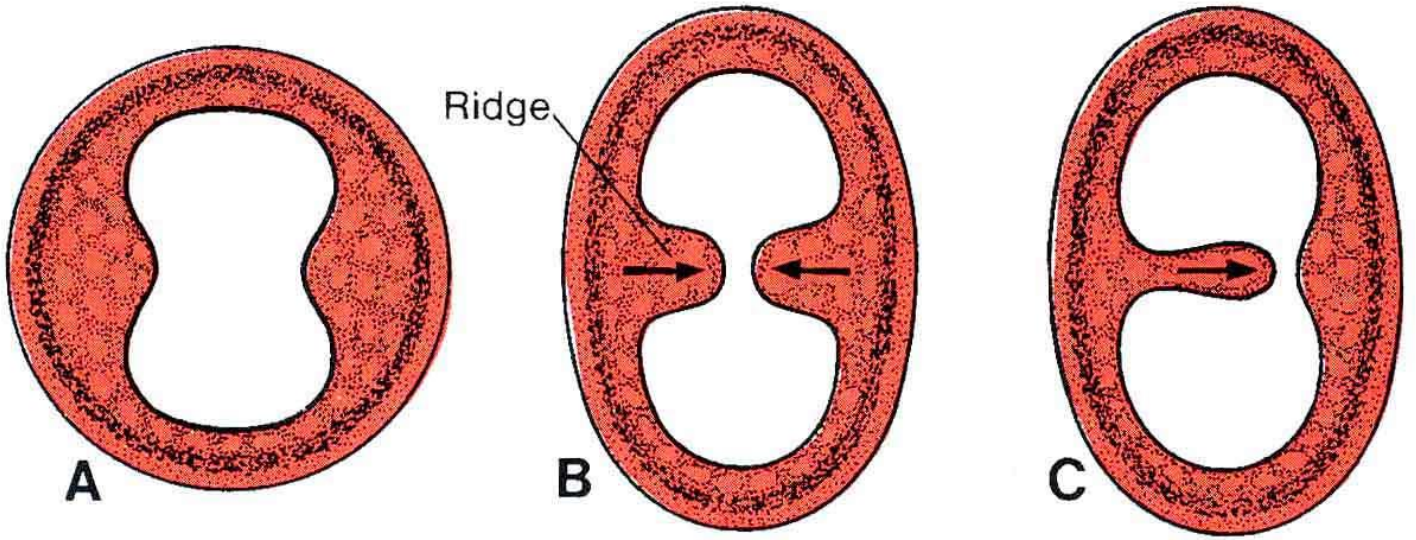
Septace primitivního srdce

- začíná koncem **4. týdne** (27.den)
- ukončeno začátkem **6. týdne** (37. den)

septace (rozdělení):

- canalis atrioventricularis
- atrium commune
- ventriculus primitivus + bulbus cordis

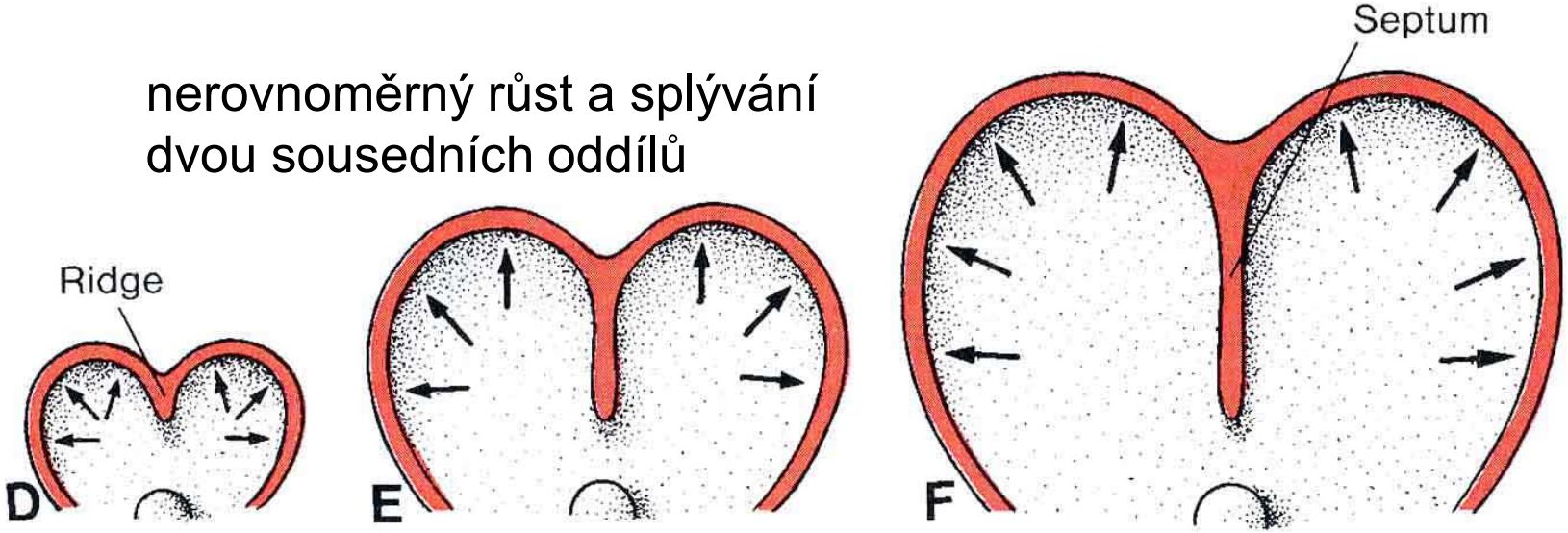
Způsoby vzniku srdečních sept



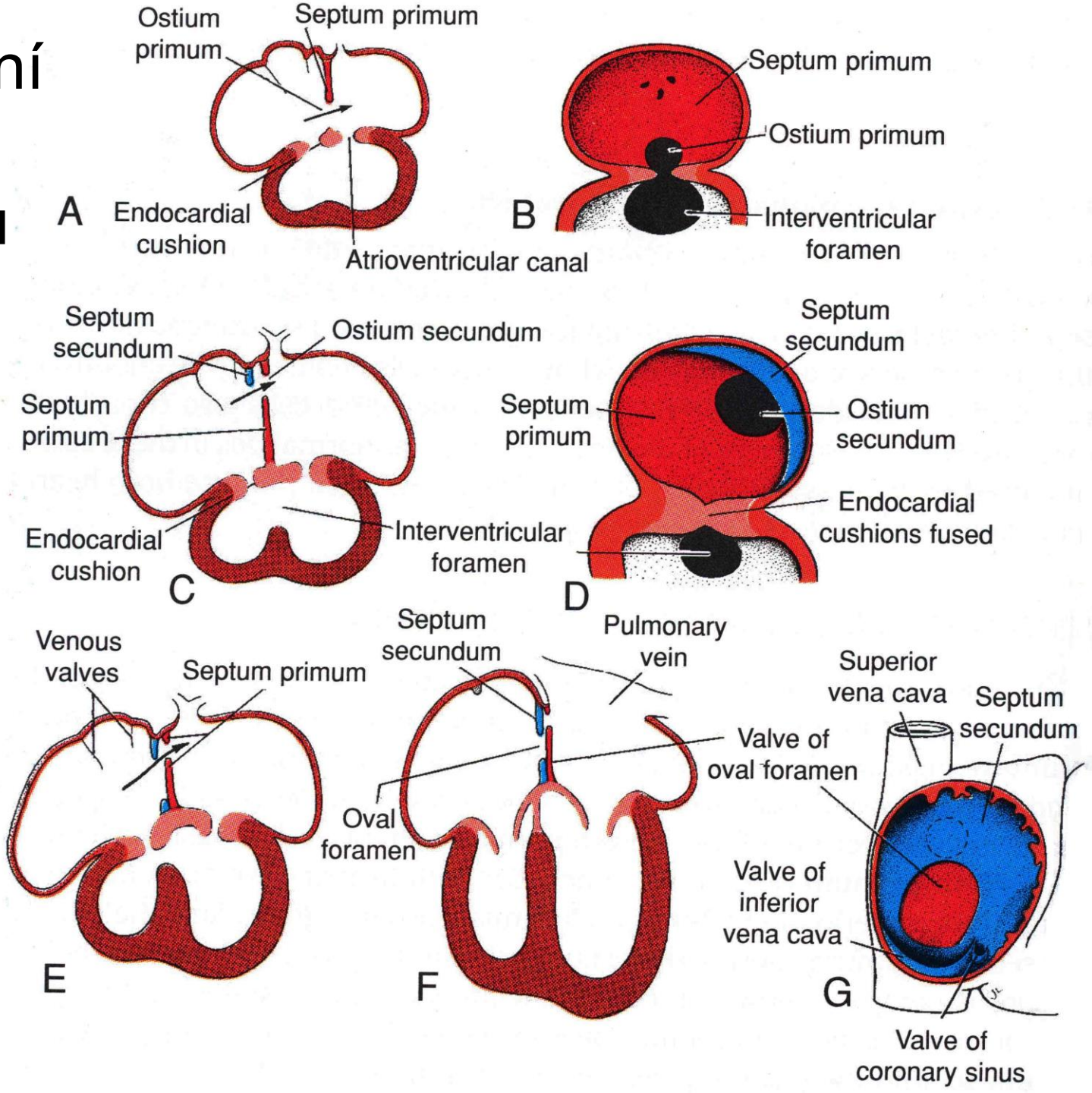
růst dvou protilehlých valů

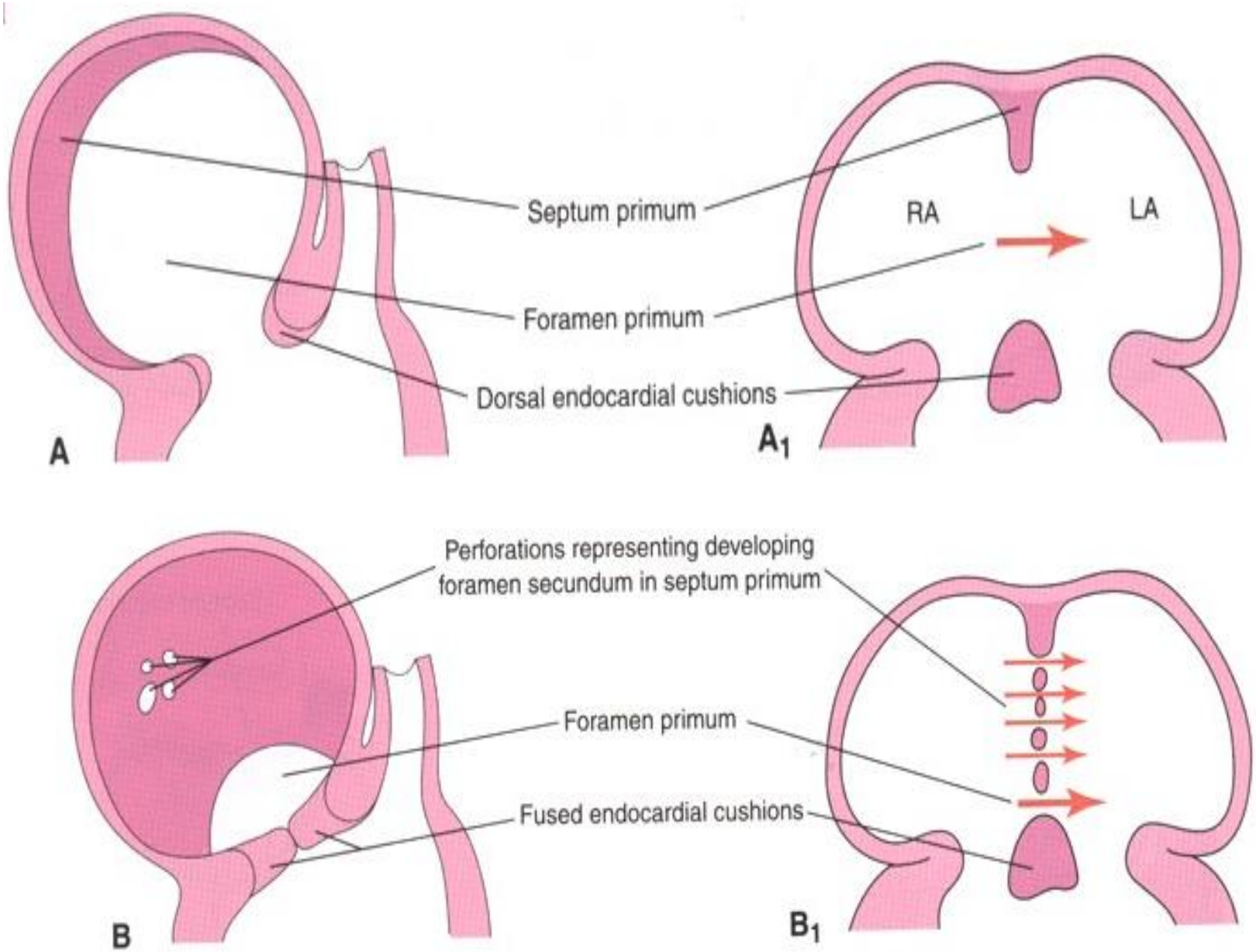
růst jednoho valu

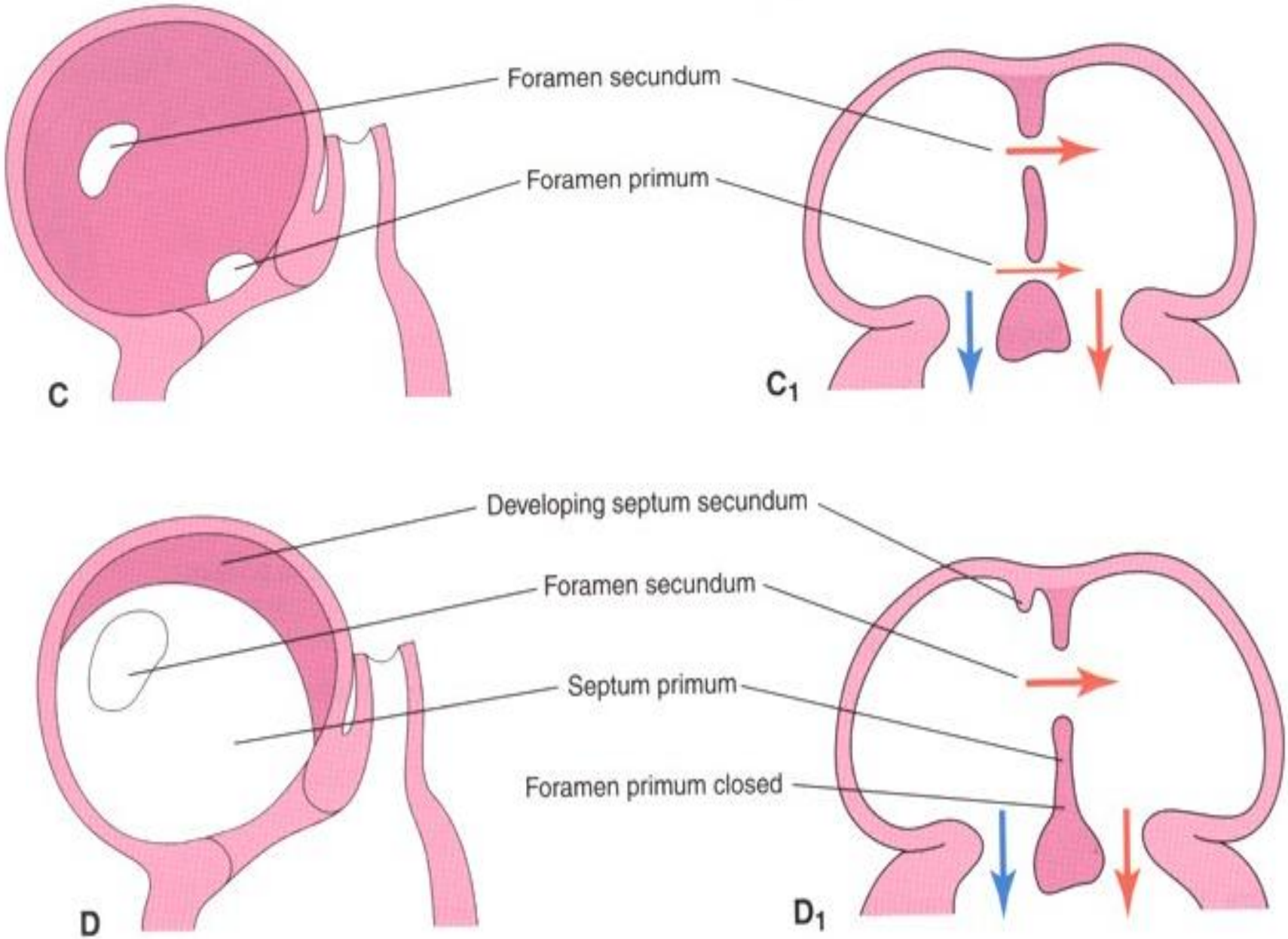
nerovnoměrný růst a splývání dvou sousedních oddílů

