Urinary system, structure and development. Congenital disorders of urinary system. Suprarenal gland.

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2021 / 2022

Credits… voluntary subjects.

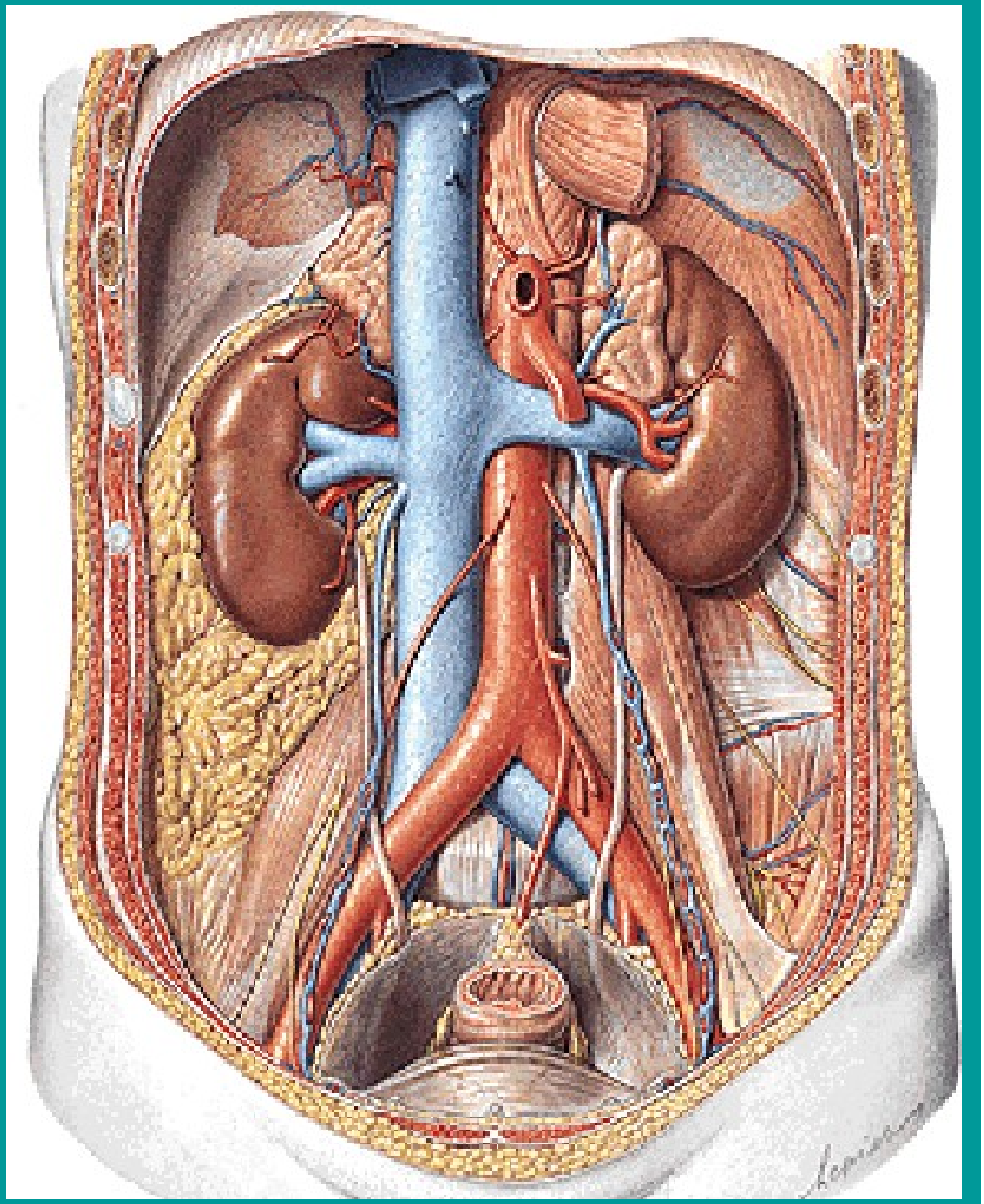
Decide, which exam you take first. Anatomy or histology…

Plan B…

Urinary system –
systema urinarium

kidney - *ren, nephros*
renal pelvis –
pelvis renalis
ureter,
urinary bladder -
vesica urinaria
Female urethra
urethra feminina
Male urethra *urethra masculina*

Development.
Congenital disorders of urinary system



Function of kidneys

1. homeostasis: water, minerals, nitrogen waste from aminoacids/proteins
2. endocrine:
    a. renin (increase blood pressure)
    b. erythropoetin (stimulates hematopoesis),
    c. vit. D – calcitriol (increases Ca absorption)
    d. prostaglandines (local effects)

Excretory passageways lined by transitional epithelium (urothelium), smooth musculature in walls - transport and expulsion of urine