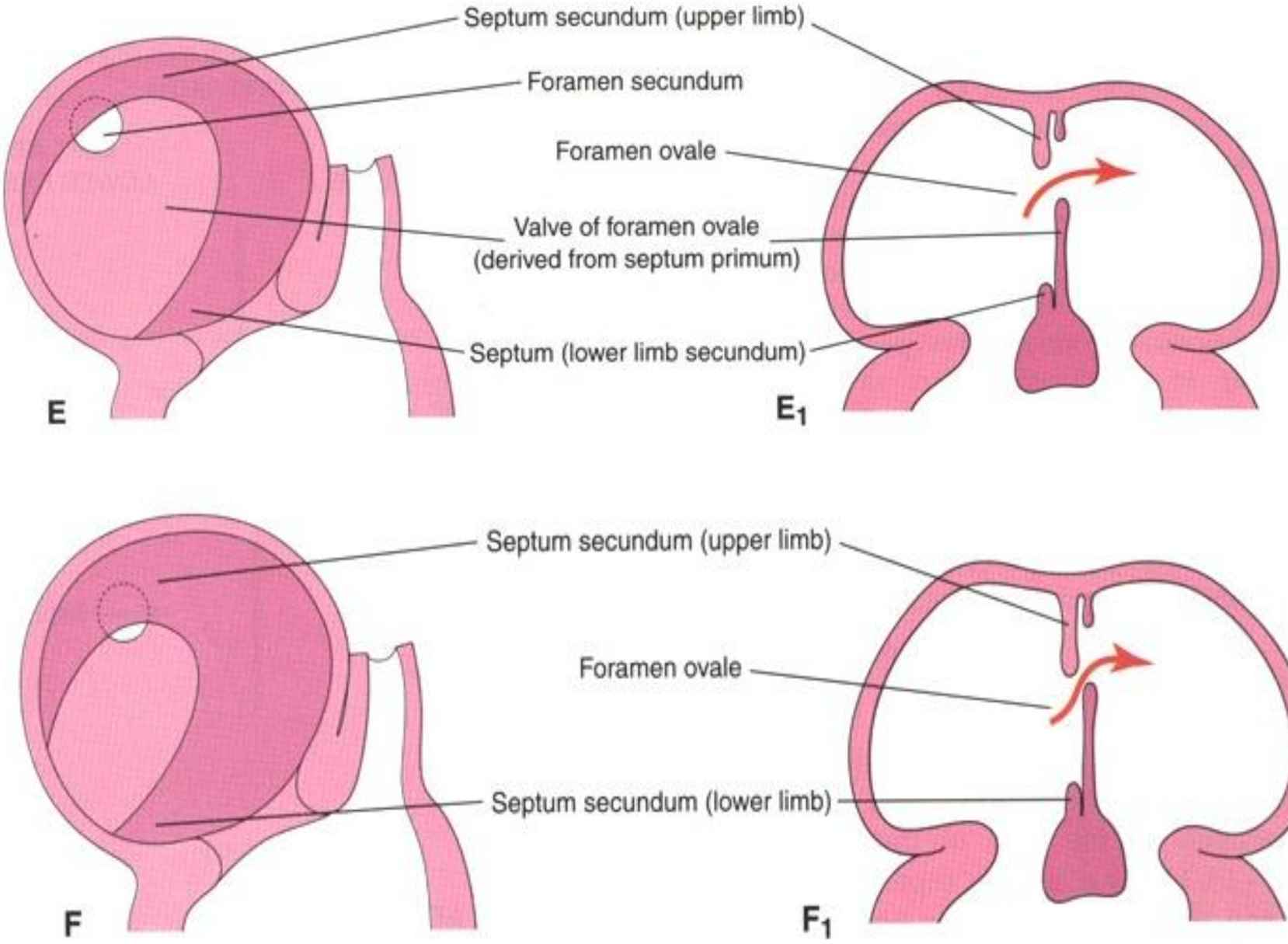


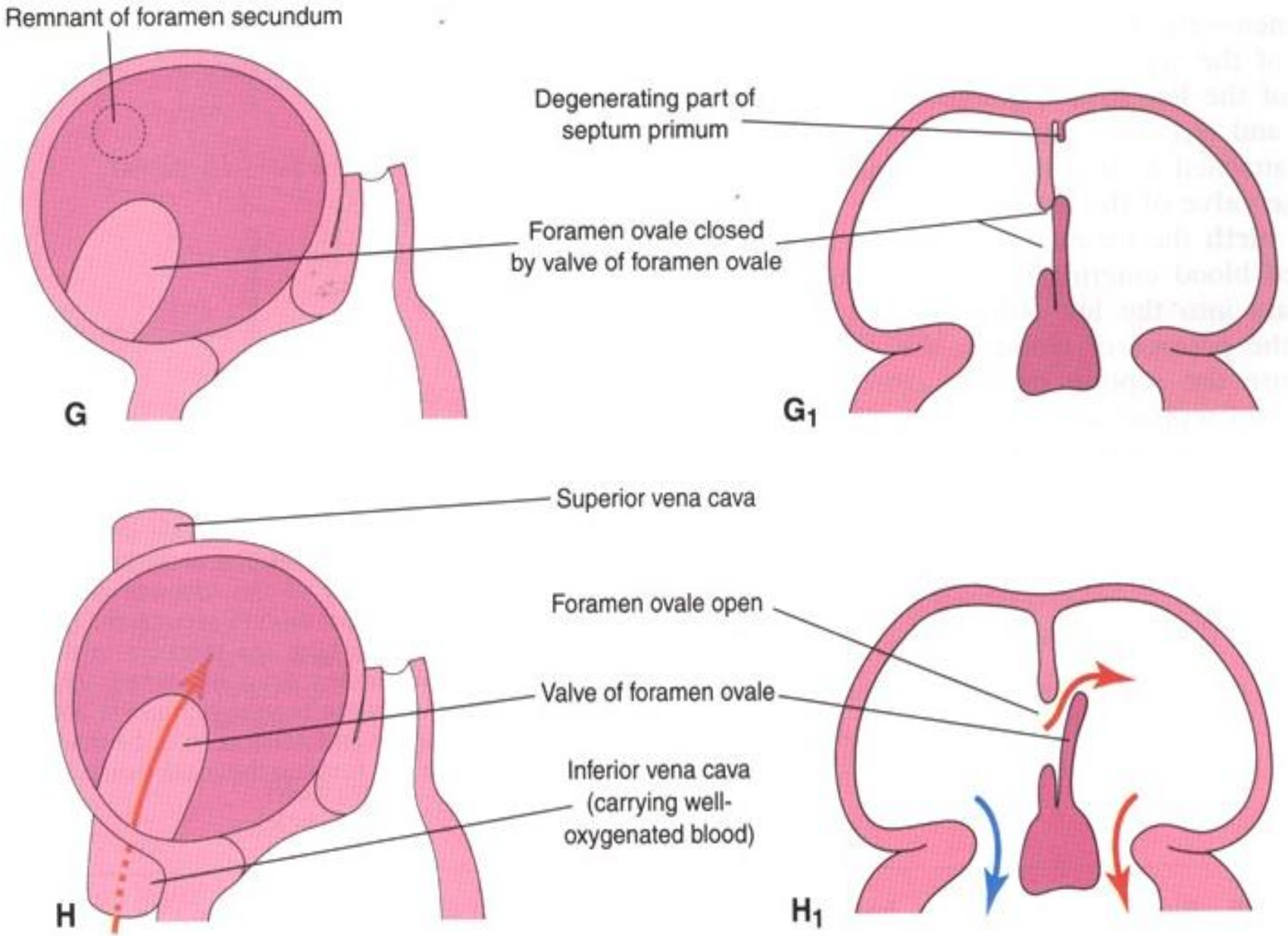
Septace síní a AV kanálu

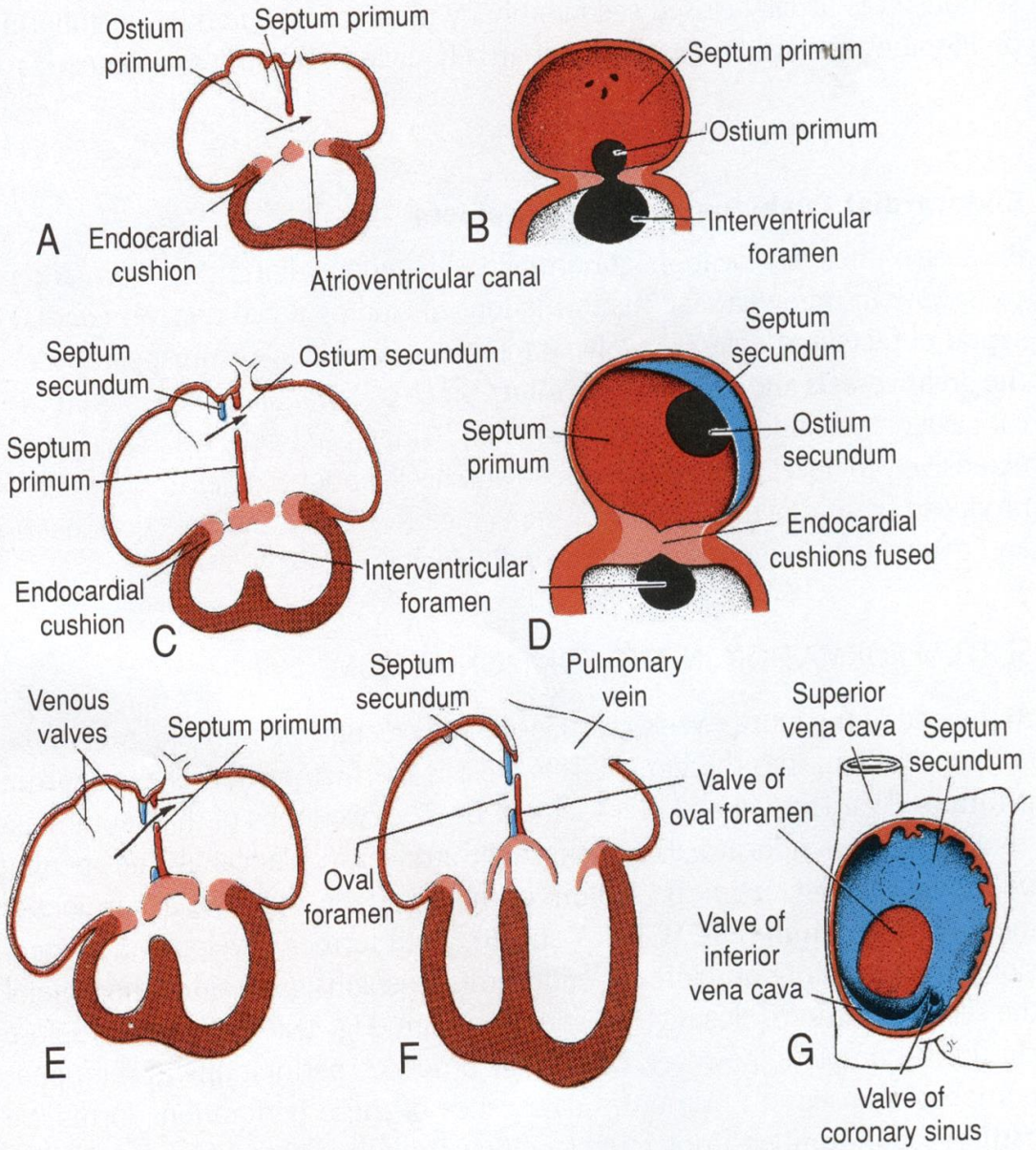



Septum primum
Foramen primum
Dorsal endocardial cushions
A
RA
LA
A1
Perforations representing developing
foramen secundum in septum primum
Foramen primum
Fused endocardial cushions
B
B1

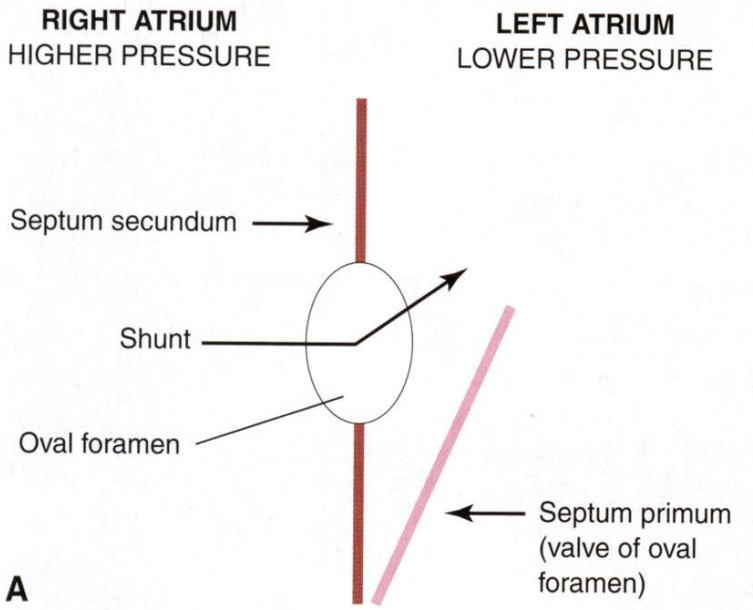

Foramen secundum
Foramen primum
C
C1
Developing septum secundum
Foramen secundum
Septum primum
Foramen primum closed
D
D1

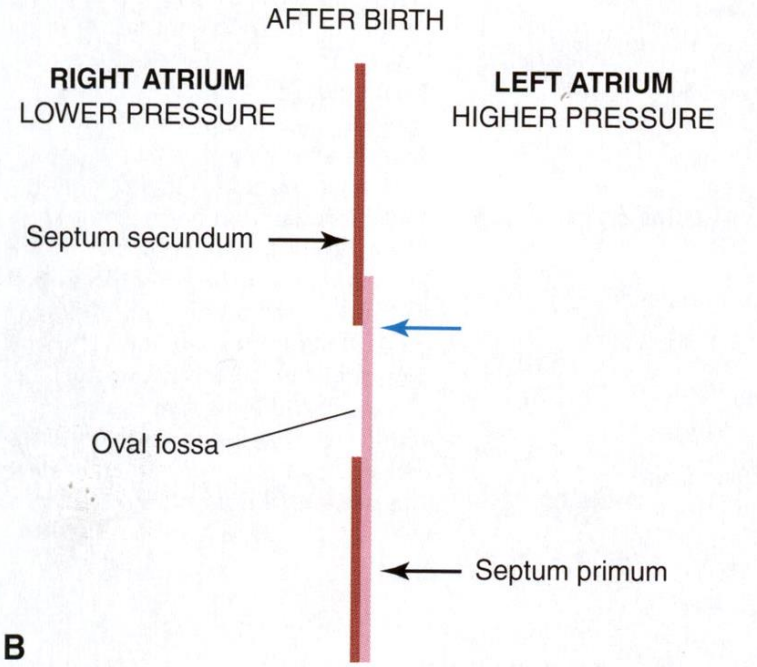

Septum secundum (upper limb)
Foramen secundum
Foramen ovale
Valve of foramen ovale
(derived from septum primum)
Septum (lower limb secundum)
E
E1
Septum secundum (upper limb)
Foramen ovale
Septum secundum (lower limb)
F
F1

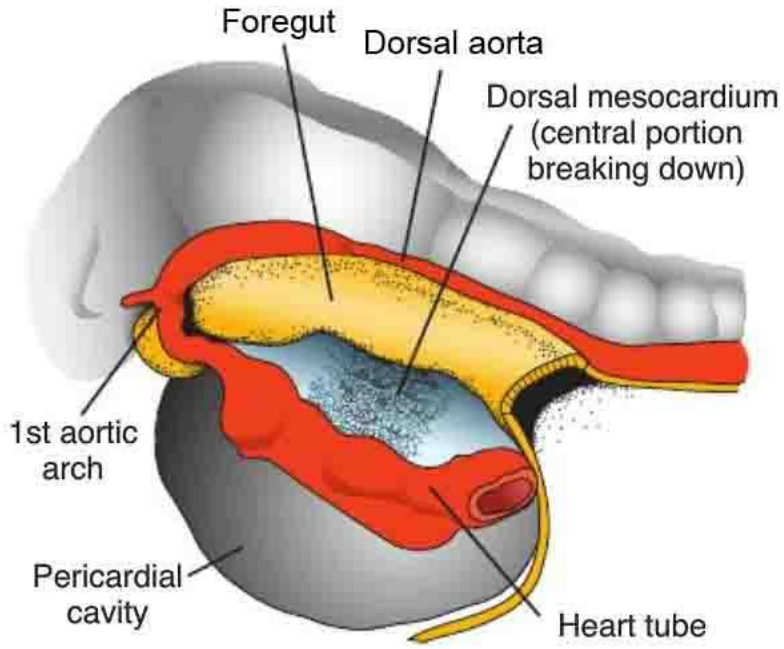

Remnant of foramen secundum
Foramen ovale closed by valve of foramen ovale
G
Degenerating part of septum primum
G1
Superior vena cava
Valve of foramen ovale
Inferior vena cava (carrying well-oxygenated blood)
H
Foramen ovale open
H1

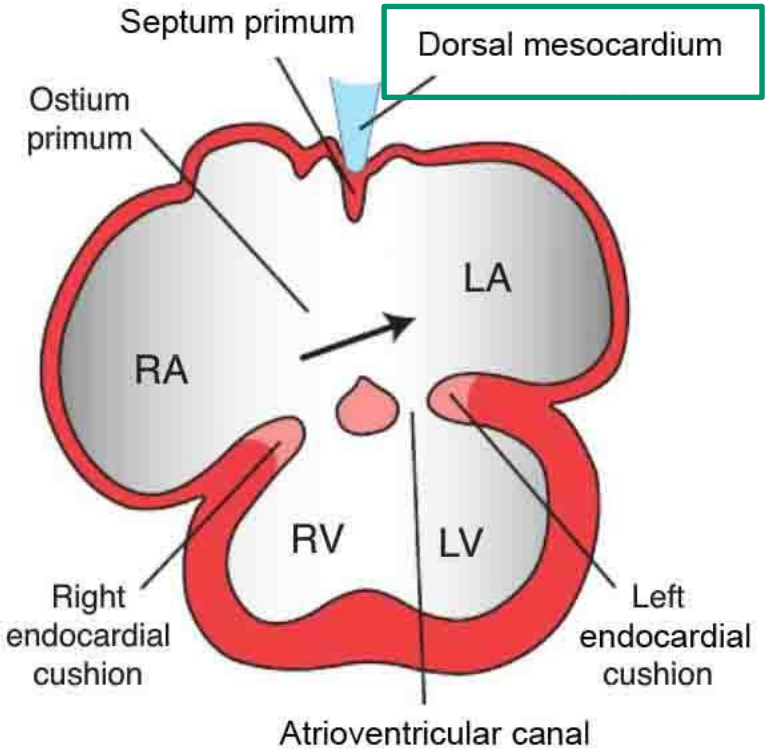


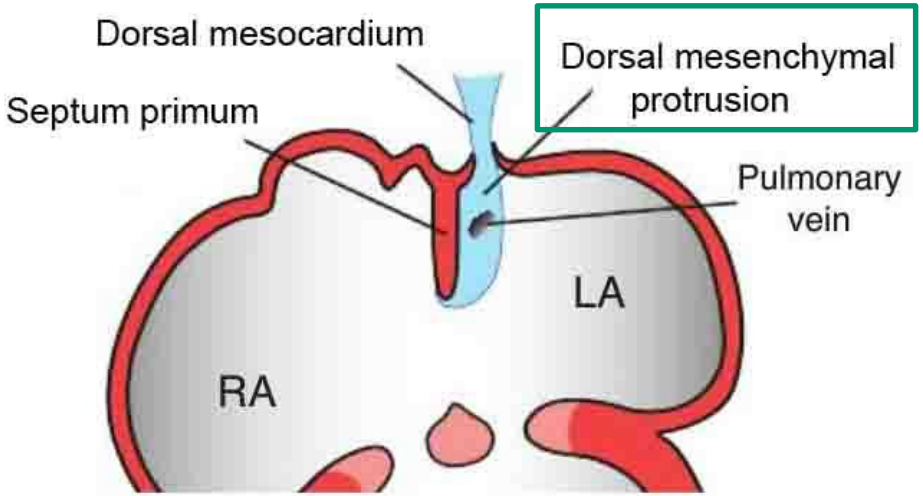
Atrial septa at various stages of development. **A.** 30 days (6 mm). **B.** Same stage as **A,** viewed from the right. **C.** 33 days (9 mm). **D.** Same stage as **C,** viewed from the right **E.** 37 days (14 mm). **F.** Newborn. **G.** The atrial septum from the right; same stage as **F.**

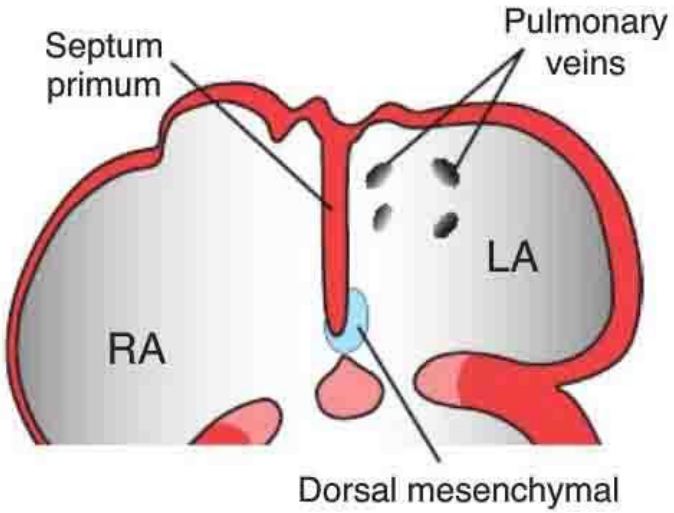




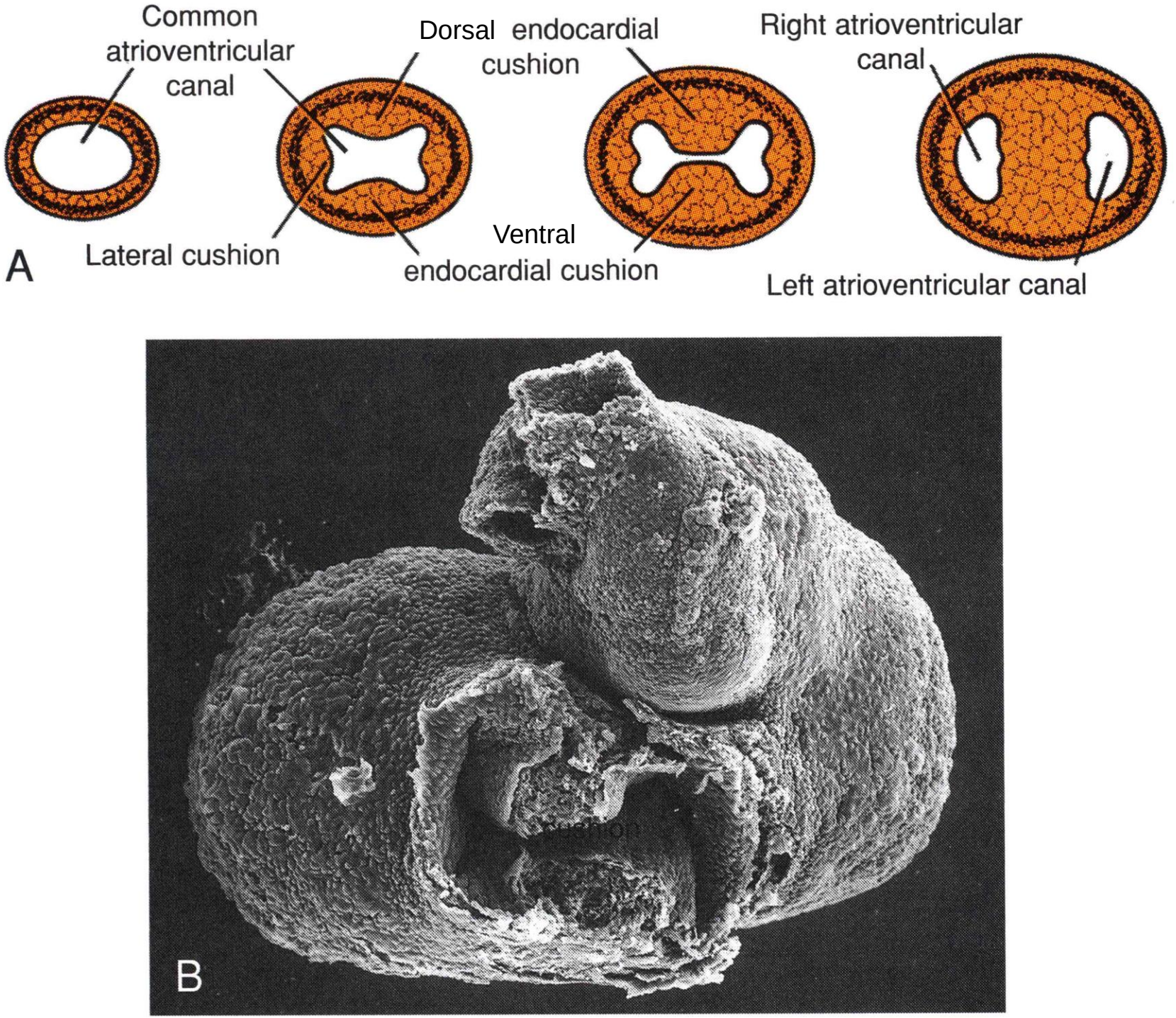

Foregut
Dorsal aorta
Dorsal mesocardium
(central portion
breaking down)
1st aortic
arch
Pericardial
cavity
Heart tube


Septum primum
Dorsal mesocardium
Ostium
primum
LA
RA
RV
LV
Right
endocardial
cushion
Left
endocardial
cushion
Atrioventricular canal

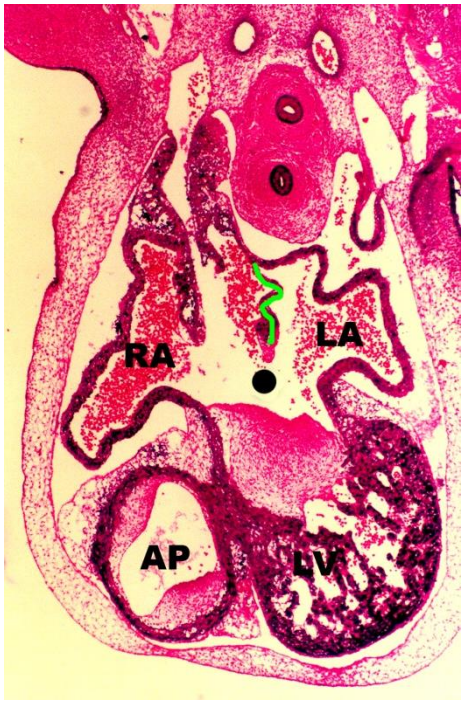

Dorsal mesocardium
Dorsal mesenchymal
protrusion
Septum primum
Pulmonary
vein
LA
RA


Septum
primum
Pulmonary
veins
LA
RA
Dorsal mesenchymal

cap


Common atrioventricular canal
Dorsal endocardial cushion
Right atrioventricular canal
A
Lateral cushion
Ventral endocardial cushion
Left atrioventricular canal
B

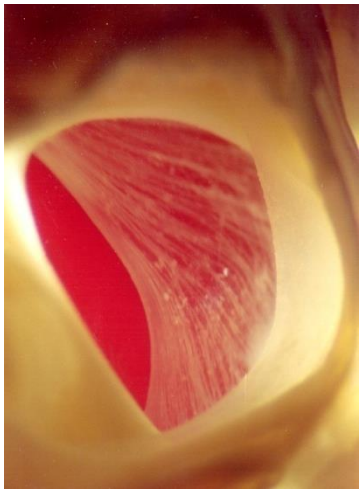
septace síní



septum primum (zelené)
a ostium primum (**tečka**)

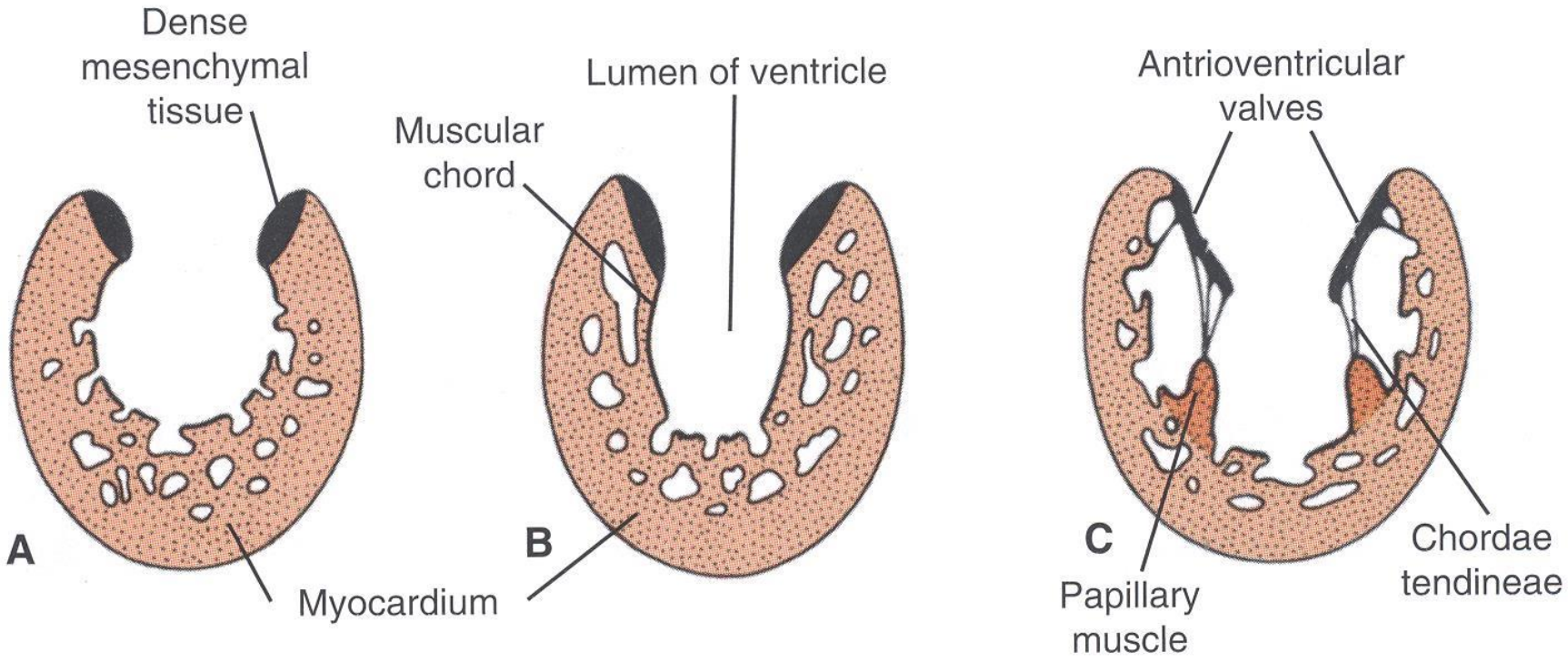
dočasné oddělení síní
pomocí septum primum

septum primum (červené) a septum secundum (zelené) ve fetálním srdci
fetální proudění krve naznačeno šipkou