Urethra in male is also a passageway for the genital system

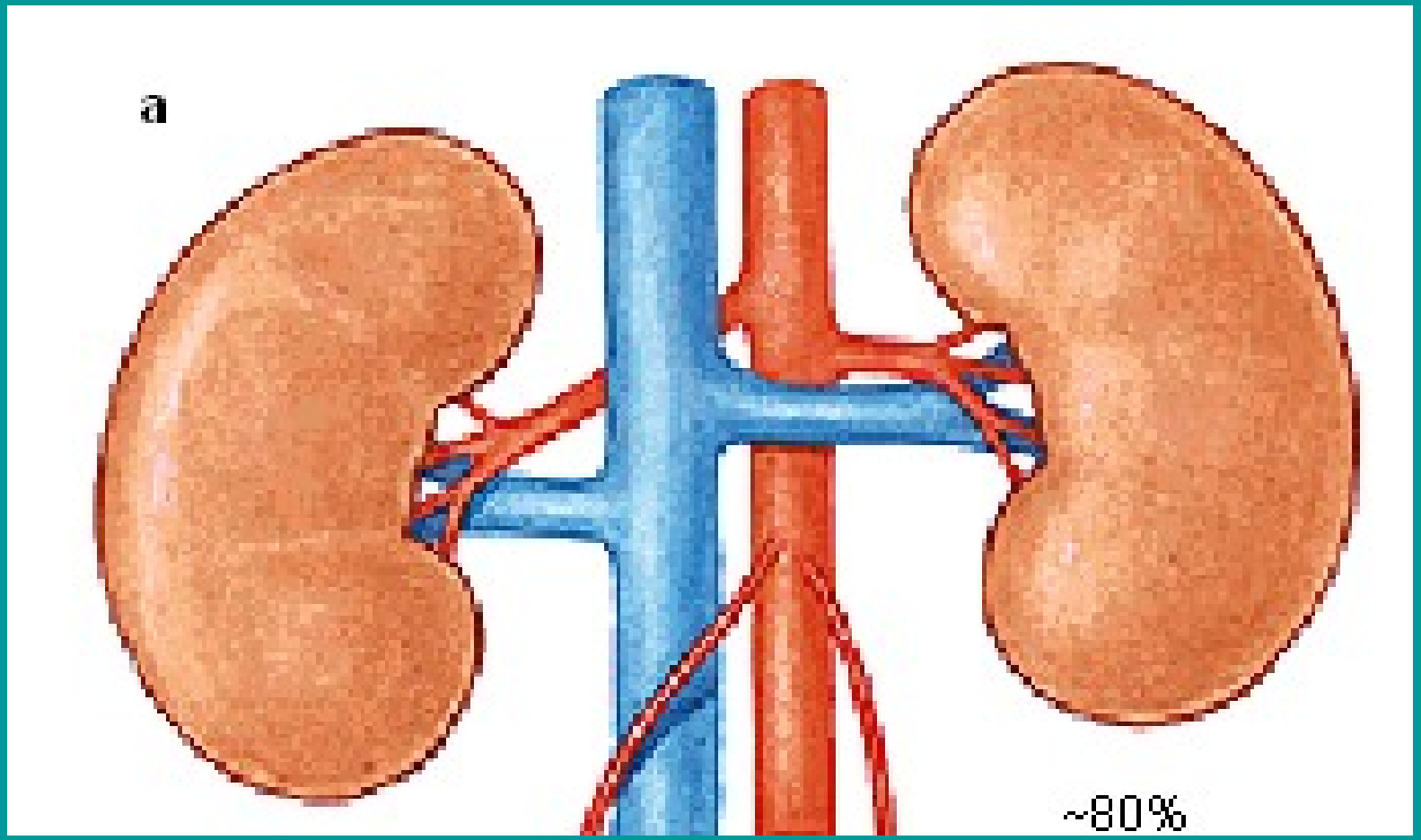
Urinary system - *systema urinarium*

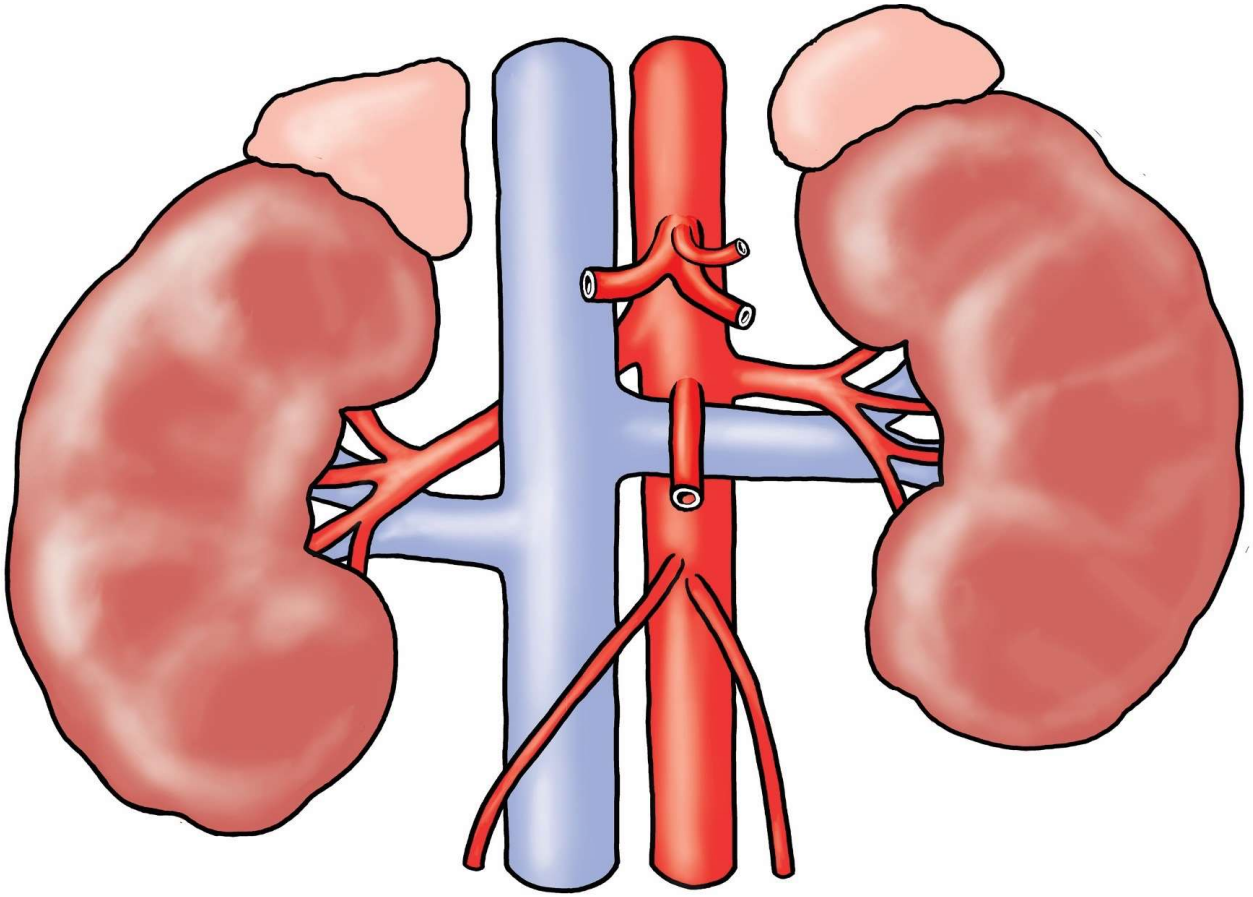
kidney - *ren, nephros*

renal pelvis - *pelvis renalis*

a. renalis

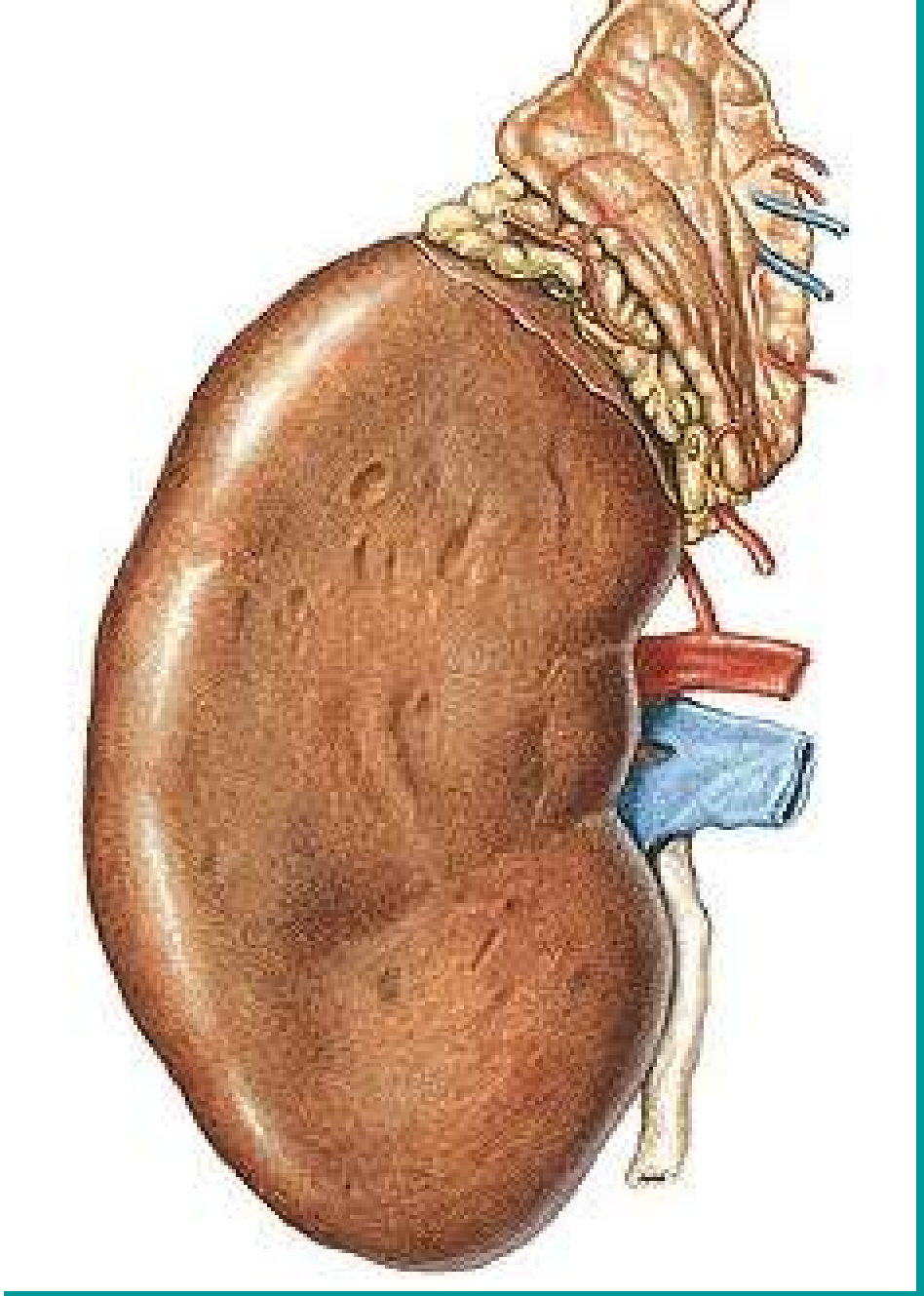
v. *renalis*

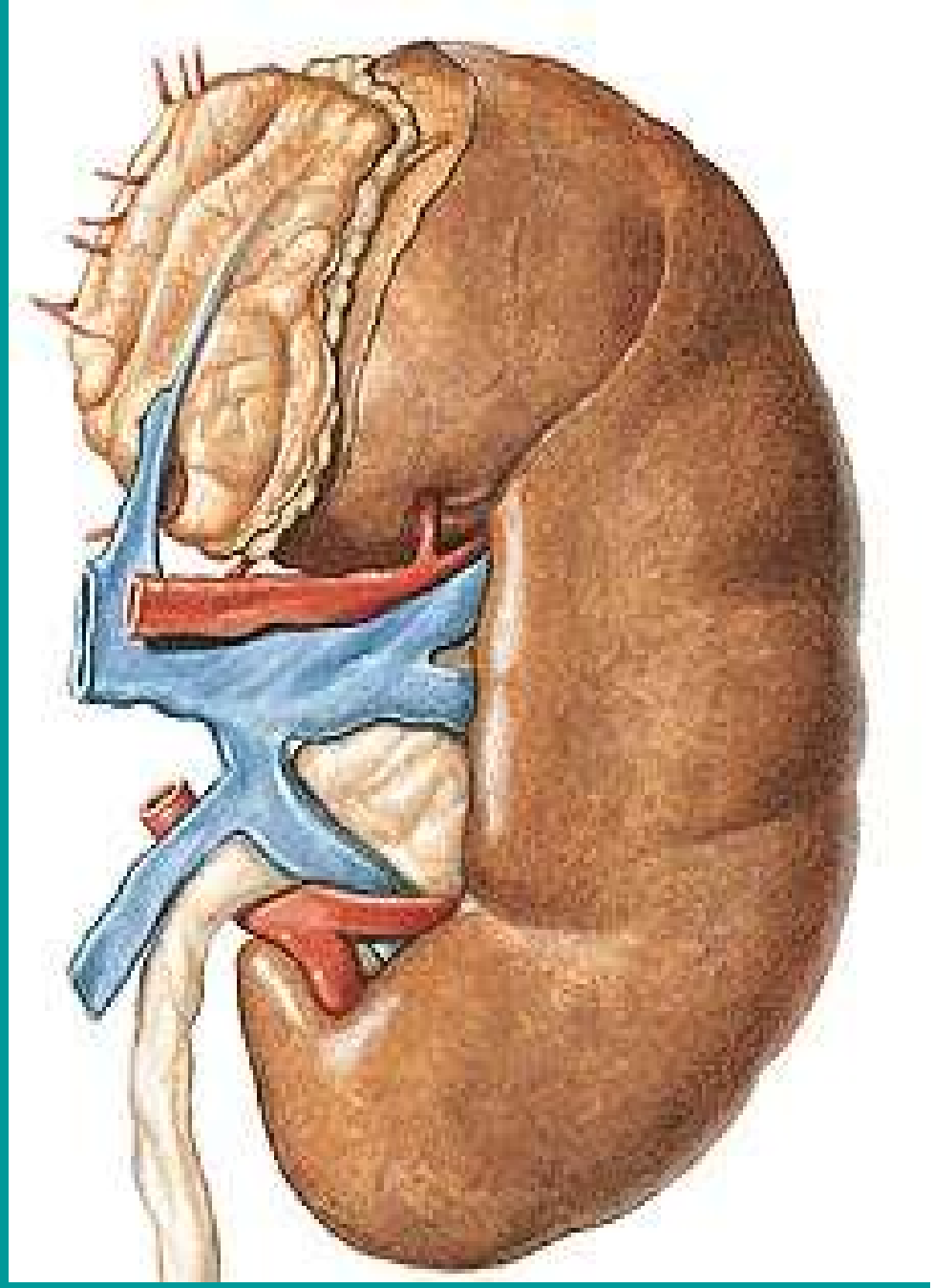




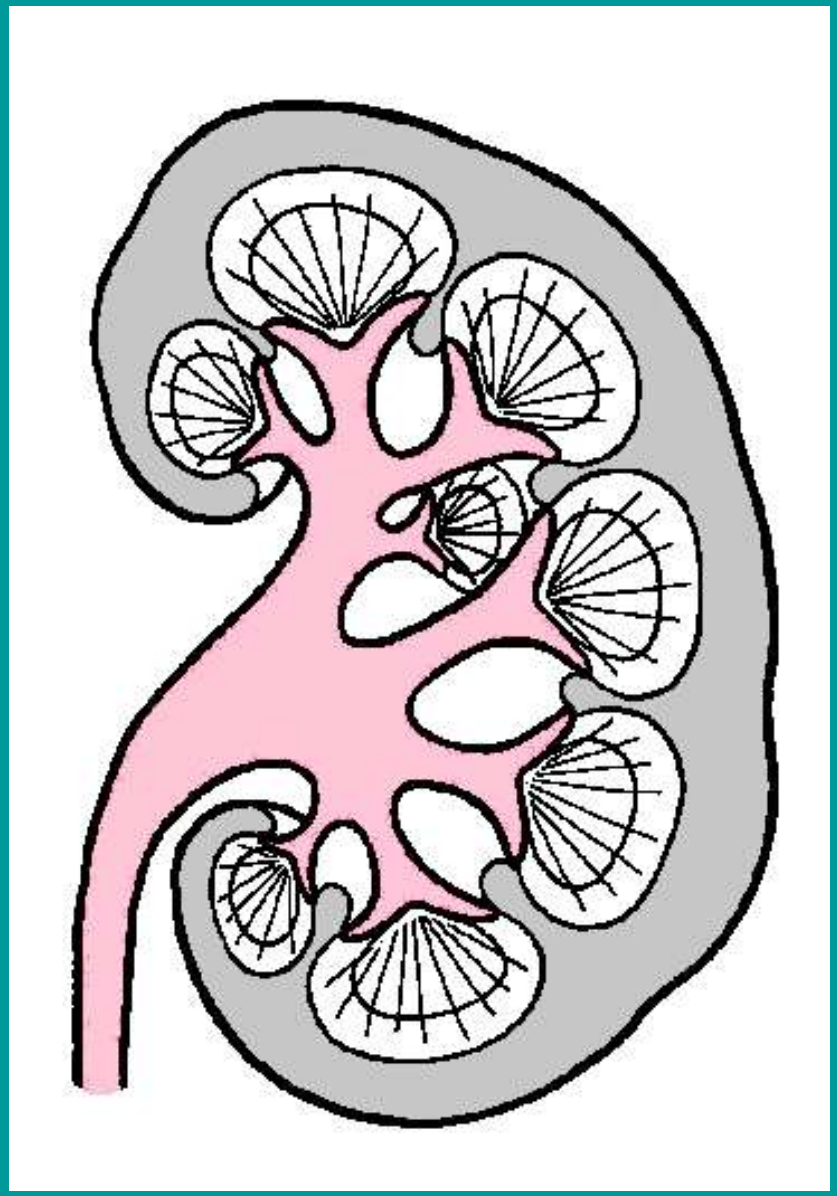
Kidneys and blood vessels

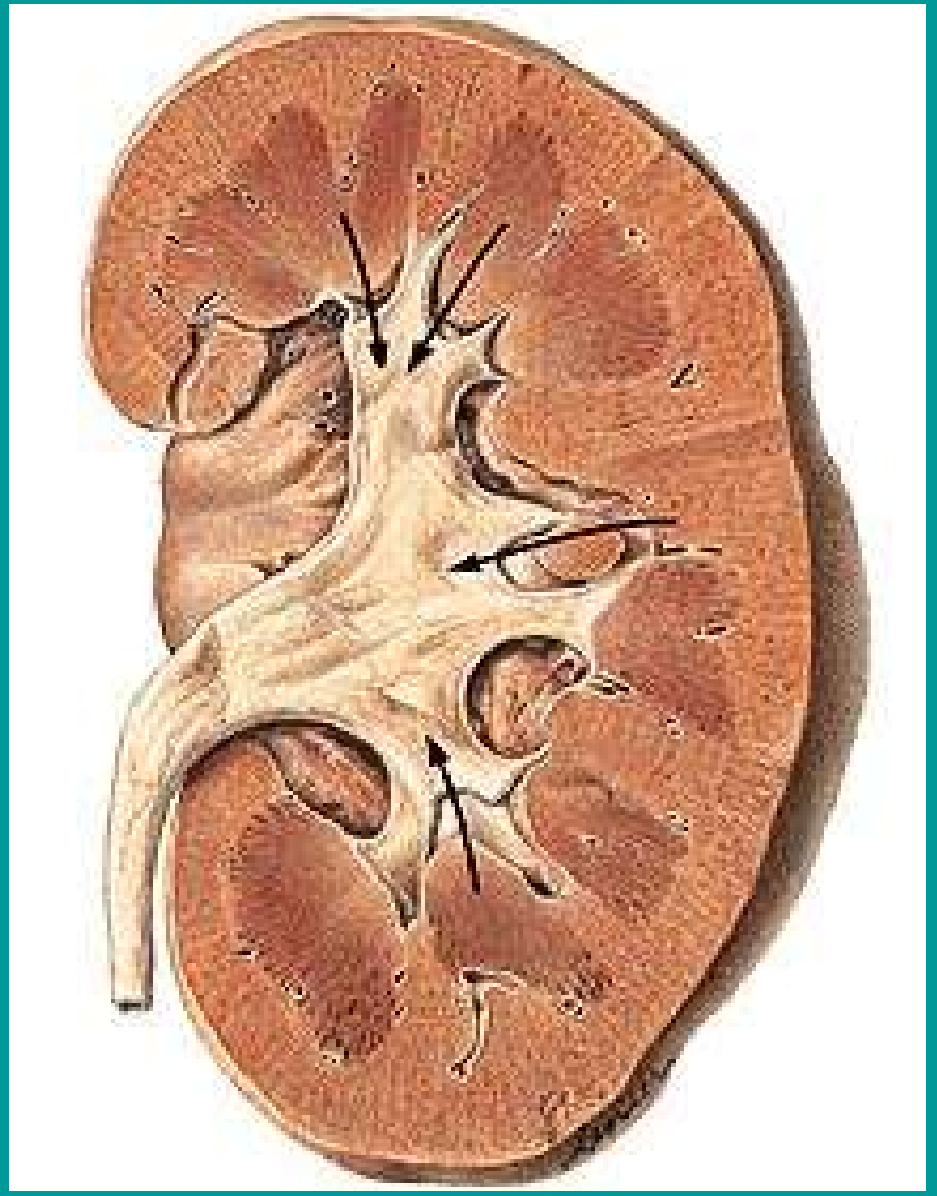
1 – aorta abdominalis,
2 – v. cava inf.,
3 - a. renalis sin.,
4 – gl. suprarenalis sin.,
6 – truncus coeliacus,
7 – a. testicularis sin.,
8 – a.mesenterica sup.,





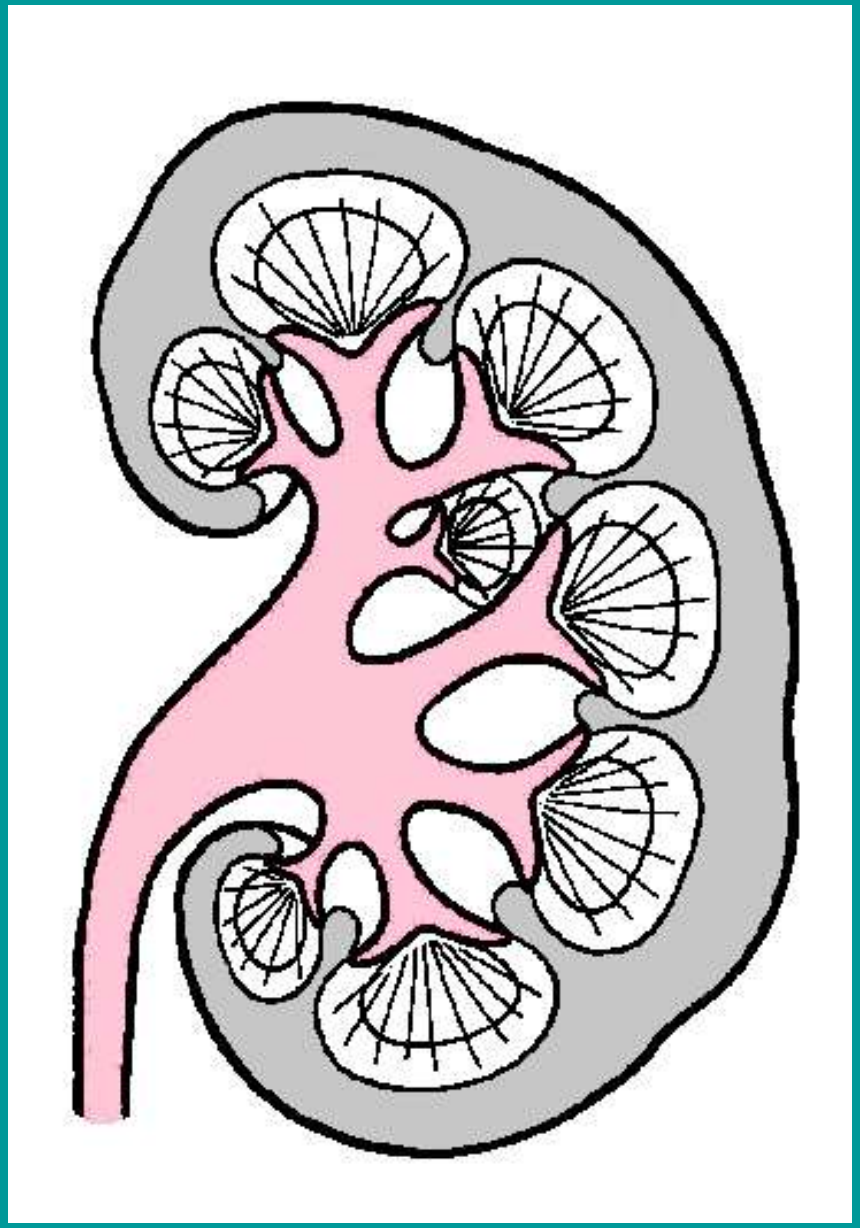