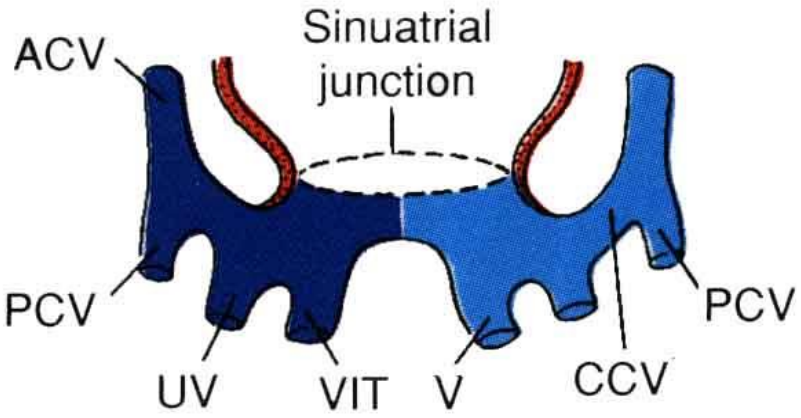


foramen ovale fetálního srdce
septum primum – blanité
septum secundum – masité

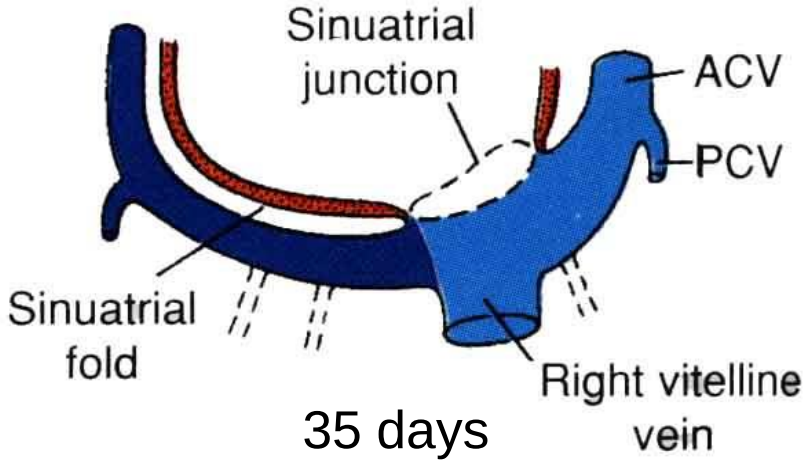
Vznik AV chlopní



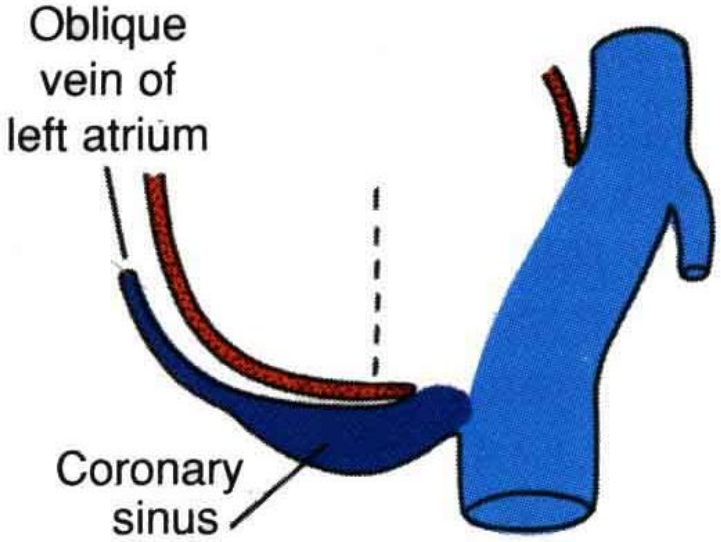
Sinus venosus



24 days



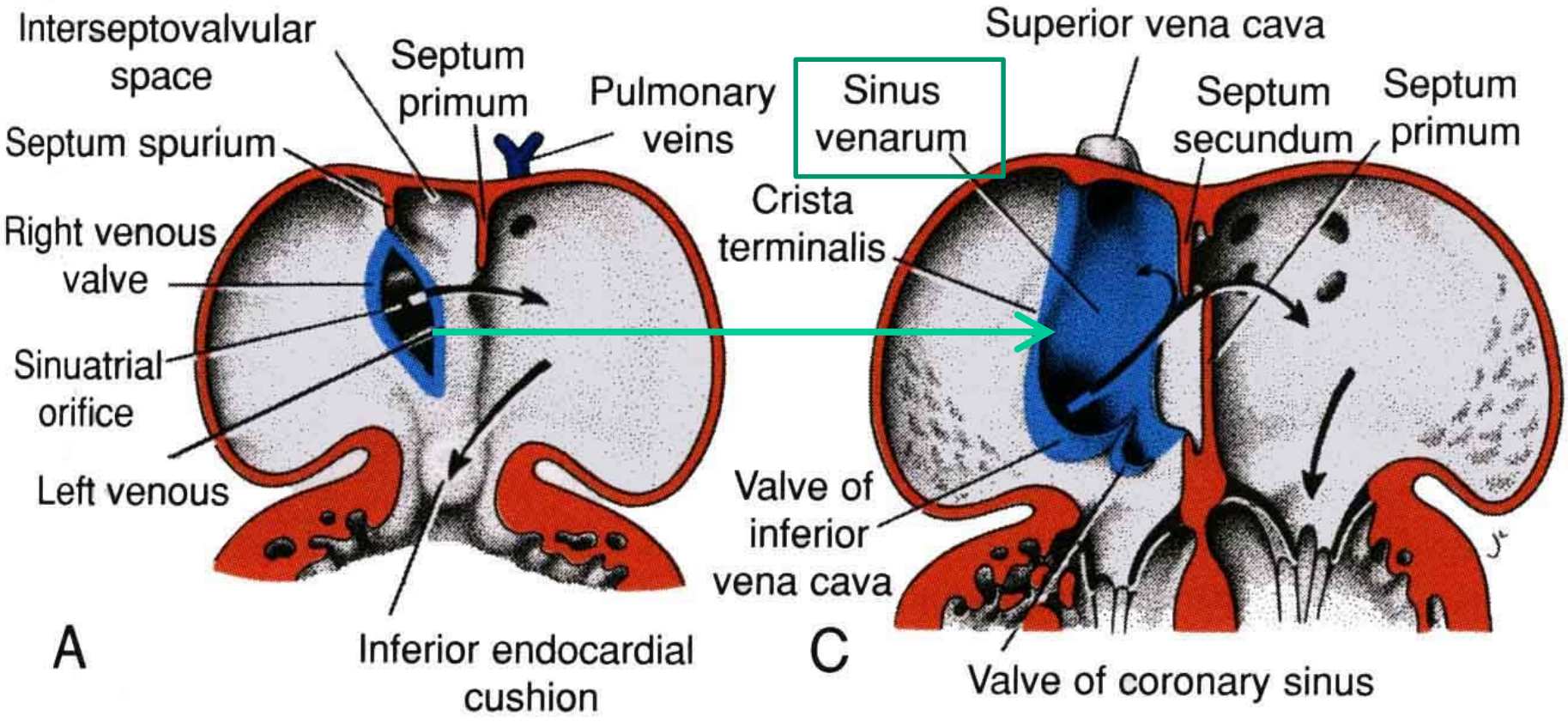
35 days



fetus

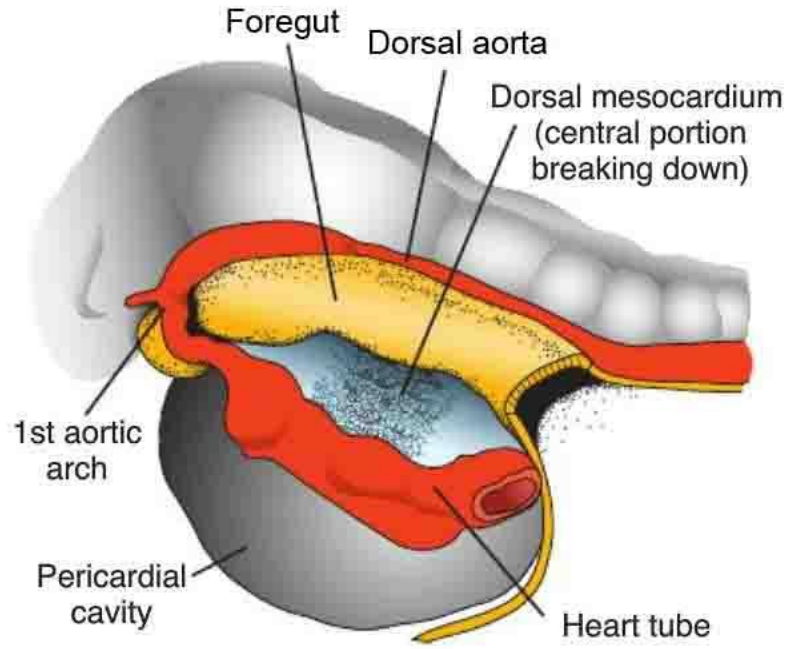
Změny v sinus venosus

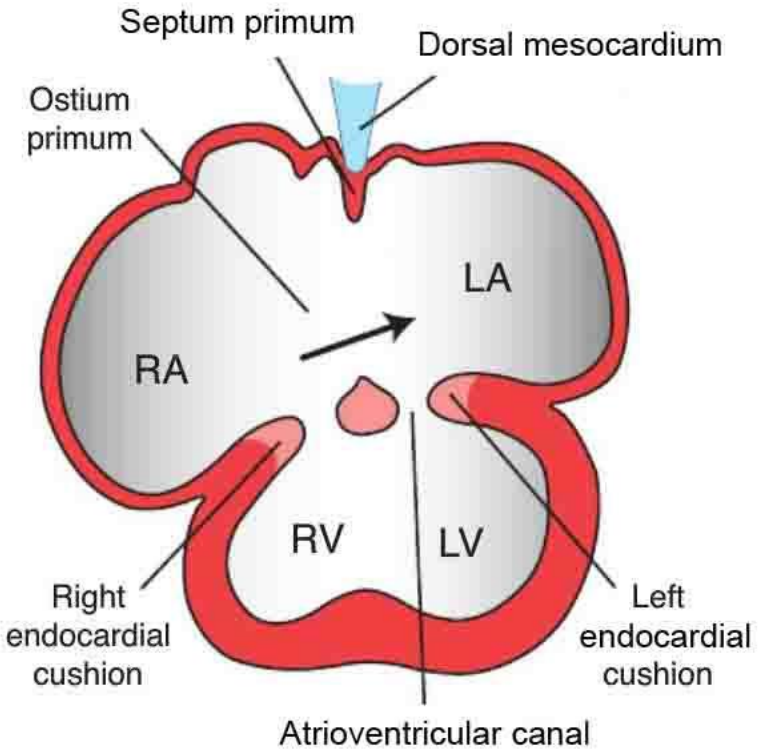
- pravý roh
  - zvětší se, přijímá veškerou krev z horní poloviny těla (VCS), z placenty a z dolní poloviny těla (VCI)
  - postupně vtažen do stěny pravé síně (= sinus venarum cavarum)
- levý roh
  - zmenšuje se a ztrácí na významu
  - zbývá jako ***sinus coronarius*** a ***vena obliqua atrii sinistri***
- valvulae sinuatriales
  - dx. → valvula VCI + valvula SC
  - sin. → součást síňové přepážky

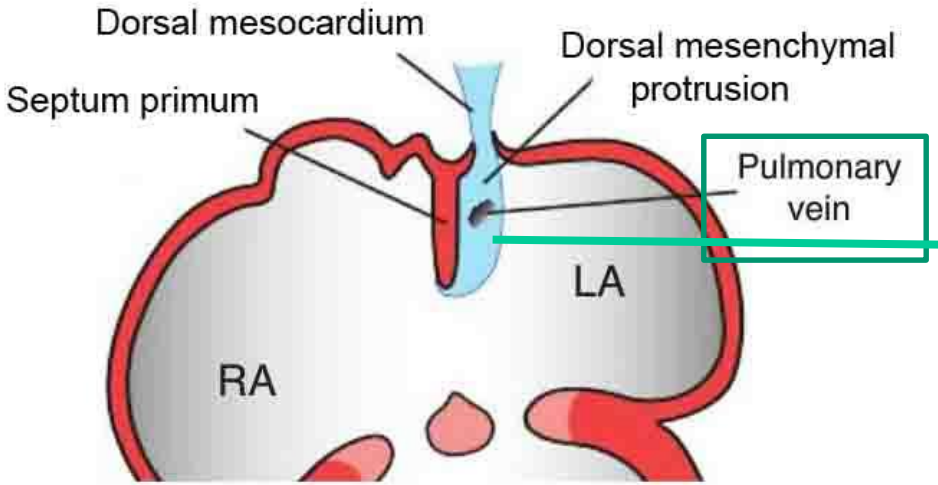


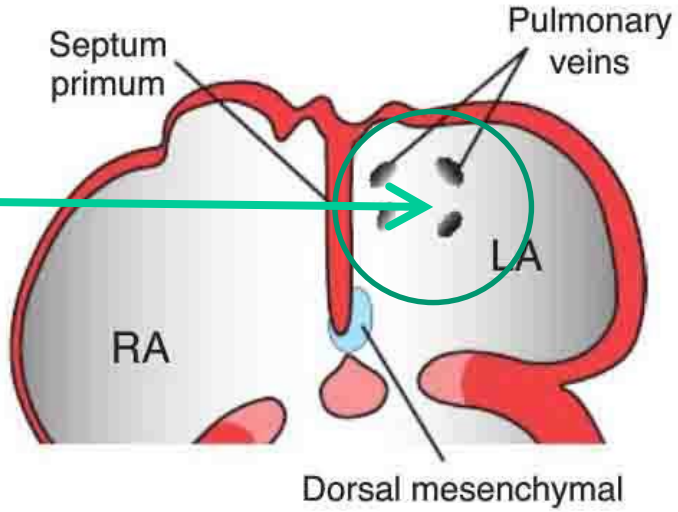
5th week

fetus


Foregut
Dorsal aorta
Dorsal mesocardium
(central portion
breaking down)
1st aortic
arch
Pericardial
cavity
Heart tube

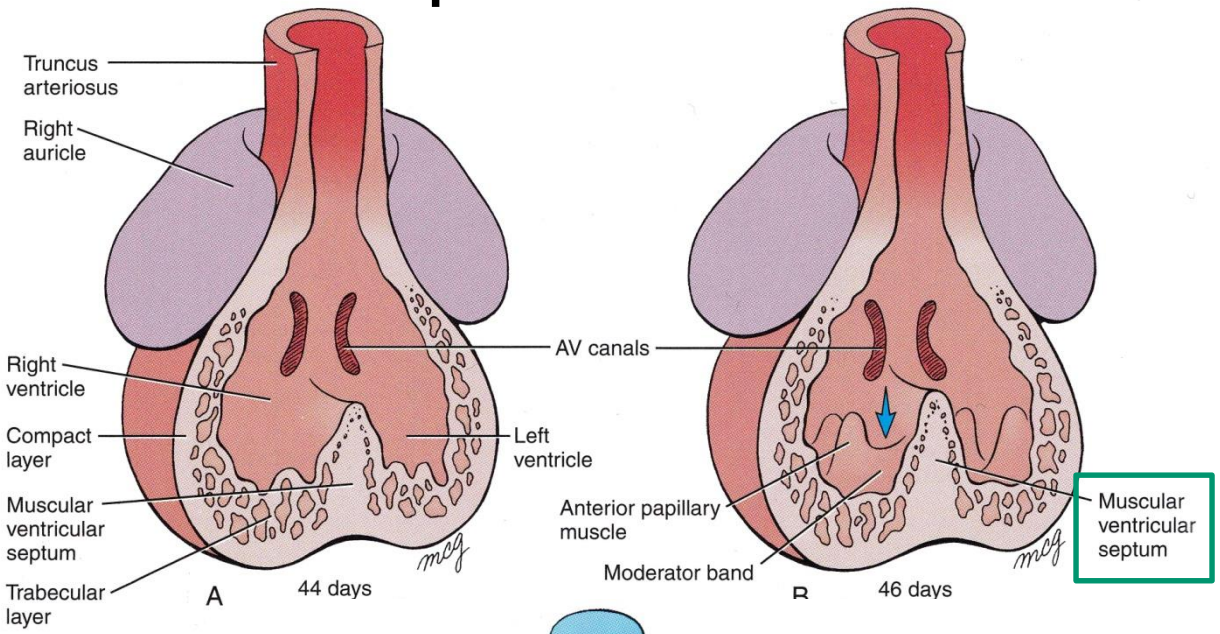

Septum primum
Dorsal mesocardium
Ostium
primum
LA
RA
RV
LV
Right
endocardial
cushion
Left
endocardial
cushion
Atrioventricular canal

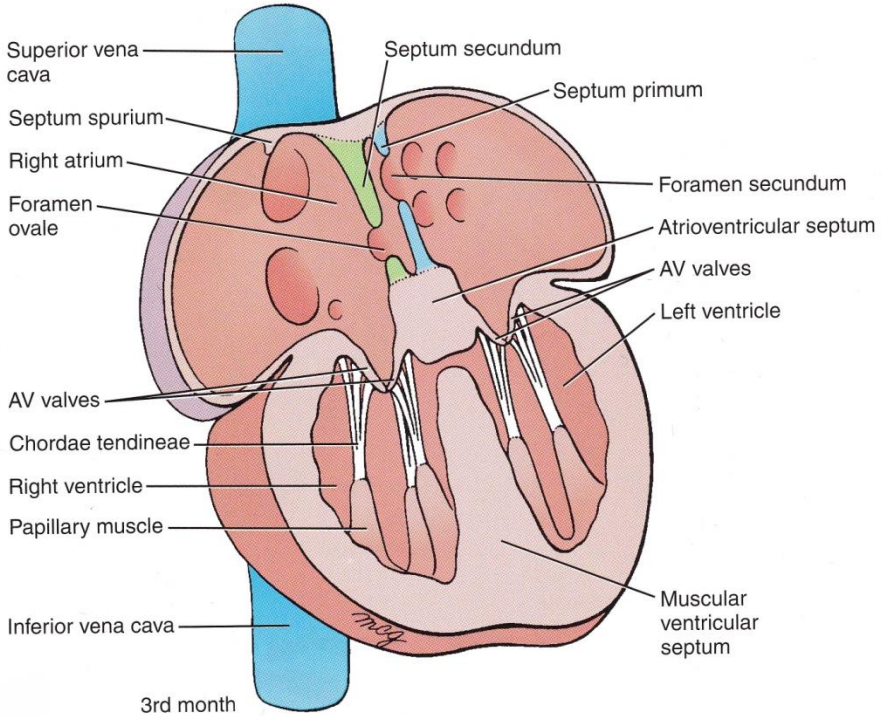

Dorsal mesocardium
Dorsal mesenchymal
protrusion
Septum primum
Pulmonary
vein
LA
RA

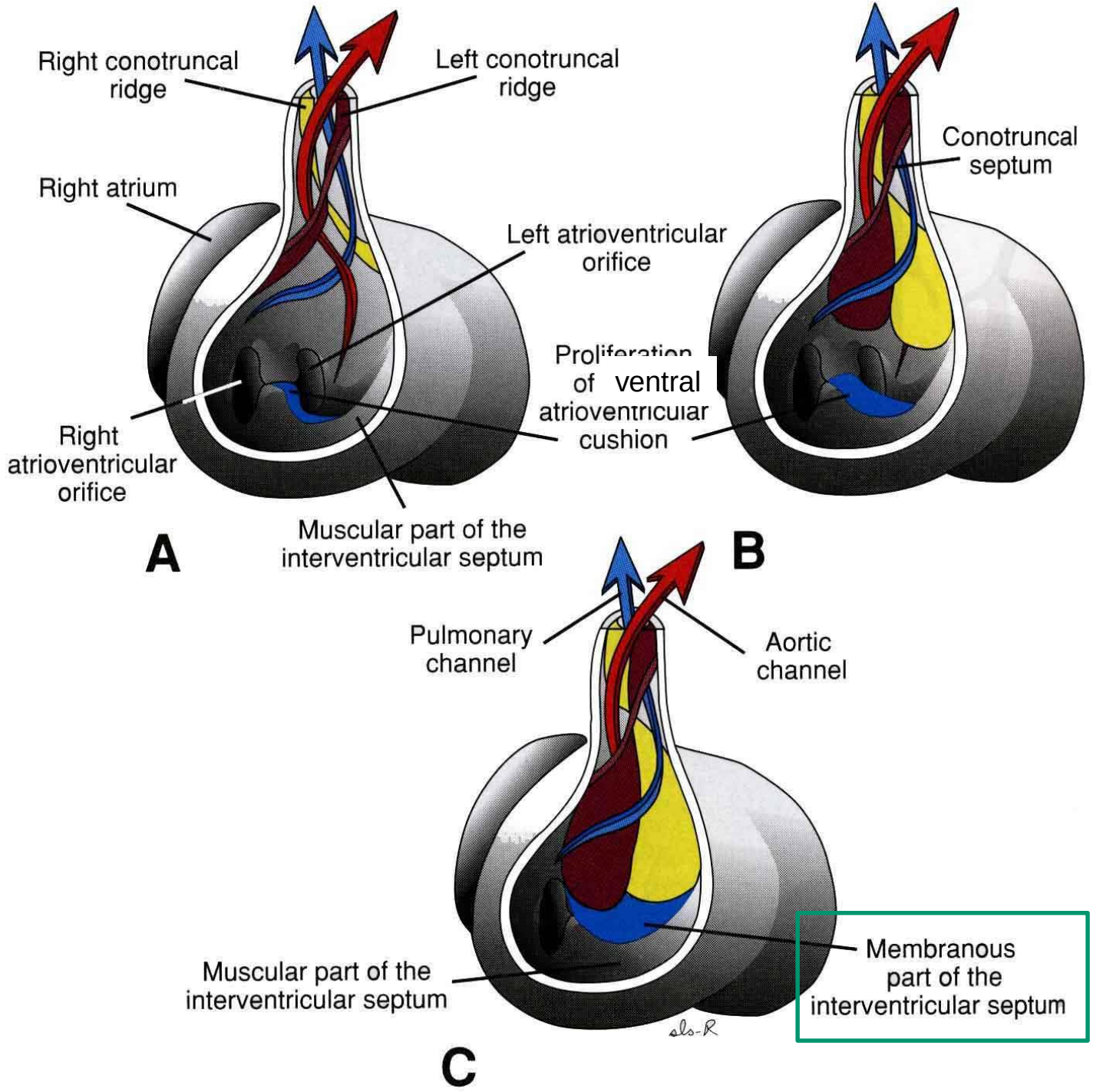

Septum
primum
Pulmonary
veins
LA
RA
Dorsal mesenchymal

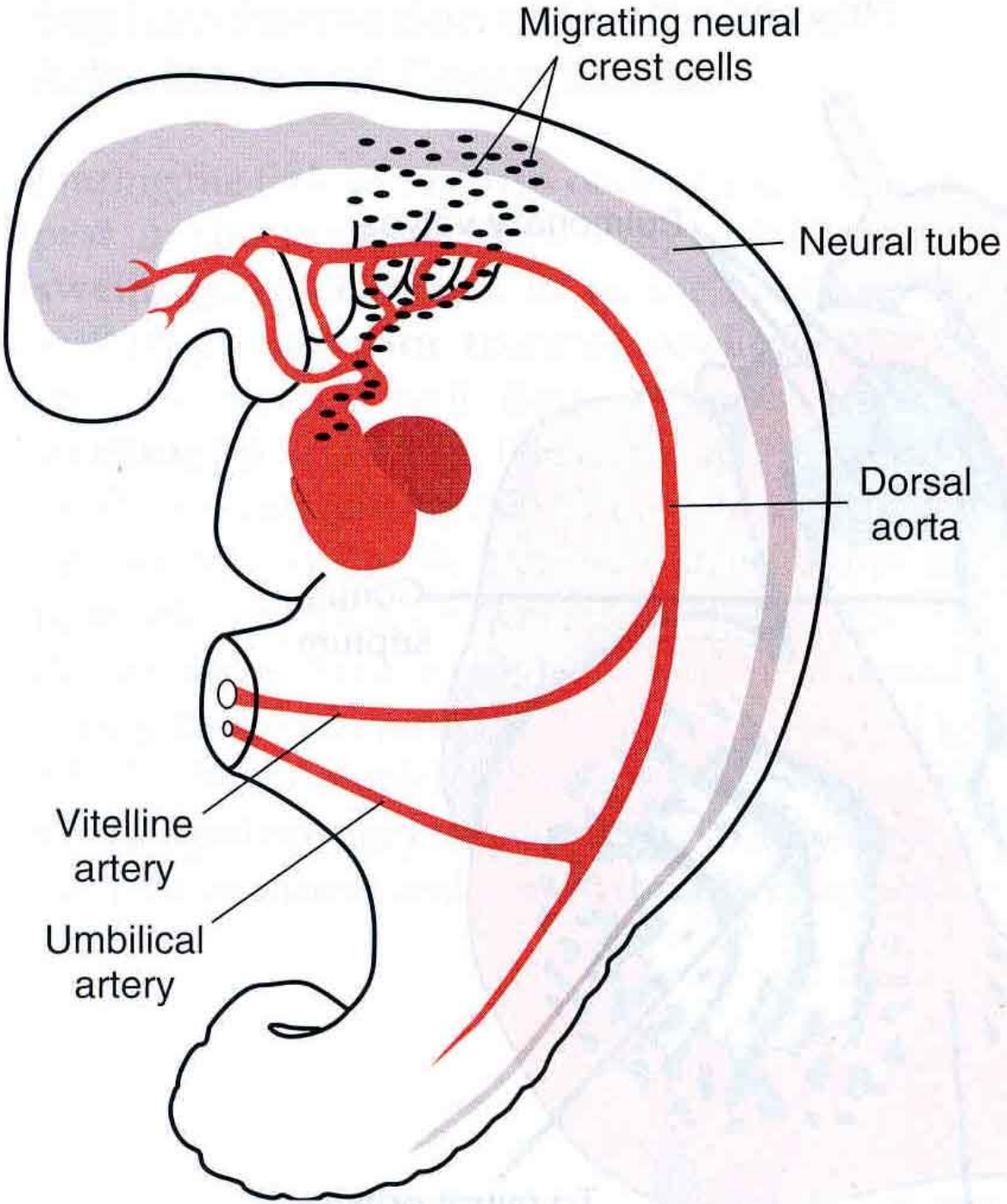
cap

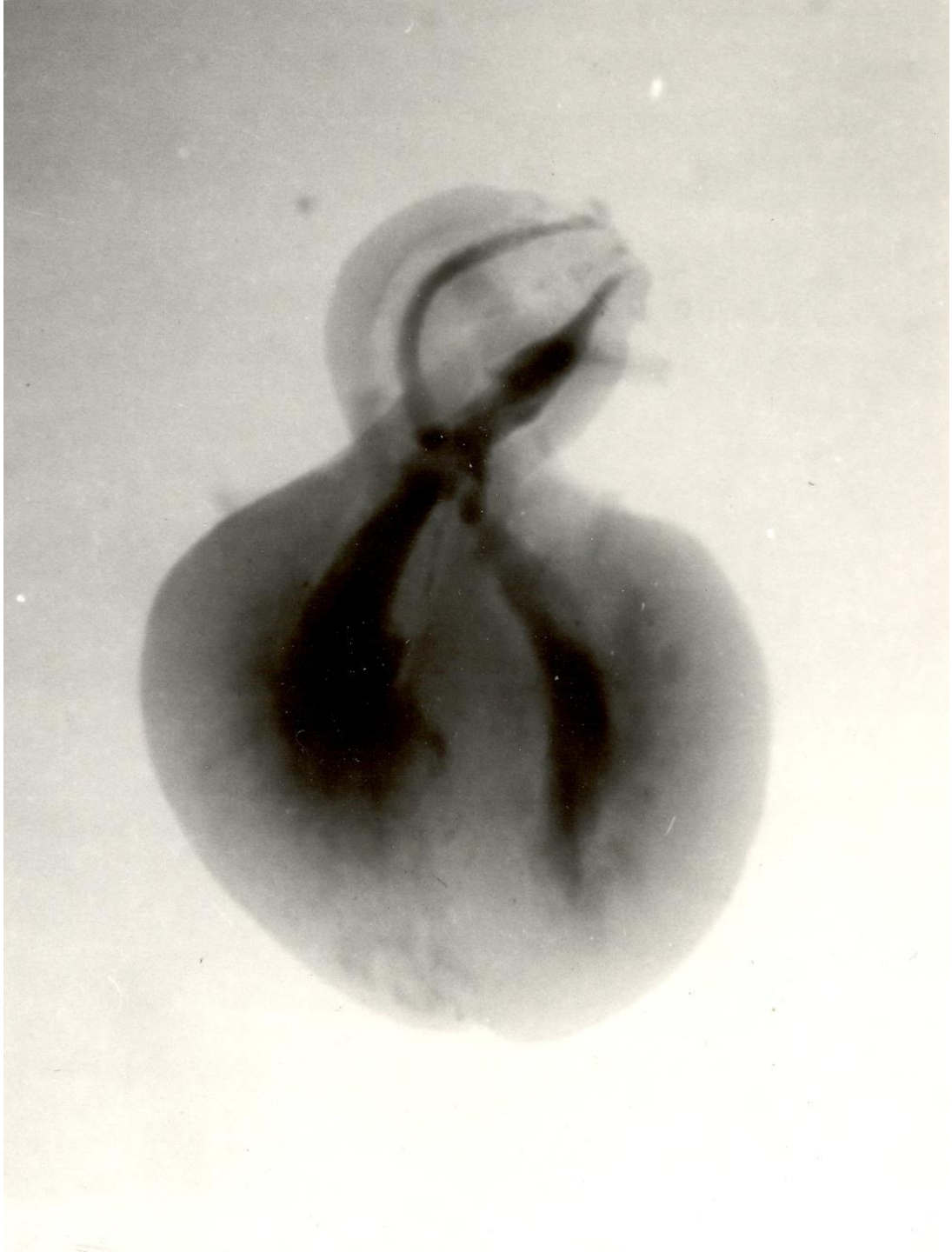
Septace komor



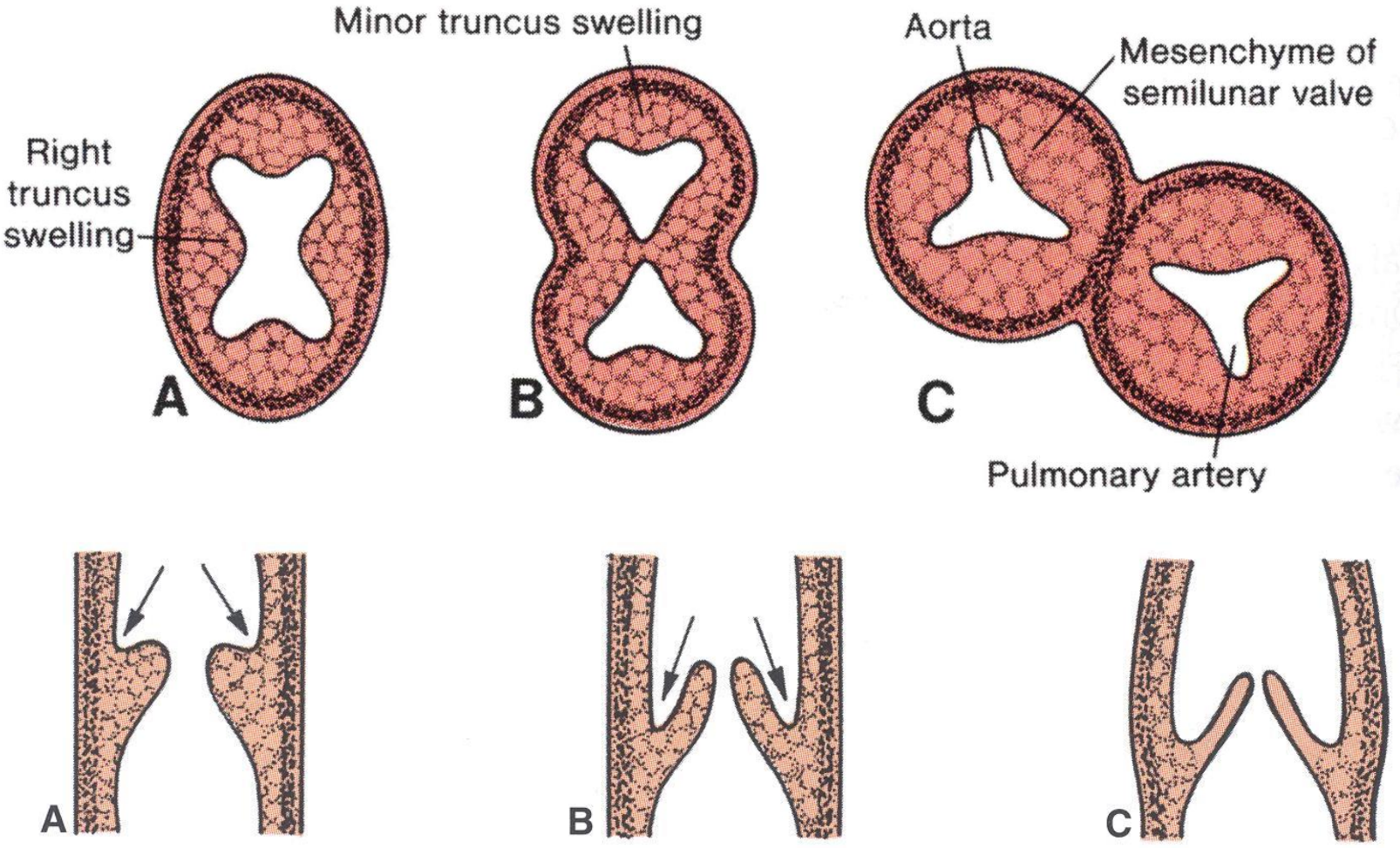



Right conotruncal ridge
Left conotruncal ridge
Right atrium
Left atrioventricular orifice
Right atrioventricular orifice
Muscular part of the interventricular septum
A
Conotruncal septum
Proliferation of ventral atrioventricular cushion
B
Pulmonary channel
Aortic channel
Muscular part of the interventricular septum
Membranous part of the interventricular septum
C