Ren (nephros) margo medialis, lateralis, hilum, sinus, facies anterior, posterior, polus (extremitas) superior, inferior





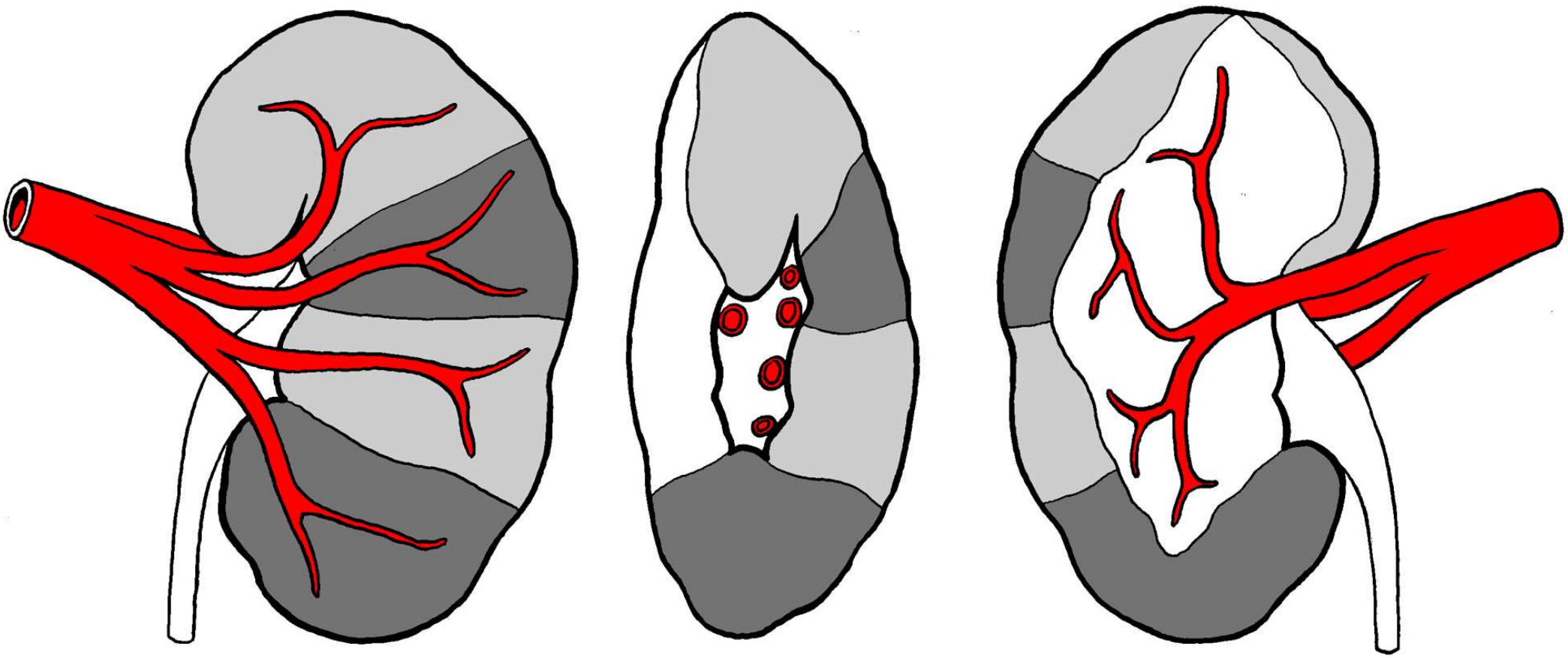
Capsula fibrosa, cortex, medulla, columnae renales, pyramides (5-14), lobi renales, papillae renales, foramina papillaria, ductus papillares (120 – 770), area cribrosa, calices renales

Branching of a. renalis



Cortex, medulla
lobi renales, calices renales, aa. segmentales

Segmenta renalia, aa. segmentales

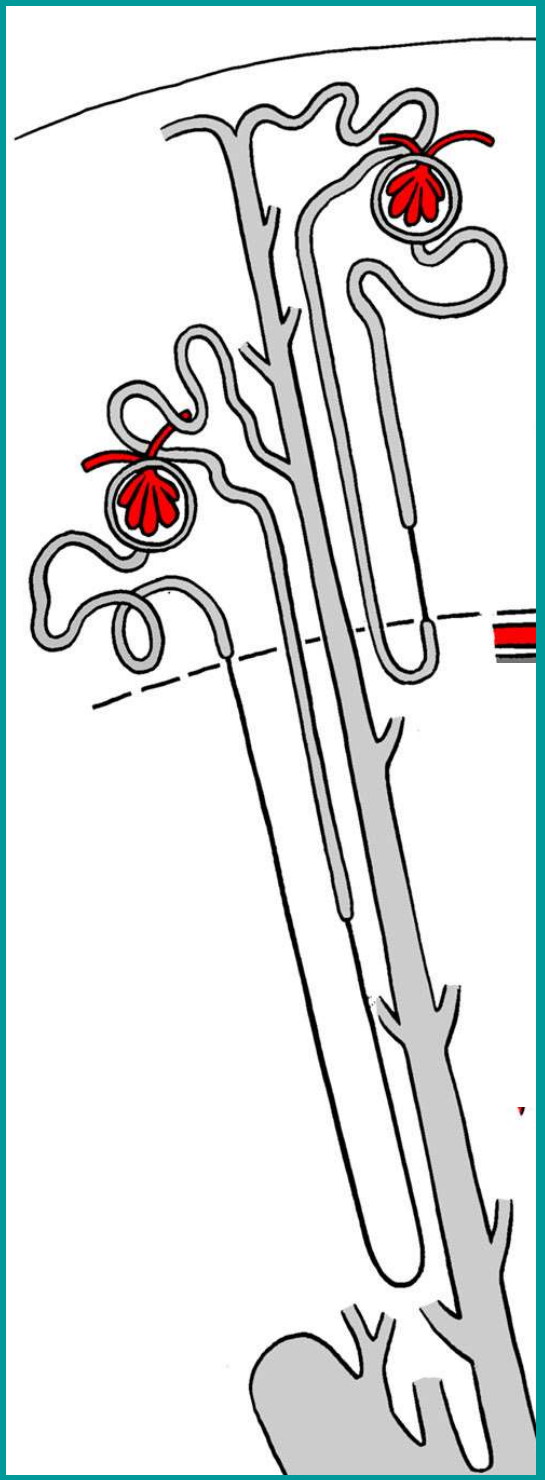


Segmentum: superius, **anterius superius**, **anterius inferius, inferius, posterius. A.renalis, rami anterio**res (praepelvici) **ramus posterior** (retropelvicus), **aa. segmentales.**

Aa. segmentales are terminal arteries without anastomoses or collaterals.

Nephron – basic functional unit of kidney.
Renal corpuscle and **renal tubules.**
1 – 1,5 millions in each kidney;
juxtamedullary nephrons (15 %)
cortical nephrons (85%)
1 nephron is made up by 10 000 cells with 12 cell types.
Regeneration – rather compensatory hypertrophy

Mechanism of urine formation:
Glomerular filtration, tubular resorption, tubular secretion
1800 litres of blood passes daily through our kidneys, 180 litres of primary urine is filtered. Due to resorption there is 1.8litre of definitive urine per day.

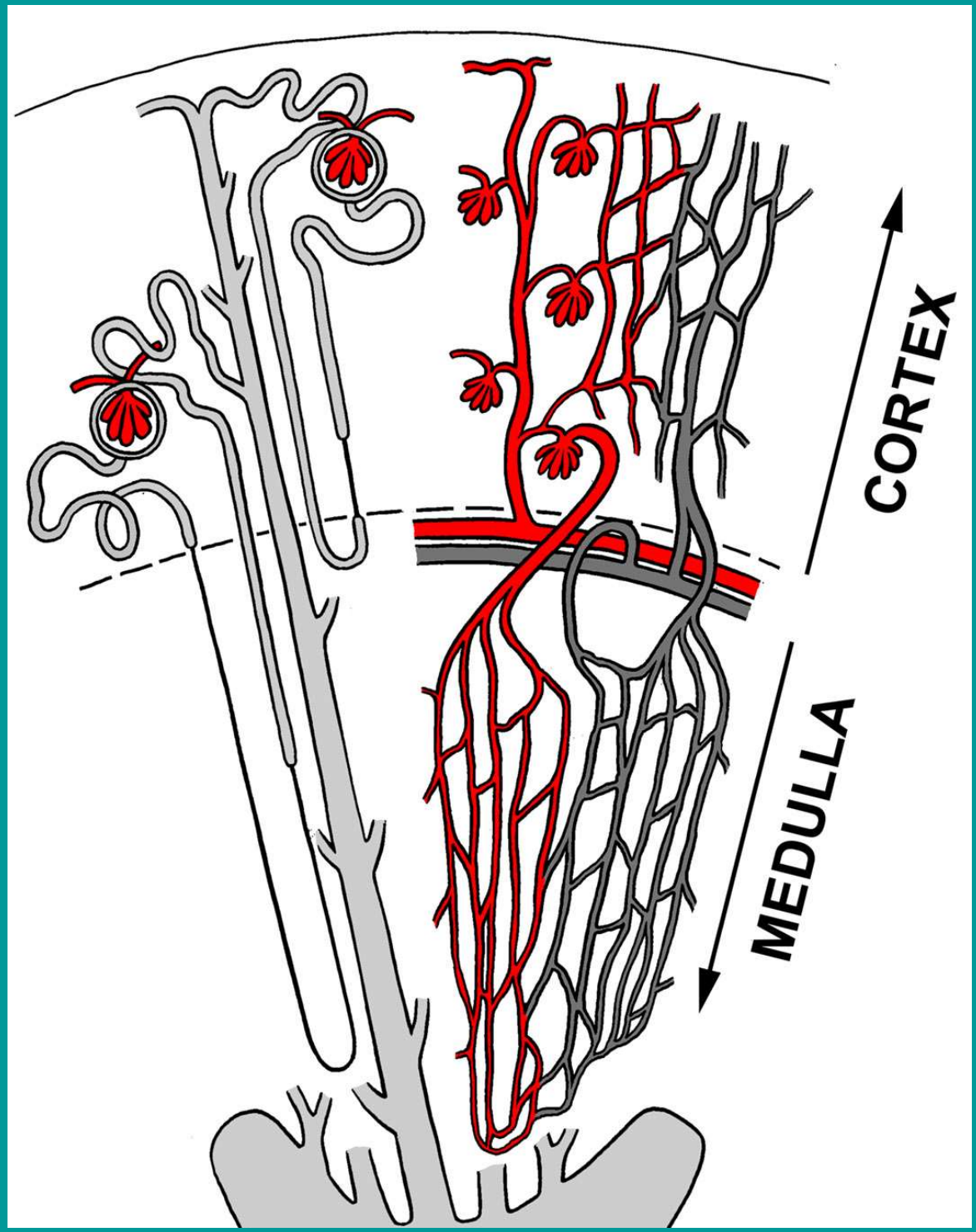


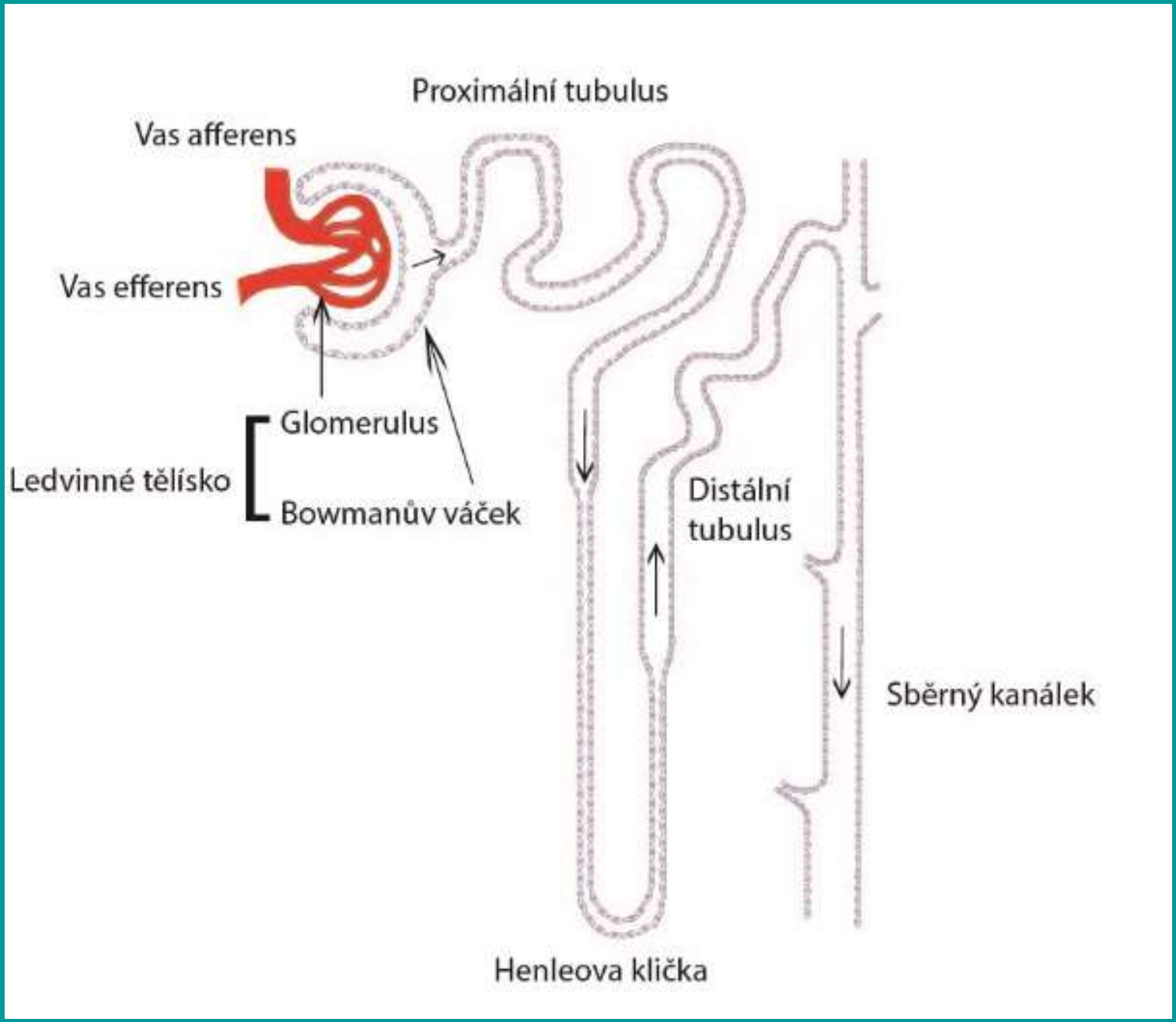
Nephron

corpusculum renale:
glomerulus + capsula glomerularis
(Bowman's capsule, podocytes)
+ tubulus renalis

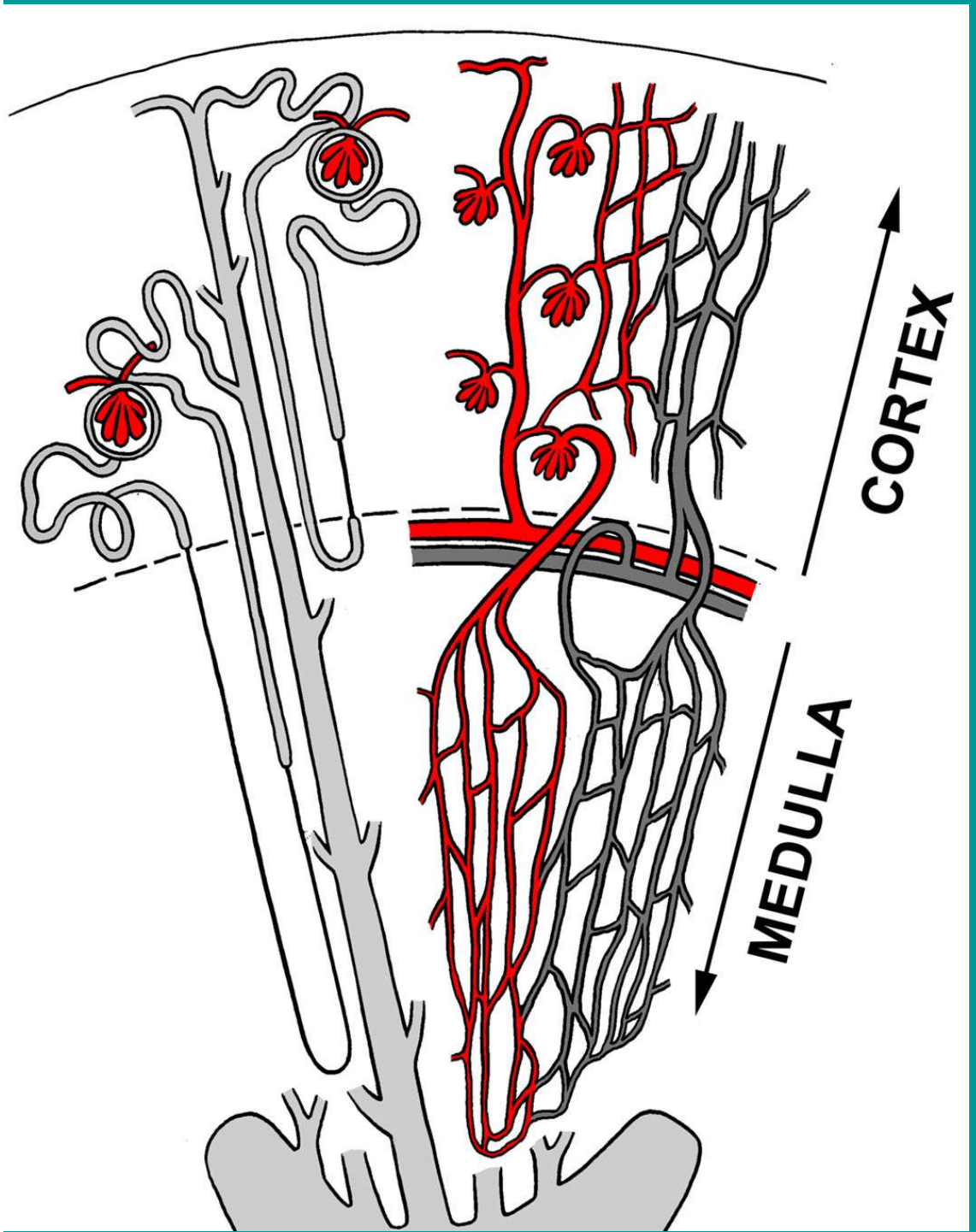
tubulus renalis:
proximal tubule
loop of Henle
distal convoluted tubule