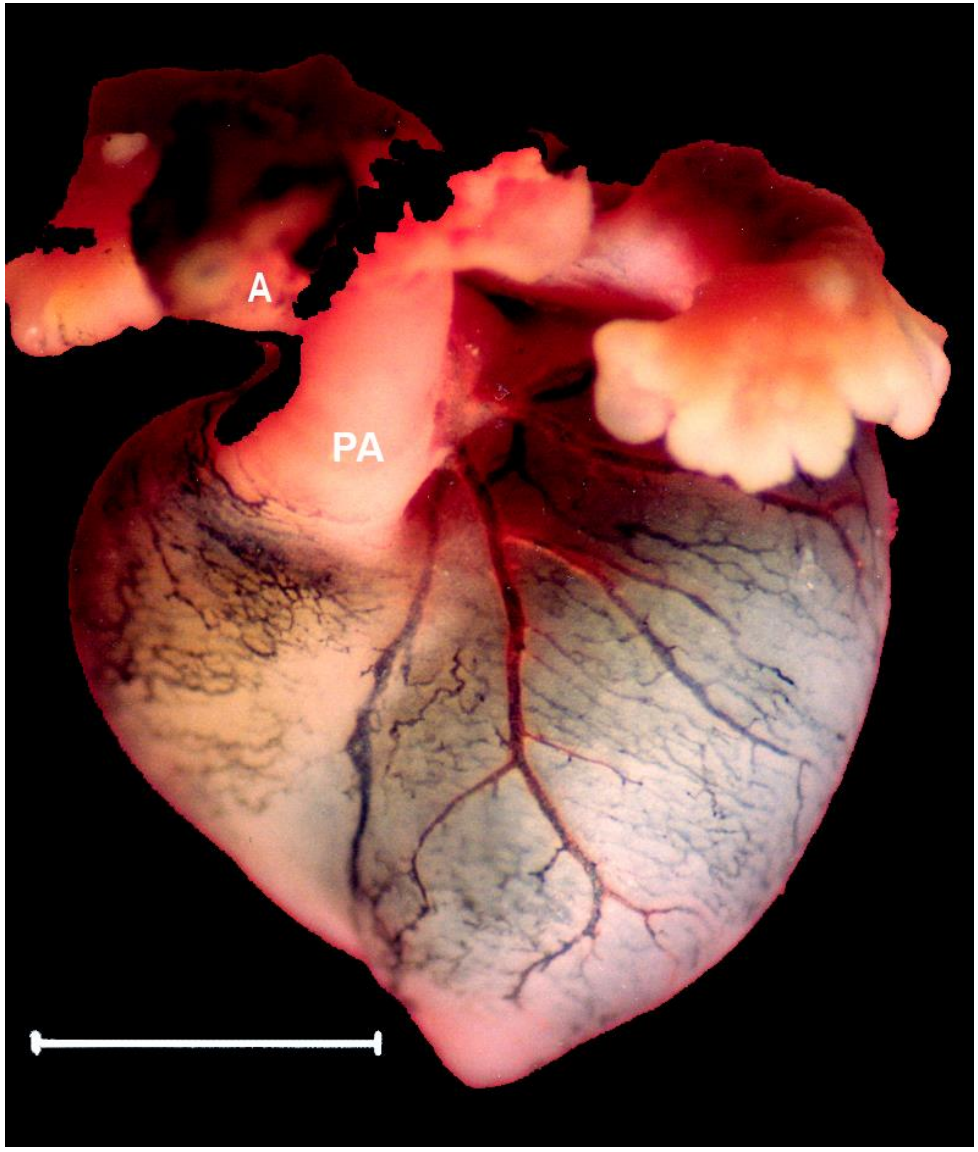

Migrating neural crest cells
Neural tube
Dorsal aorta
Vitelline artery
Umbilical artery

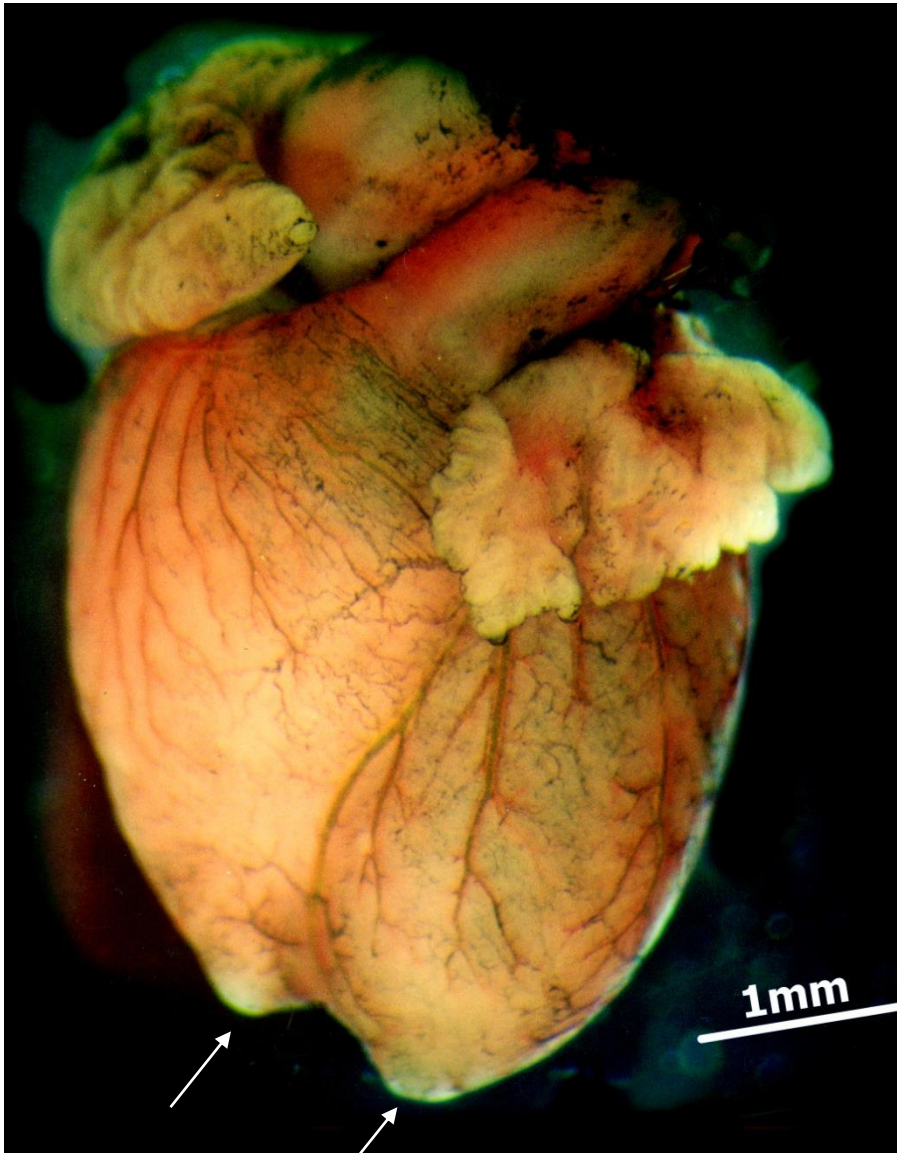


Poloměsíčité chlopně



fetální srdce





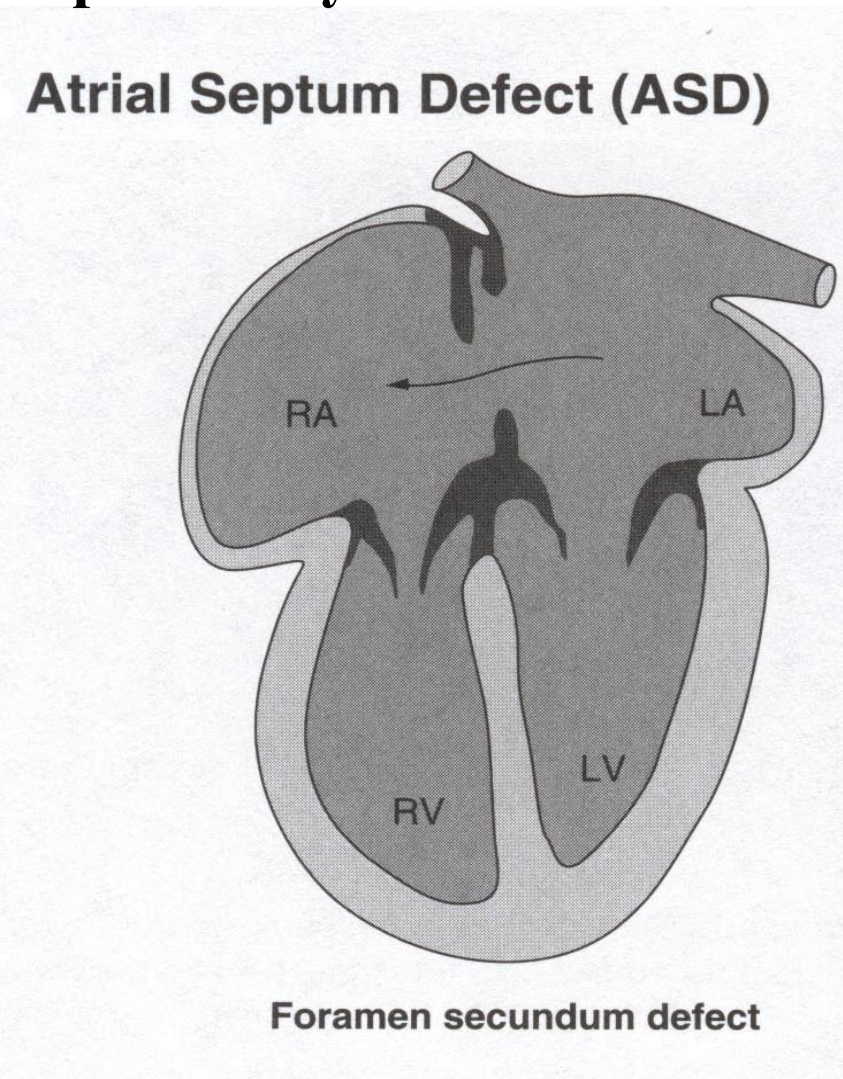
When embryology lecture wraps up and the instructor asks if we have any questions