Connecting tubule
Collecting duct system
ductus papillaris

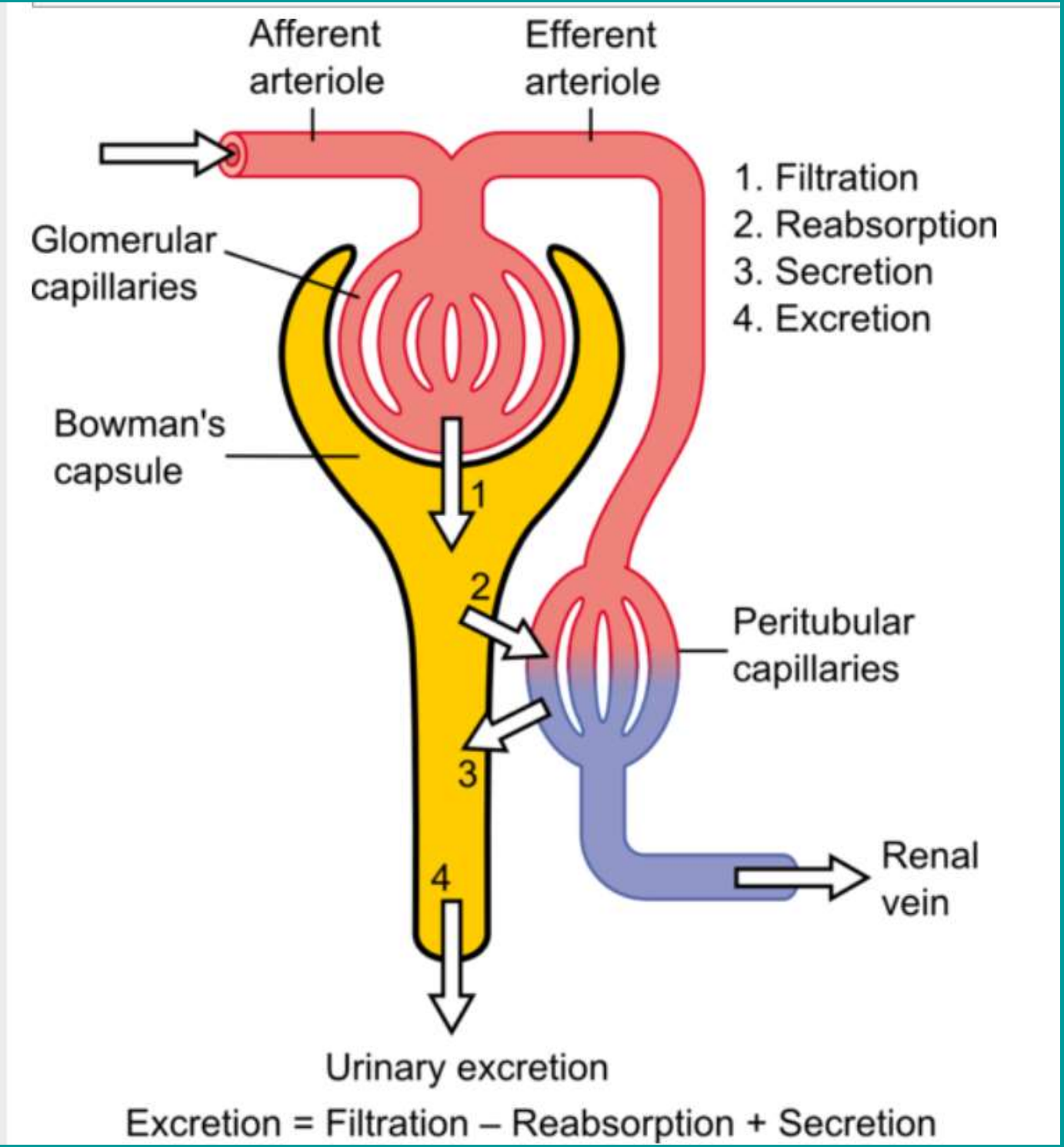


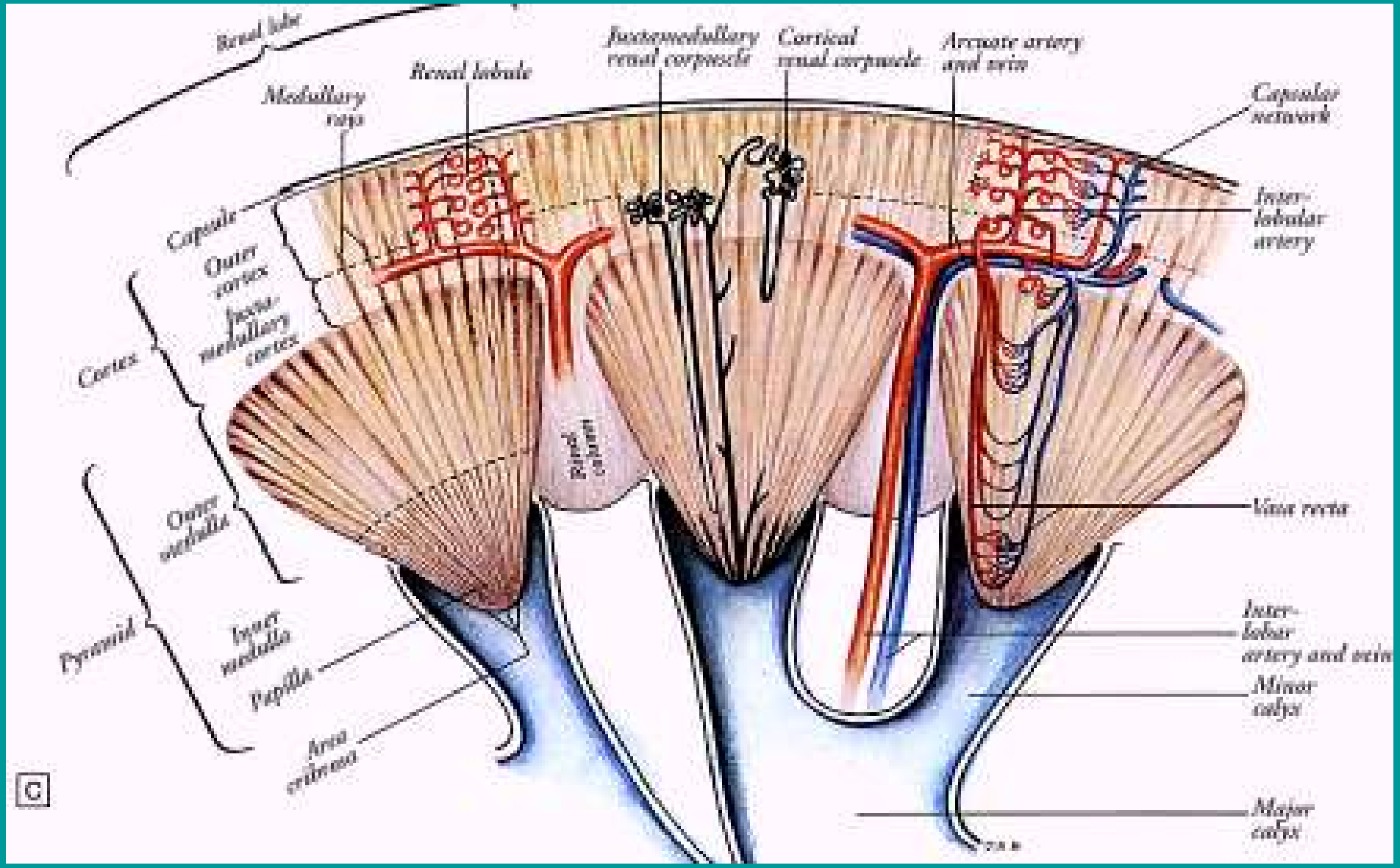

Proximální tubulus
Vas afferens
Vas efferens
Glomerulus
Ledvinné tělísko
Bowmanův váček
Distální tubulus
Sběrný kanálek
Henleova klička

Renal blood supply



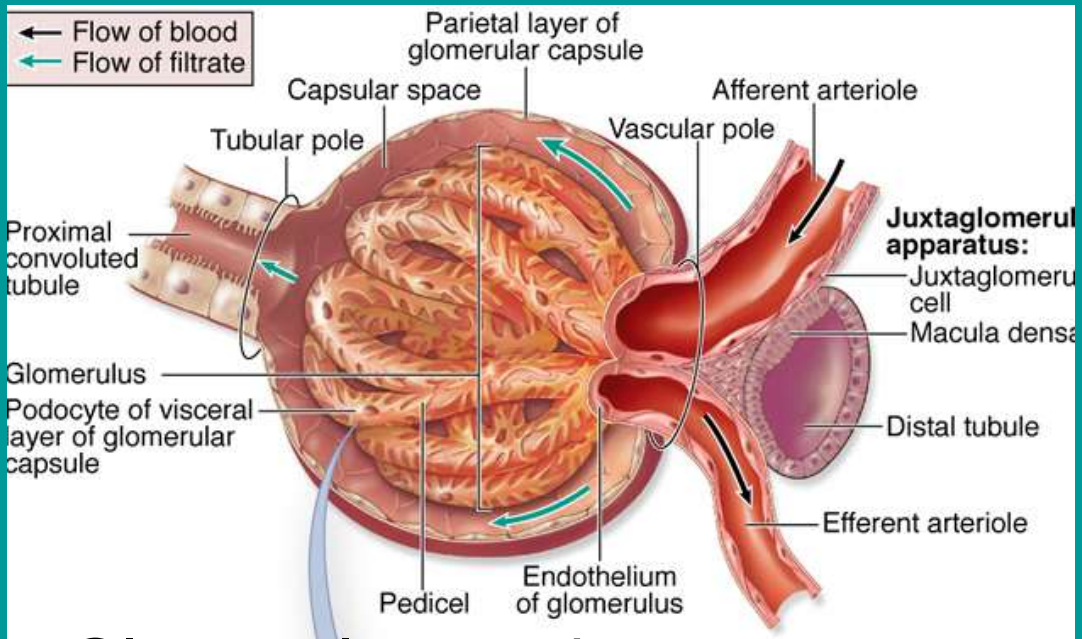
a. interlobares
aa. arcuatae
aa. corticales radiatae
aa. afferentes
glomerulární kapiláry
glomerulus
• kortikální
aa. efferentes
kapilární peritubulární pleteň
rete capillare peritubulare
• juxtamedulární
aa. efferentes
aa. rectae medullares, jejich kapilární pleteň
venulae rectae
vv. stellatae
vv. corticales radiatae
vv. arcuatae
vv. interlobares