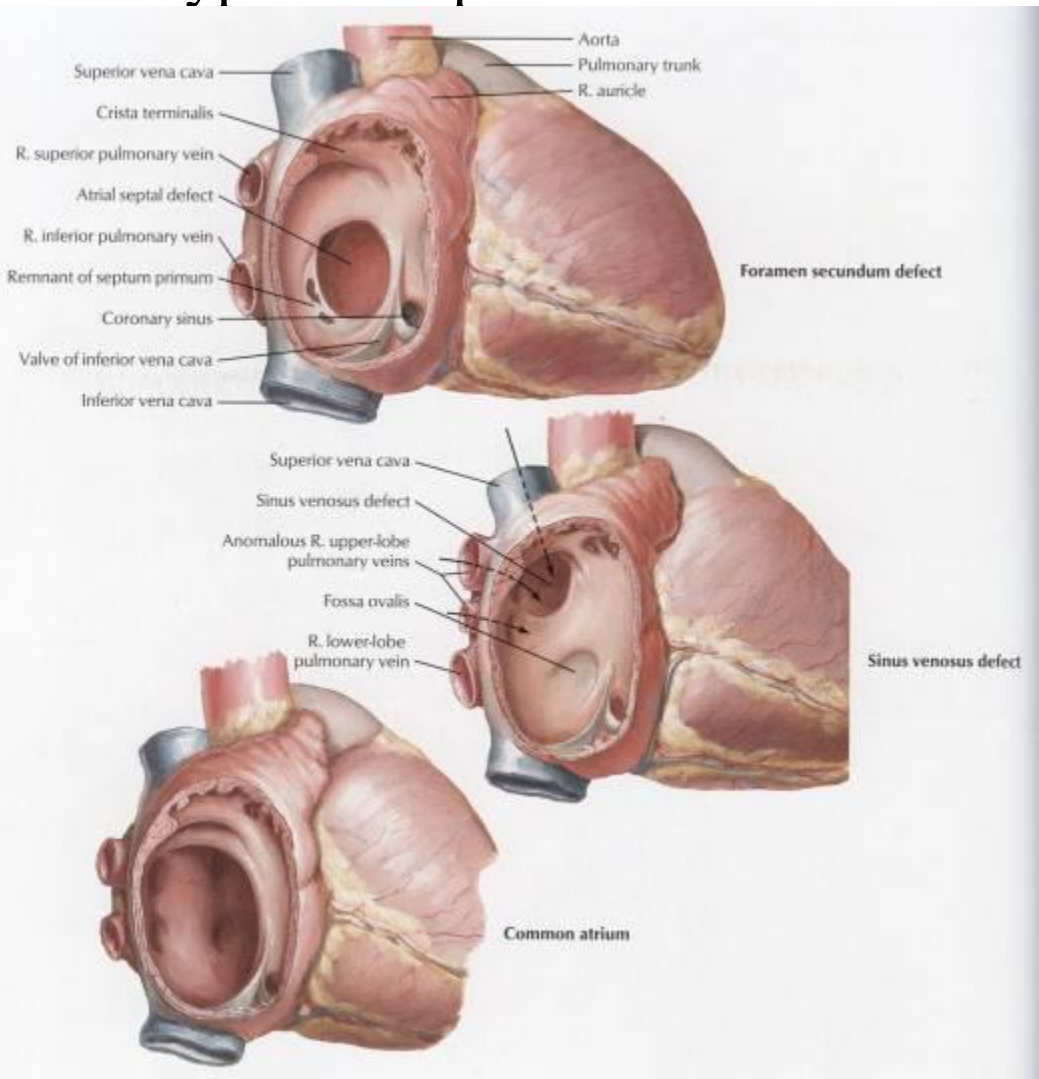
Defekt síňového septa

levo-pravý zkrat

malé defekty – klinická manifestace třeba až ve 3. dekádě

předčasný uzávěr foramen ovale → hypertrofie pravého srdce

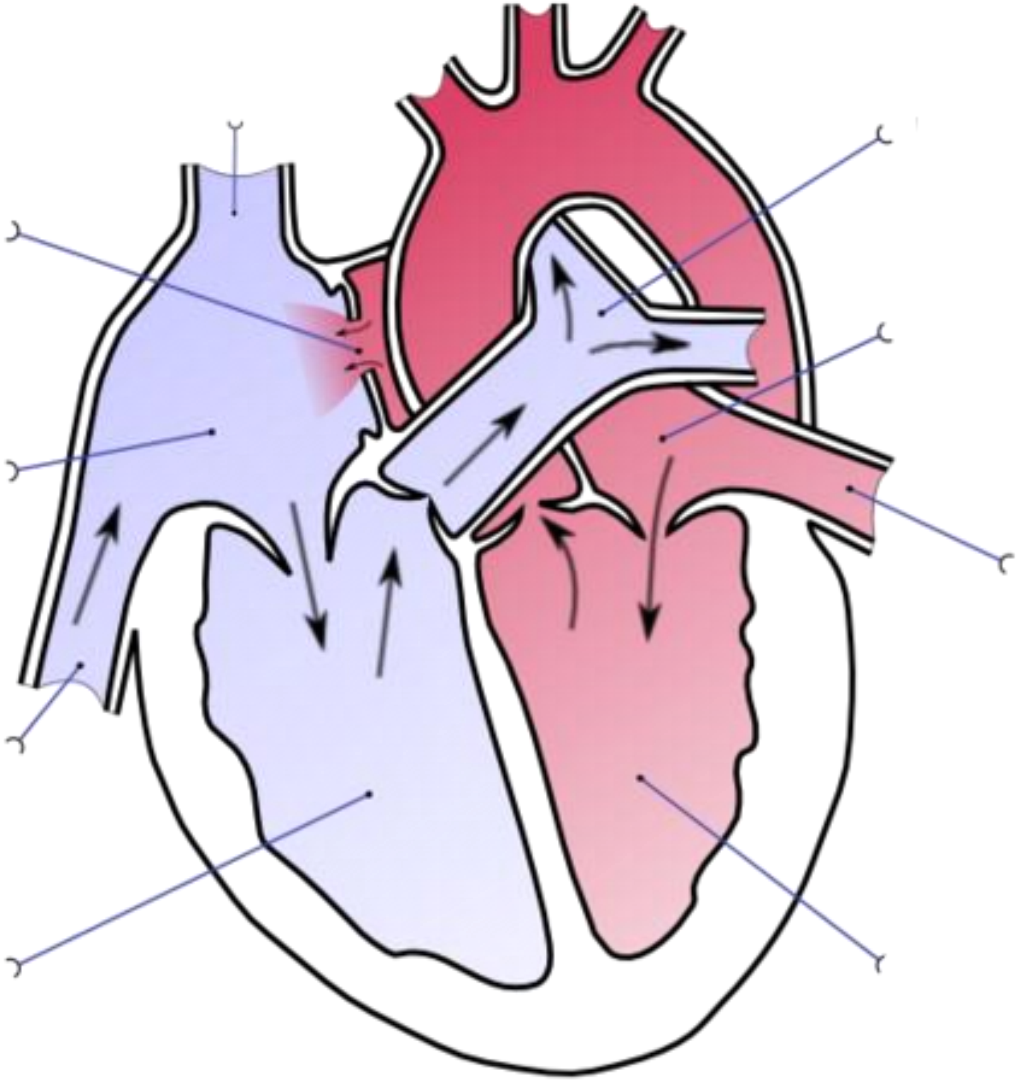




Atrial septal defect

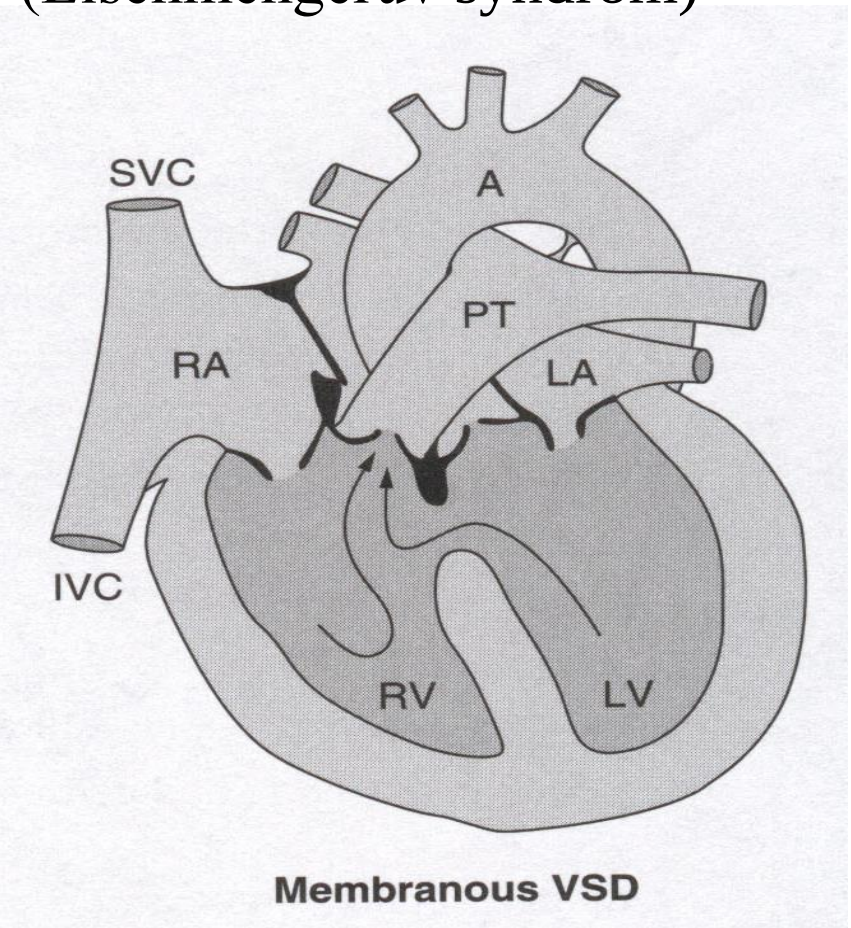
Small defects - clinical symptoms may be delayed (age 30)

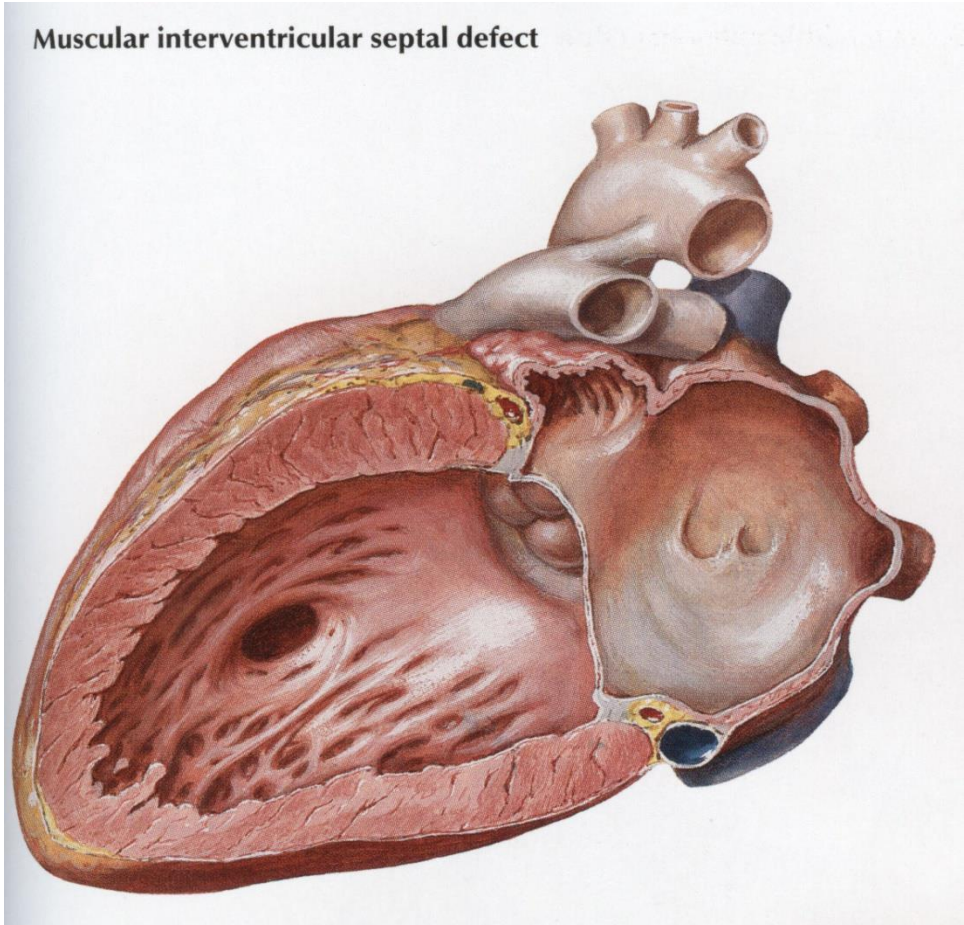
Foramen ovale patens



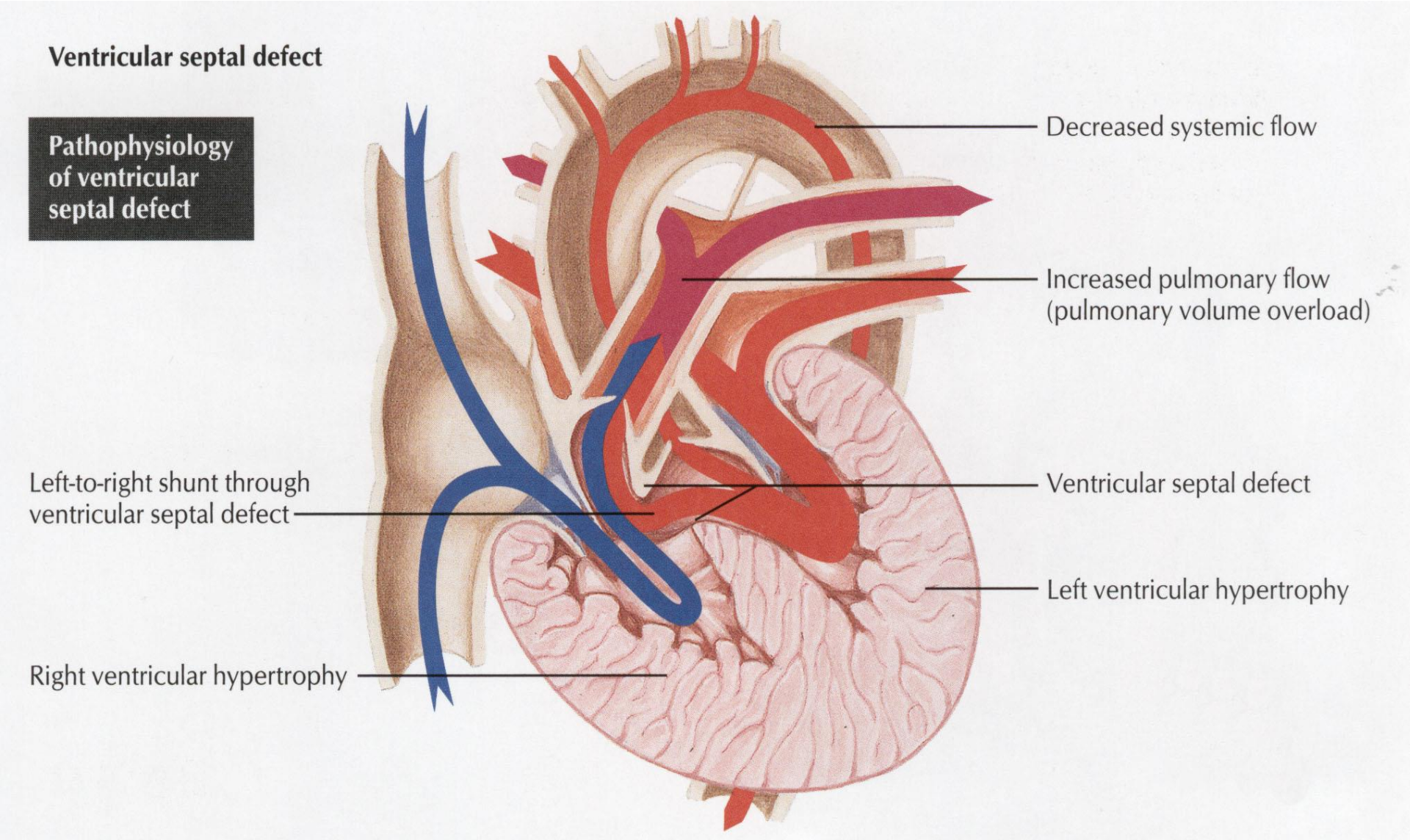
Defekt komorového septa

- levo-pravý zkrat s velkou únavností při zátěži
- zvýšený průtok plicním řečištěm → plicní hypertenze → zesílení tunica intima et media plicních tepen → zúžení plicních tepen → později zvýšená plicní rezistence obrátí zkrat na pravo-levý → cyanóza (Eisenmengerův syndrom)

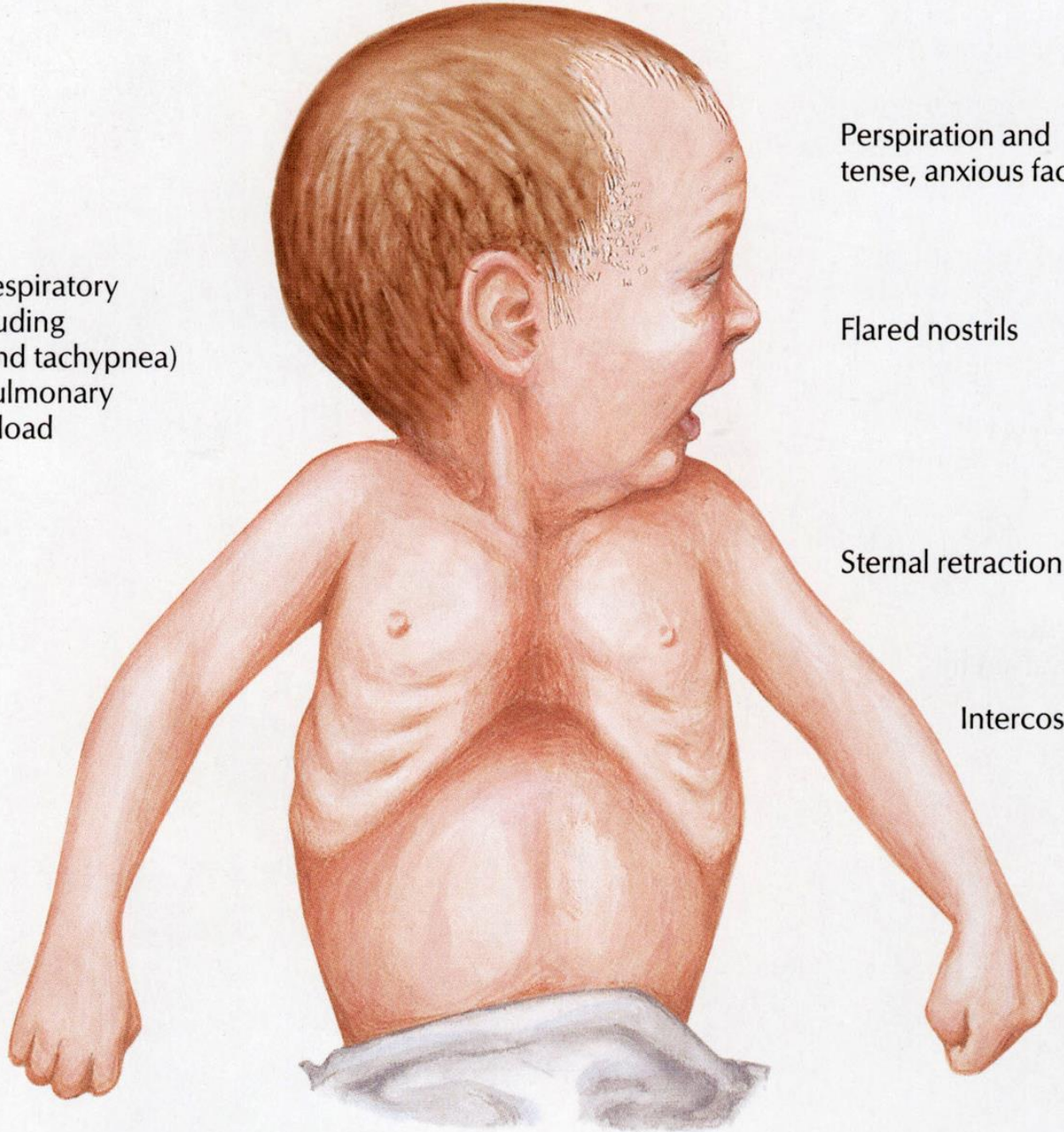




Defekt komorového septa



Clinical characteristics of too much pulmonary flow (pulmonary volume overload)



Infant with respiratory distress (including orthopnea and tachypnea) caused by pulmonary volume overload