Afferent arteriole
Efferent arteriole
1. Filtration
2. Reabsorption
3. Secretion
4. Excretion
Glomerular capillaries
Bowman's capsule
1
2
3
4
Peritubular capillaries
Renal vein
Urinary excretion
Excretion = Filtration – Reabsorption + Secretion



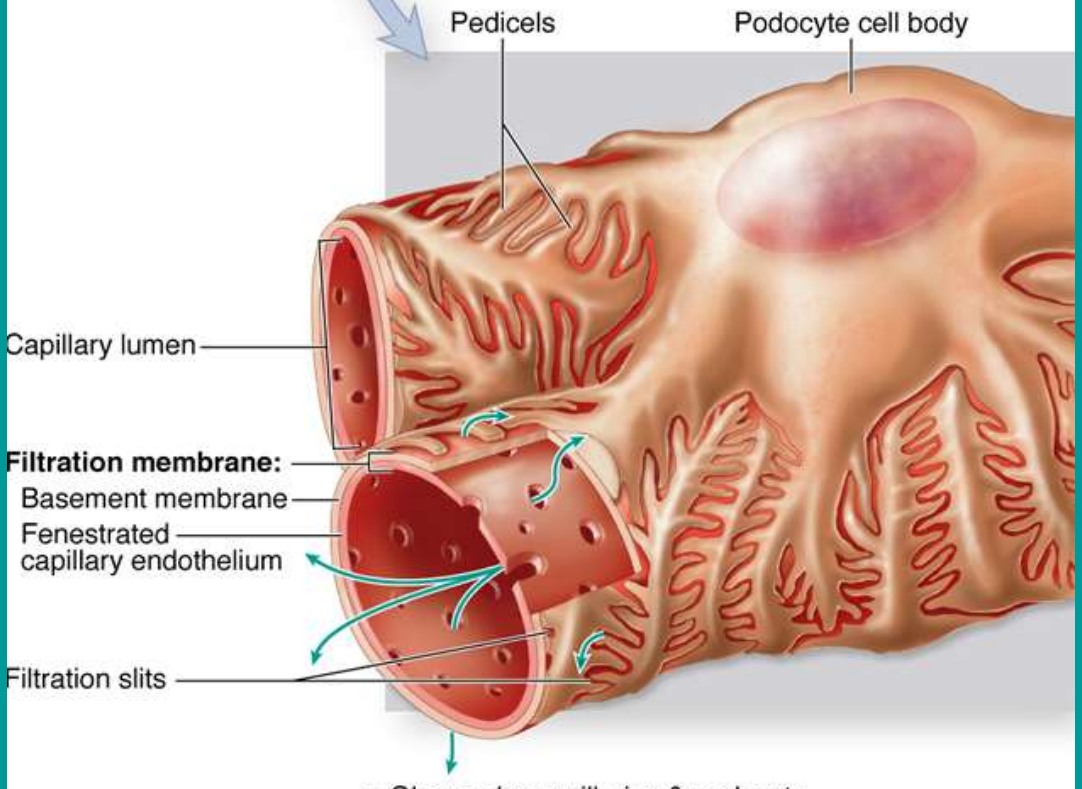
cortex renalis, medulla renalis, pyramides renales, lobi renales, columnae renales, papillae renales, foramina papillaria, area cribrosa, calices renales,

aa. interlobares, aa. arcuatae, aa. corticales radiatae



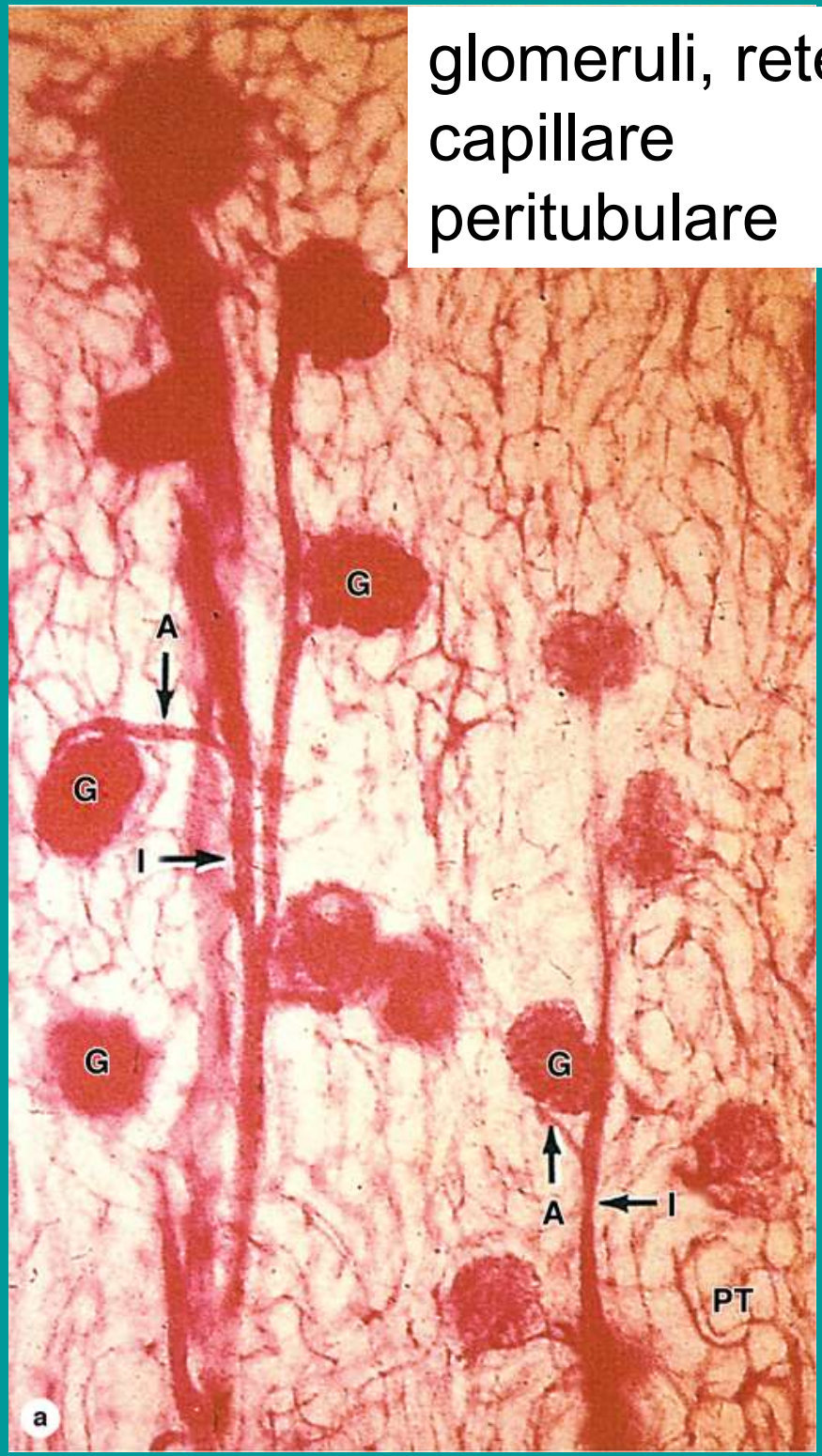
Glomerulus, podocytes

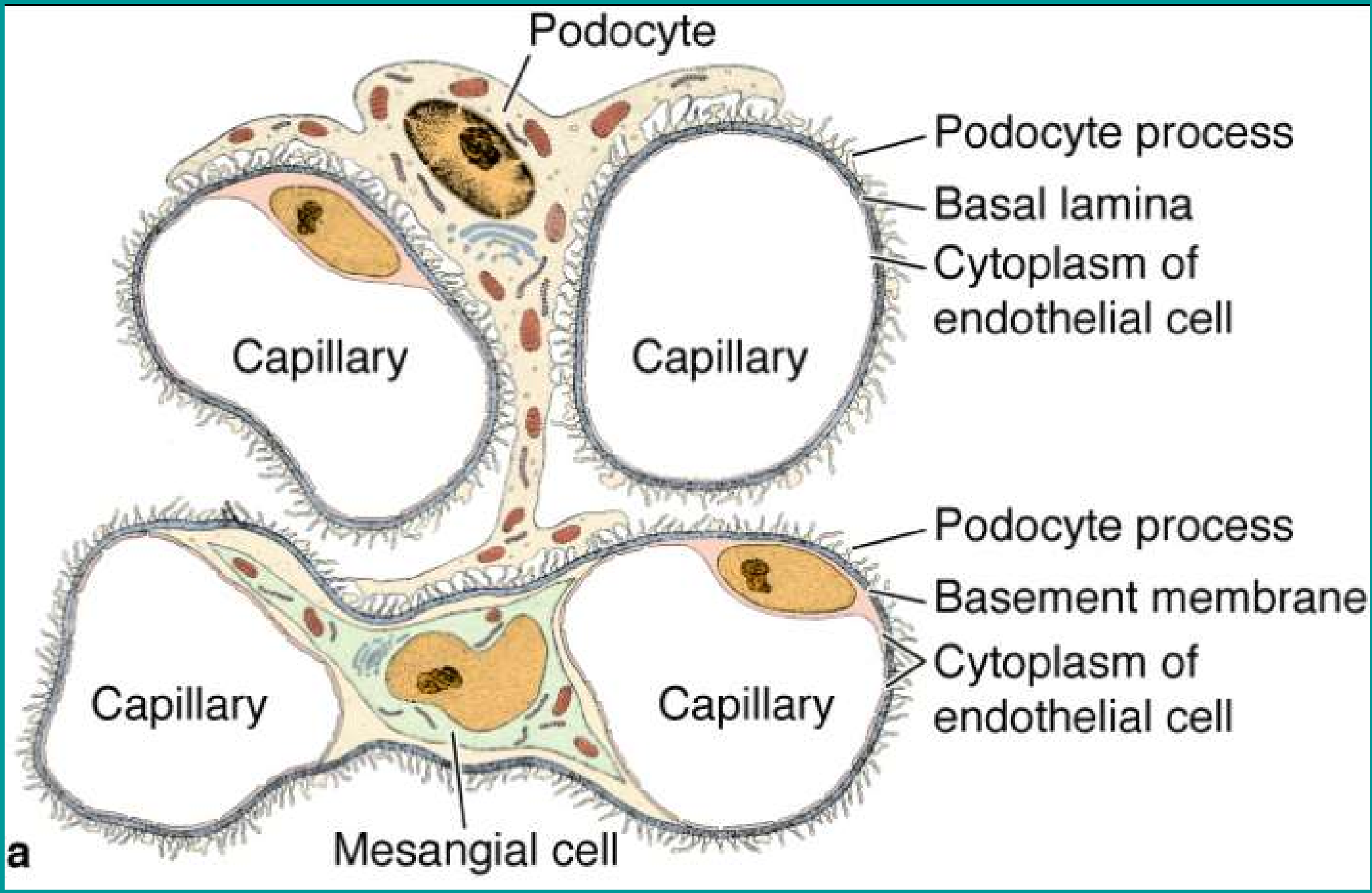
a Renal corpuscle



c Glomerular capillaries & podocyte

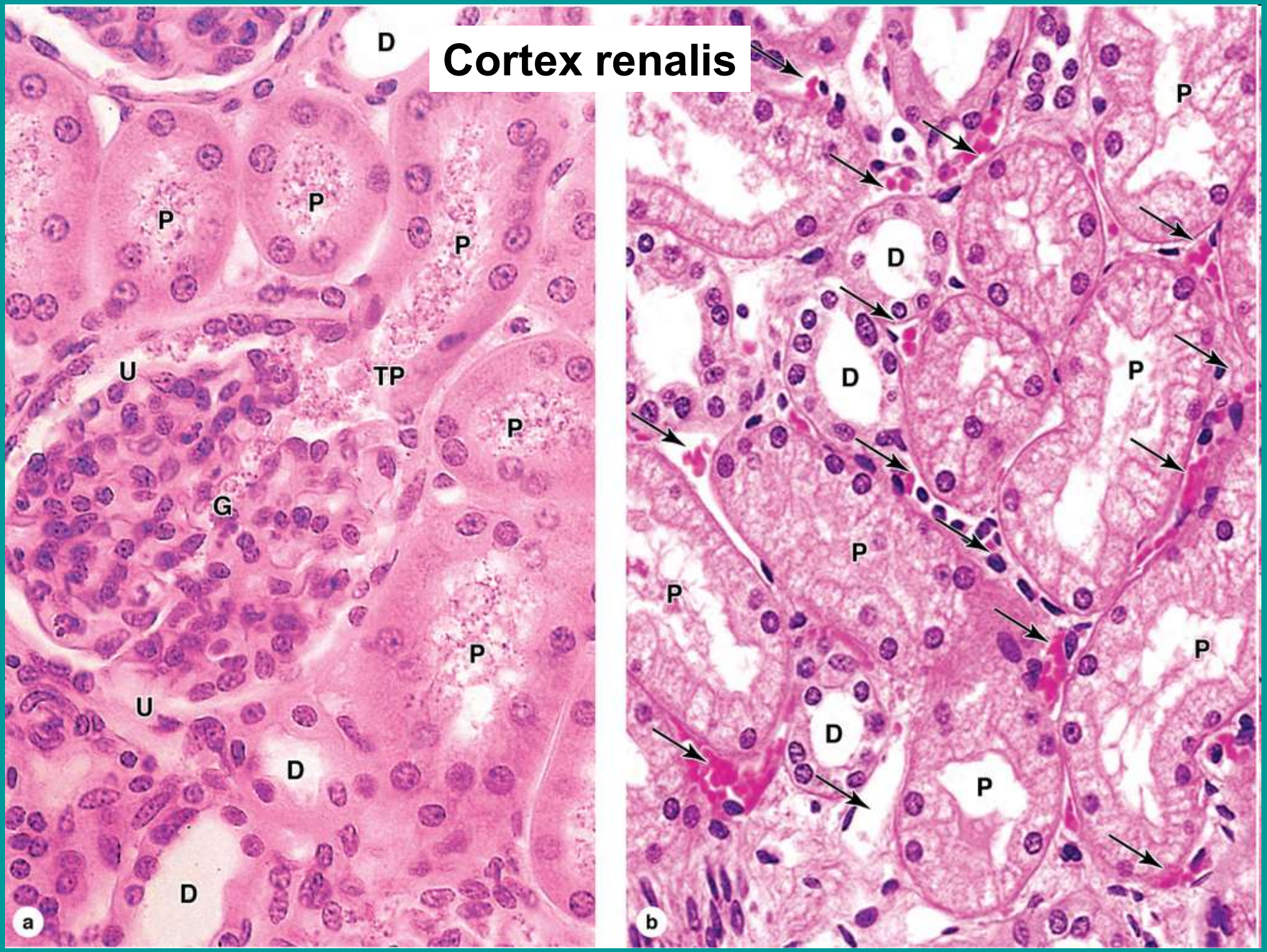
glomeruli, rete capillare peritubulare

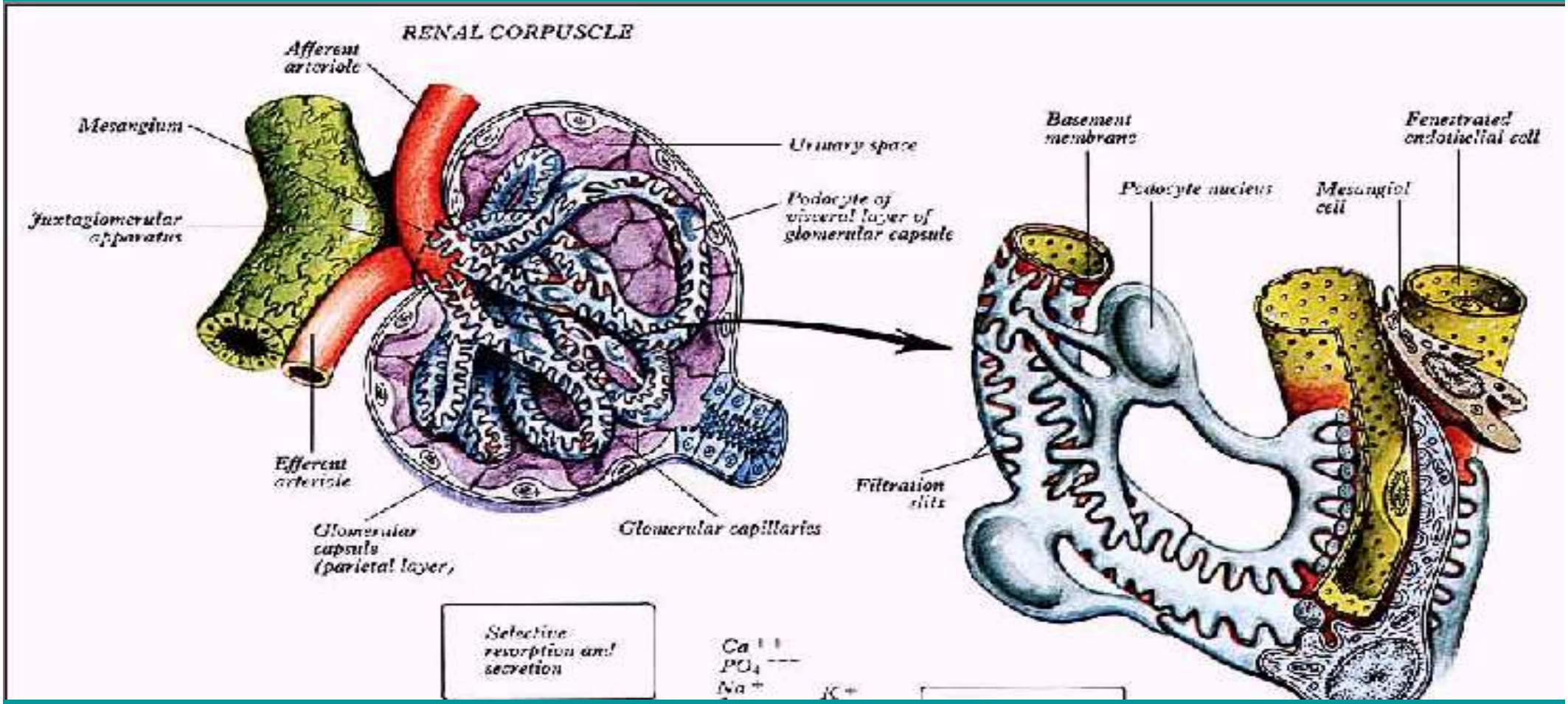




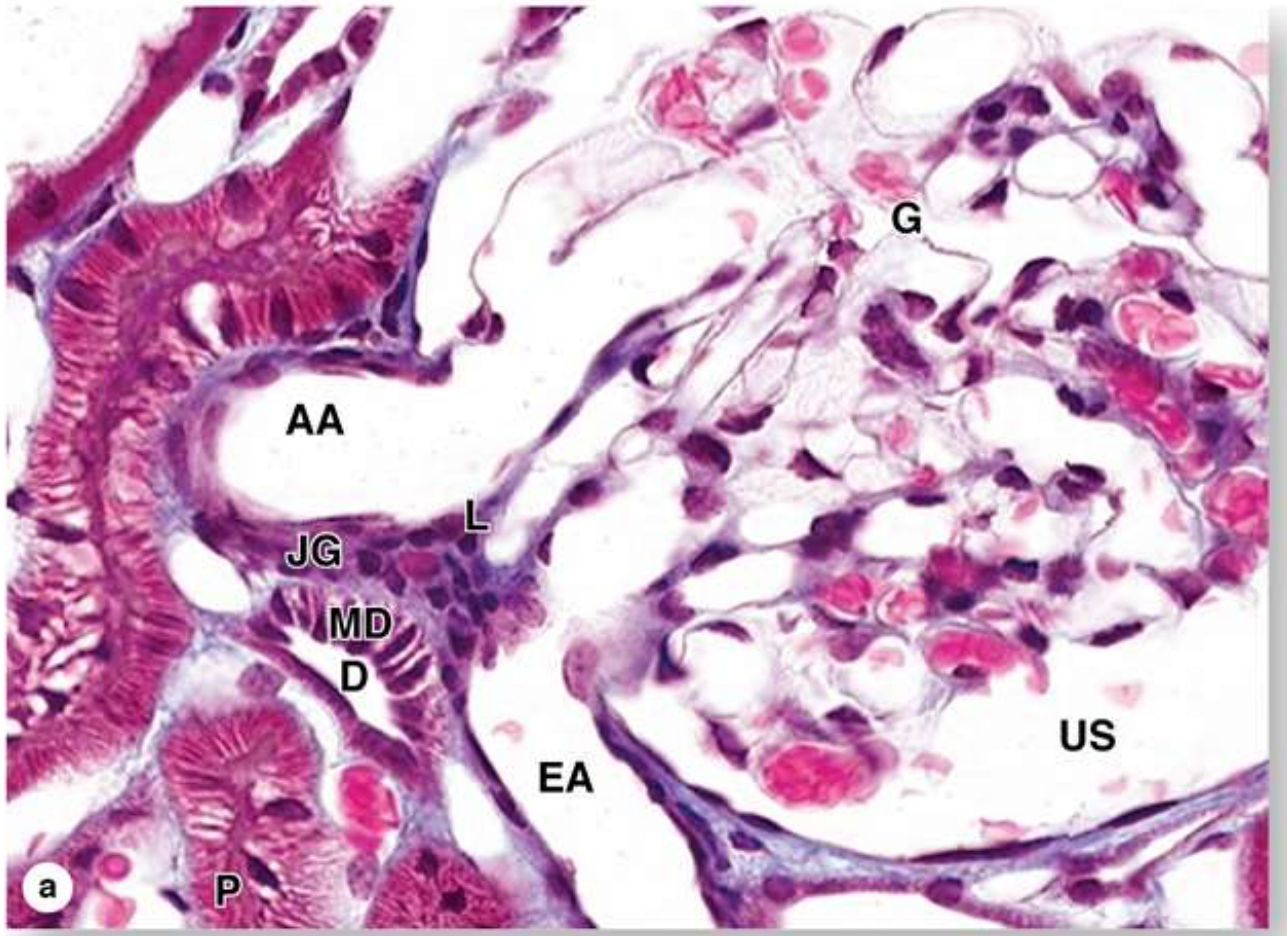
Glomerular capillaries –filter barrier: fenestrated endothelium, basal lamina, pedicles podocytů