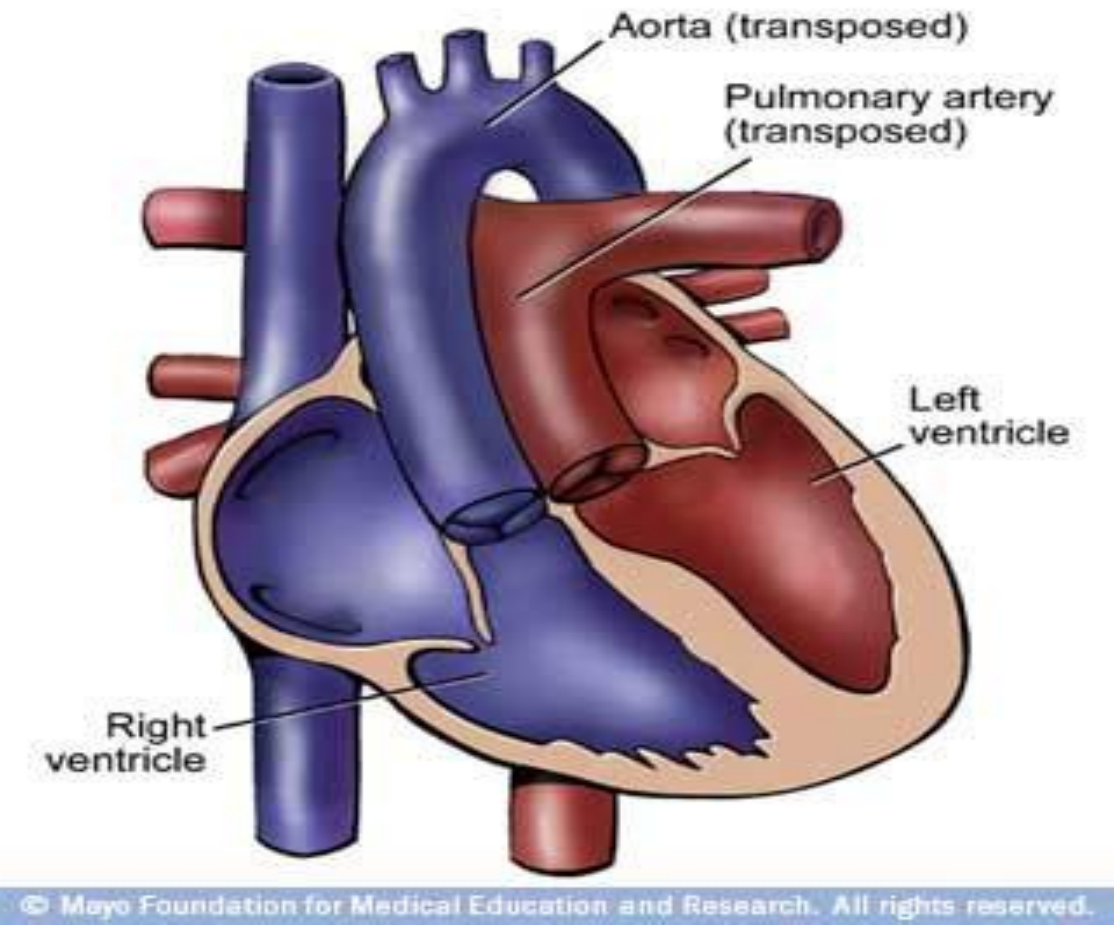
Perspiration and tense, anxious facies

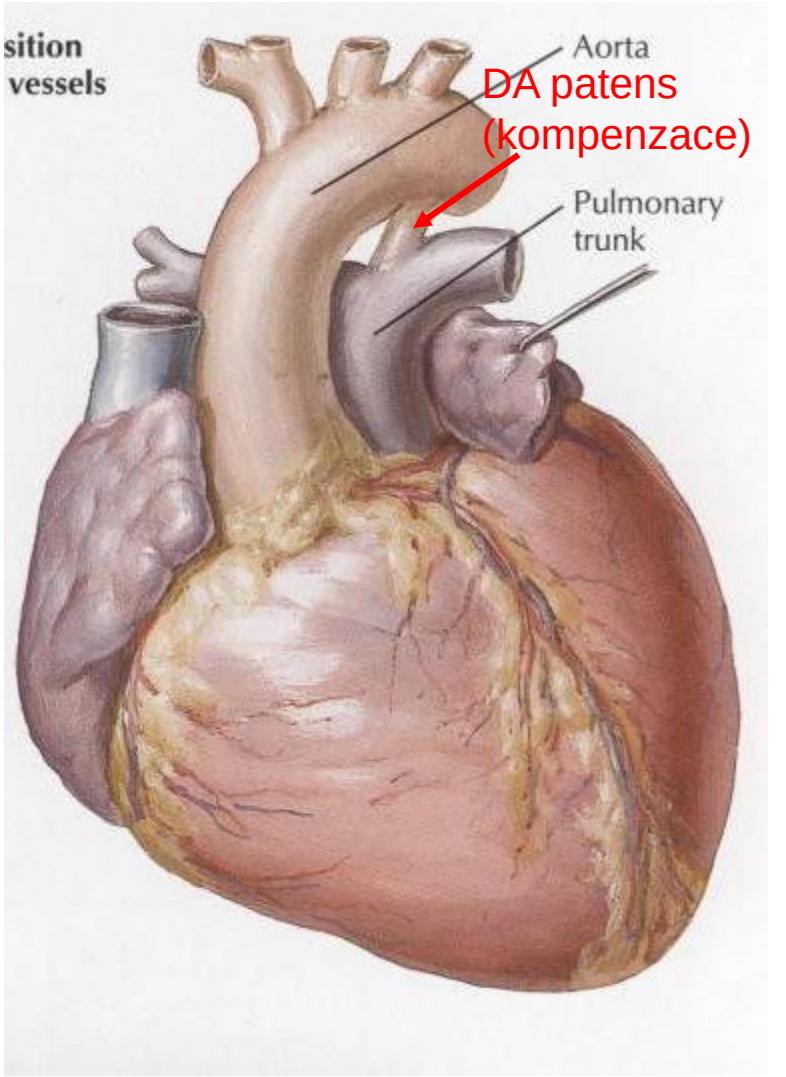
Flared nostrils

Sternal retraction

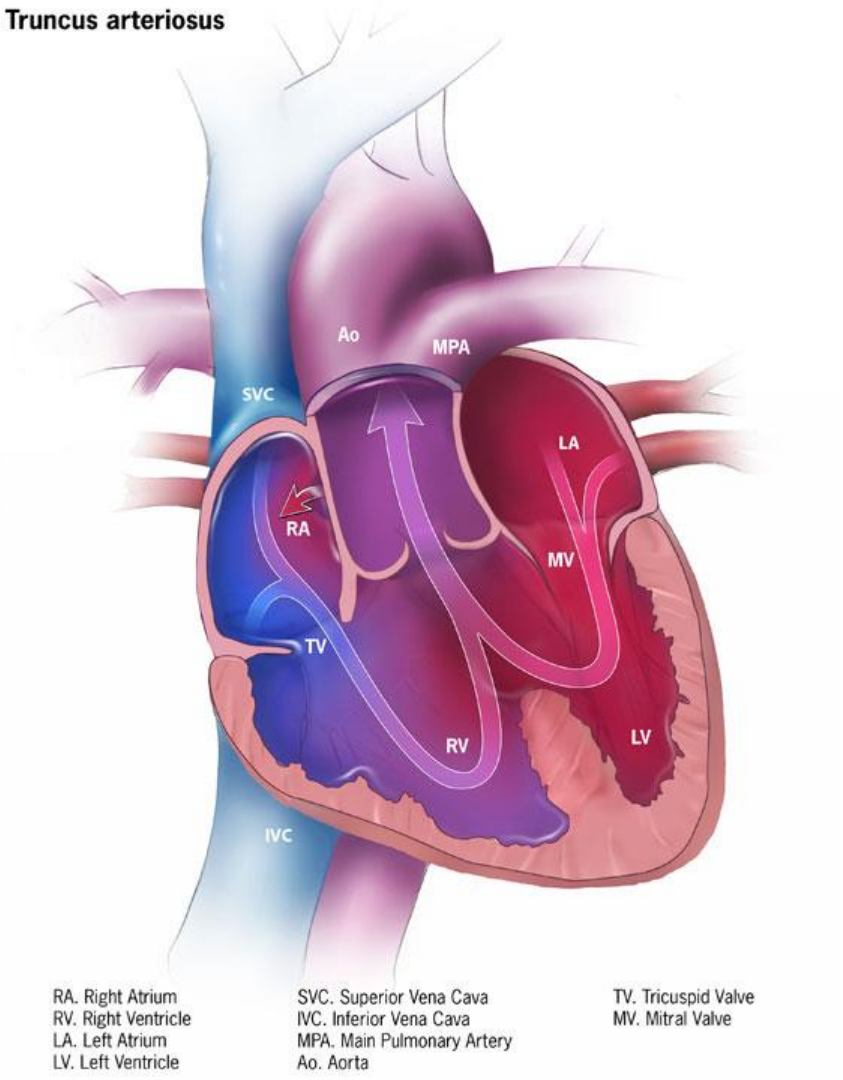
Intercostal retractions

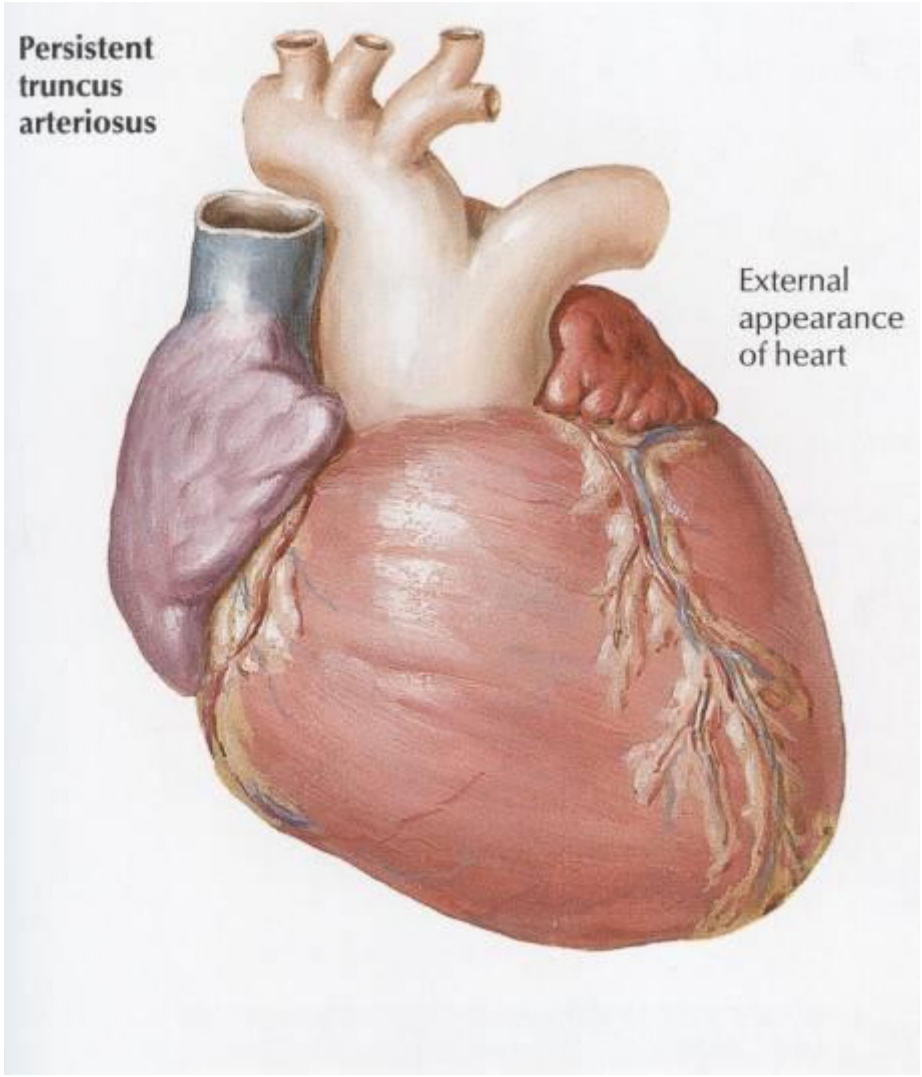
Transpozice velkých artérií (cév)





Truncus arteriosus persistens





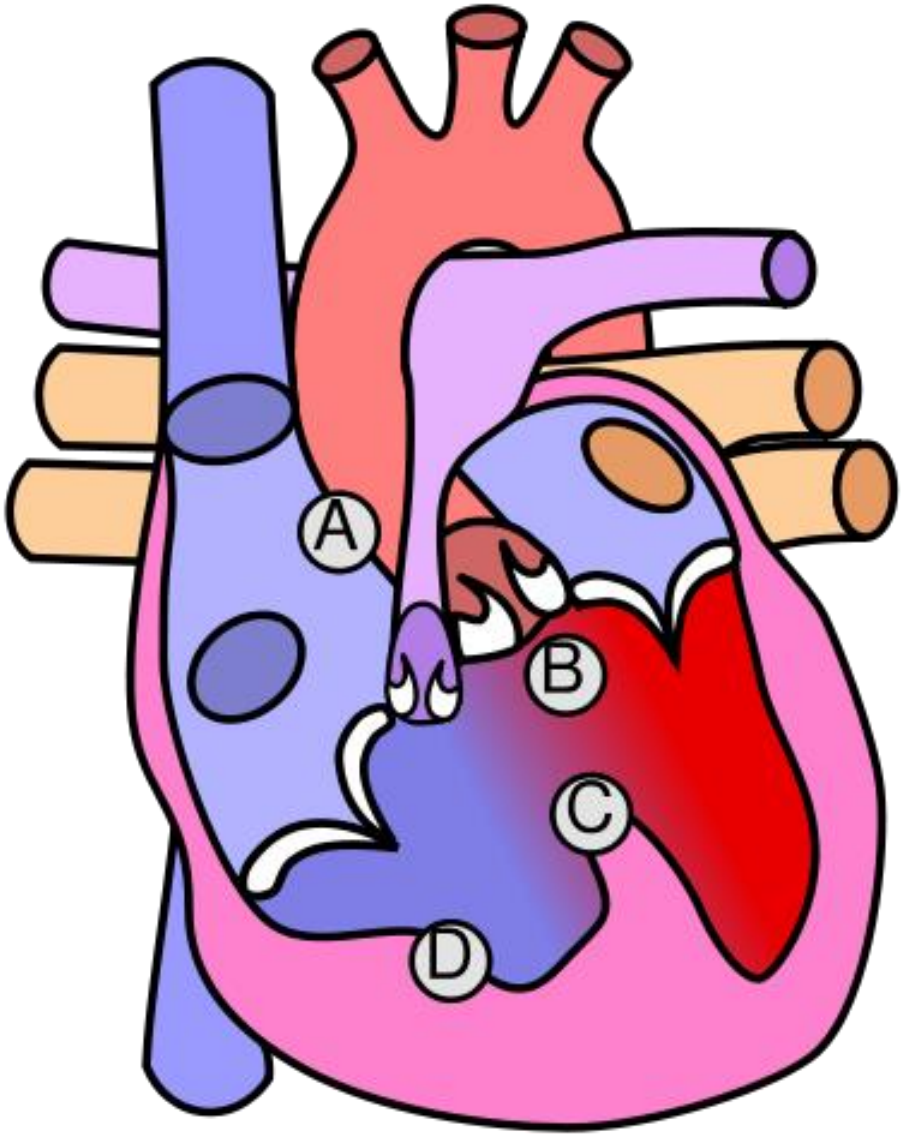
Fallotova tetralogie

A – dextropozice aorty
(nasedající aorta)

B – stenóza plícnice
(obstrukce ve výtoku z pravé komory)

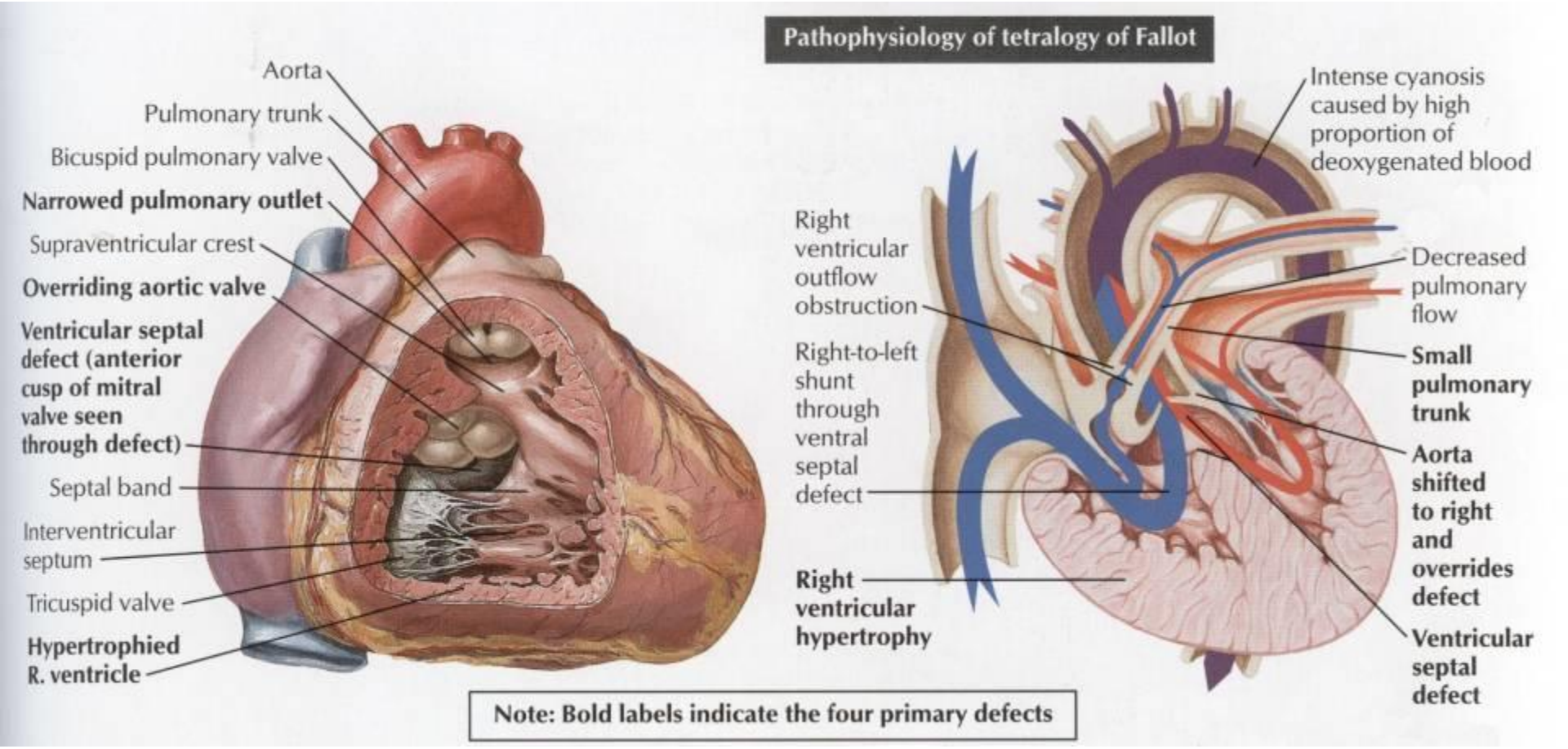
C – defekt komorového septa

D – hypertrofie pravé komory



Fallotova tetralogie

1 ‰



Clinical characteristics of too little pulmonary flow

Cyanosis

Clubbing of fingers