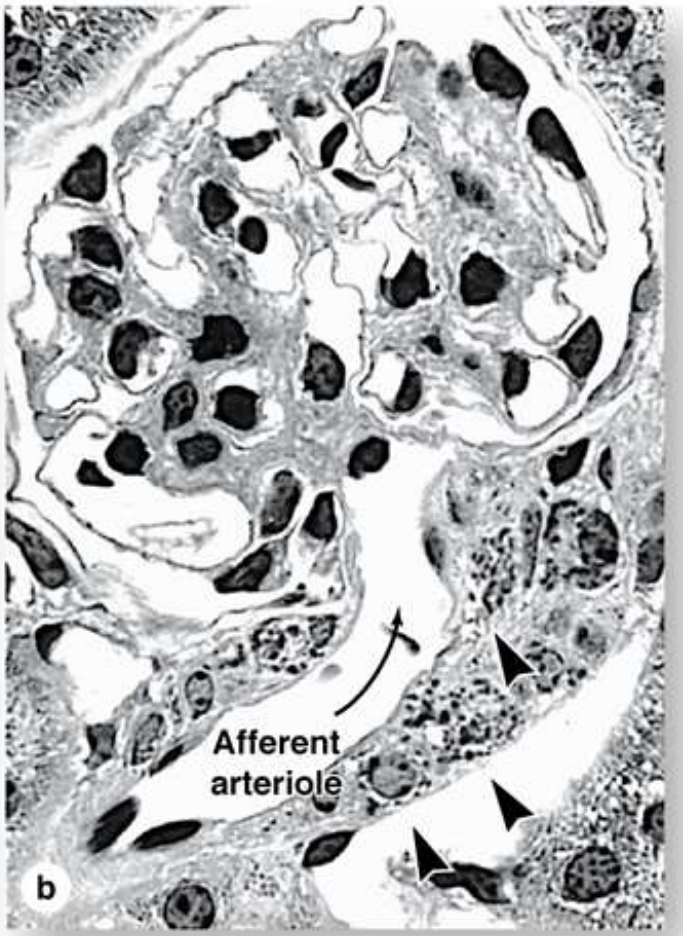
Cortex renalis



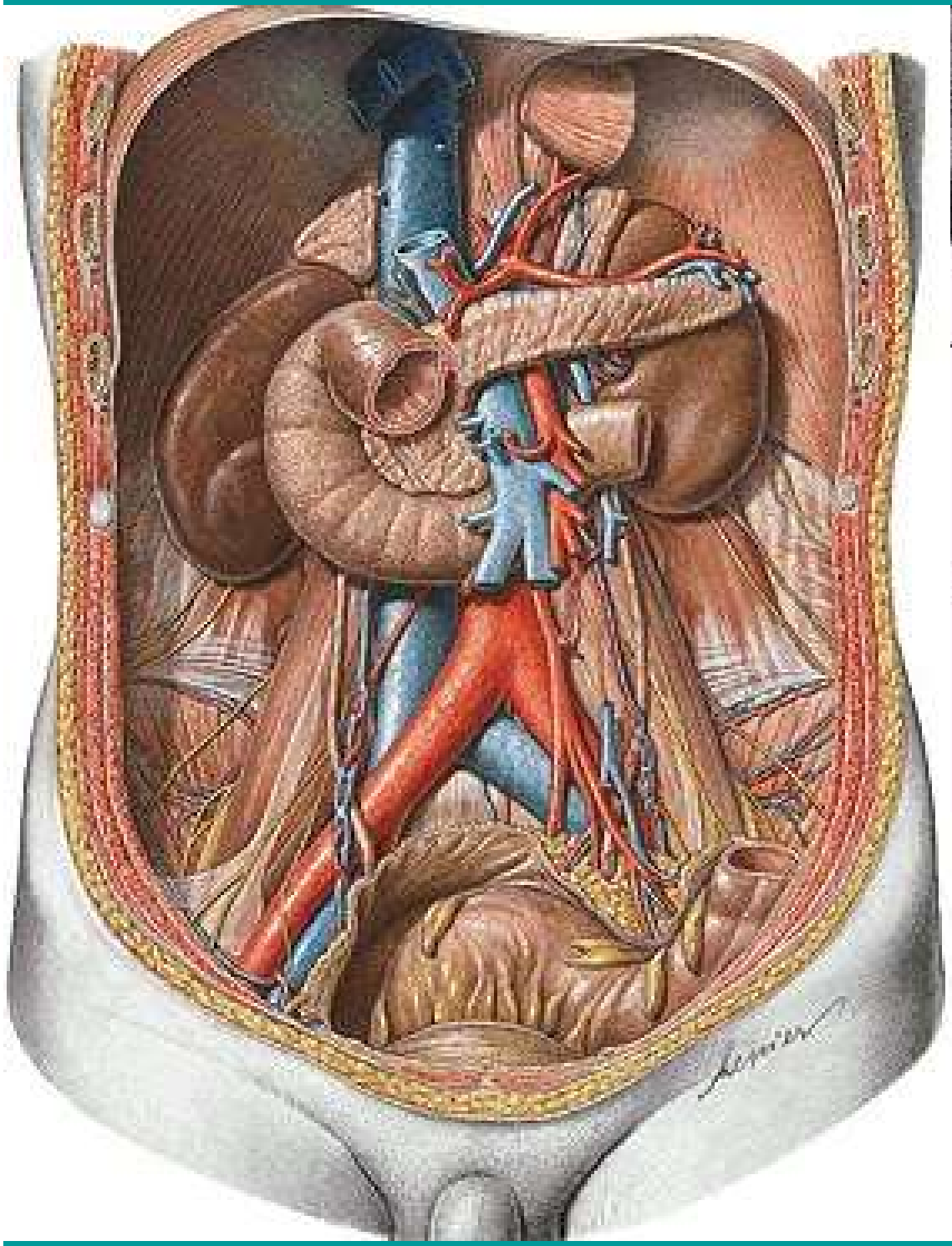


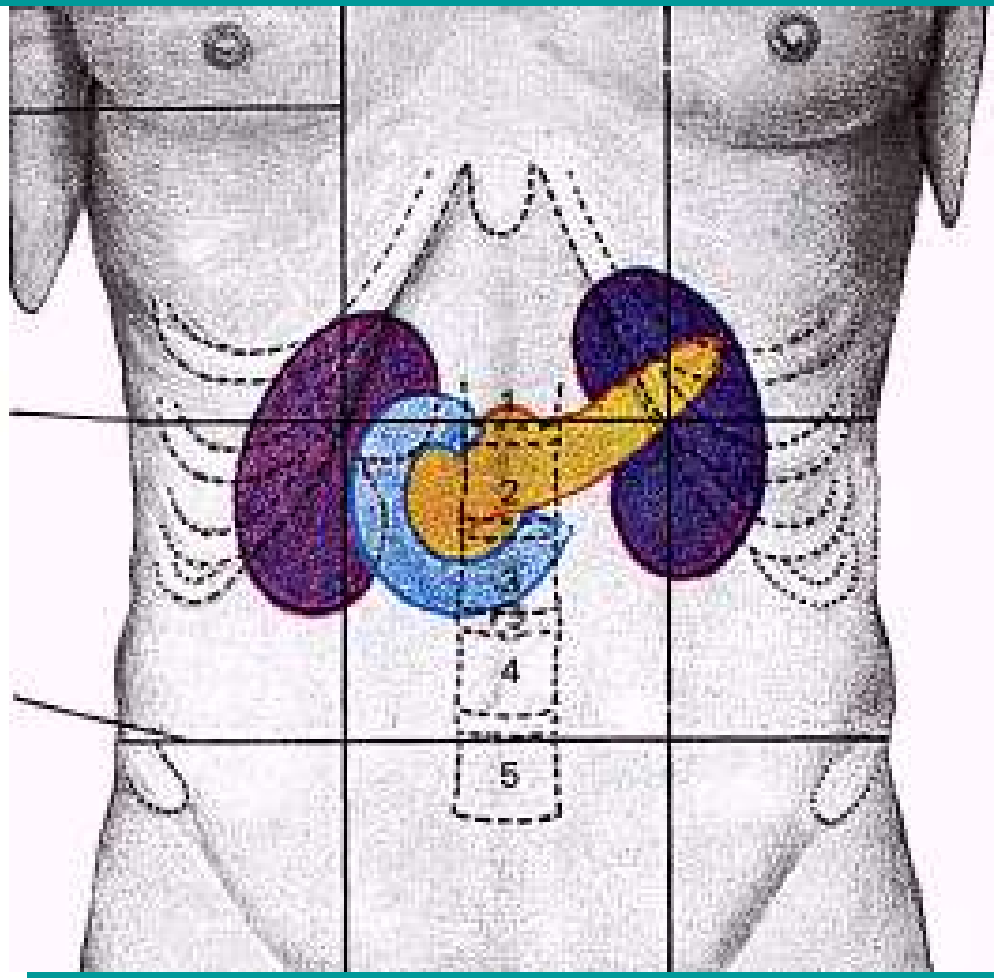
Juxtaglomerular apparatus (JGA):
macula densa, juxtaglomerular cells producing renin
JGA is a feedback system regulating glomerular filtration





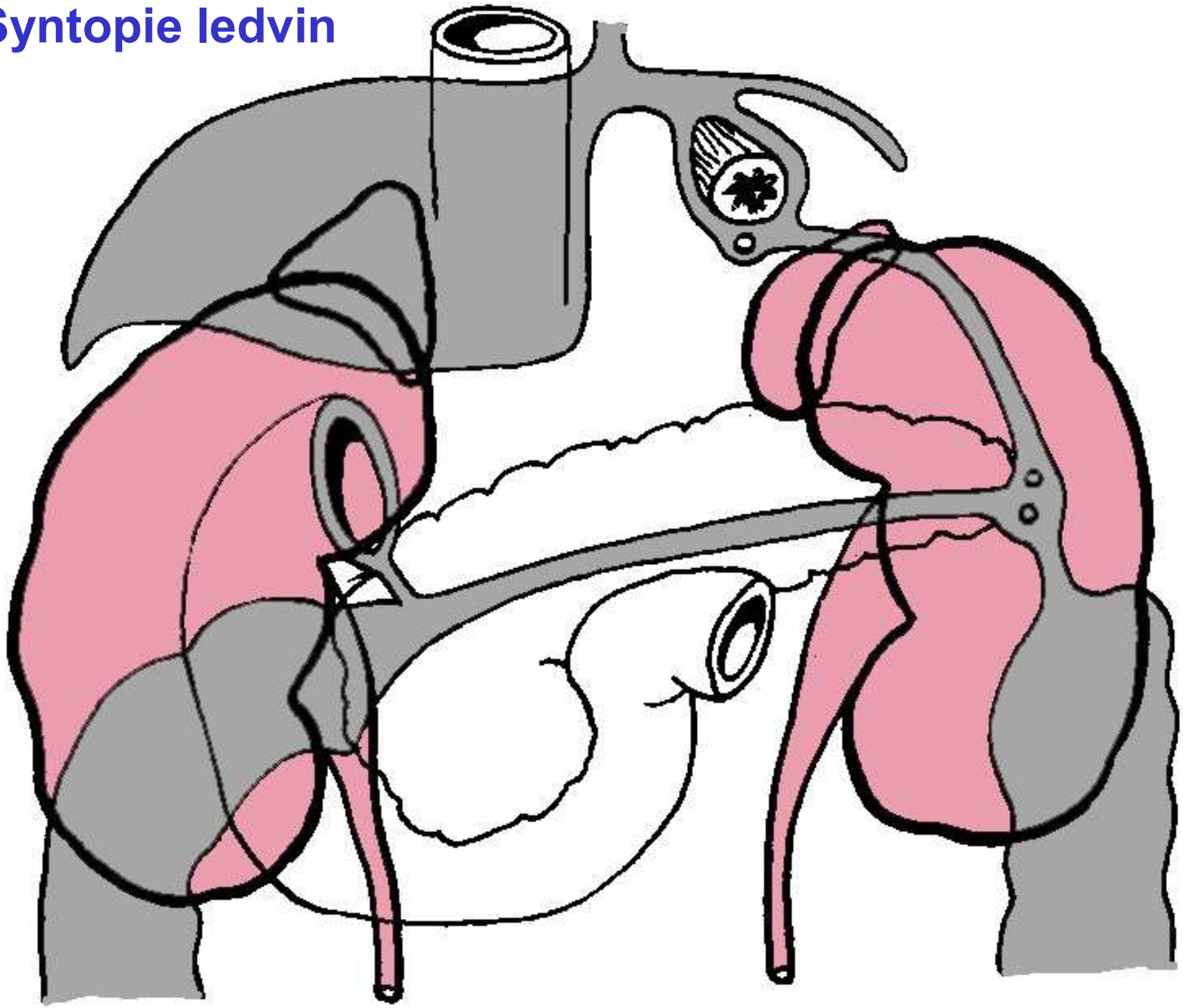
Juxtaglomerularní aparát (JGA), juxtaglomerular cells = modif. smooth muscle cells in media art. afferens, produce renin if lower blood pressure, macula densa – cells in the wall of distal tubule (react to changes of ion concentration), extraglomerular mesangial cells

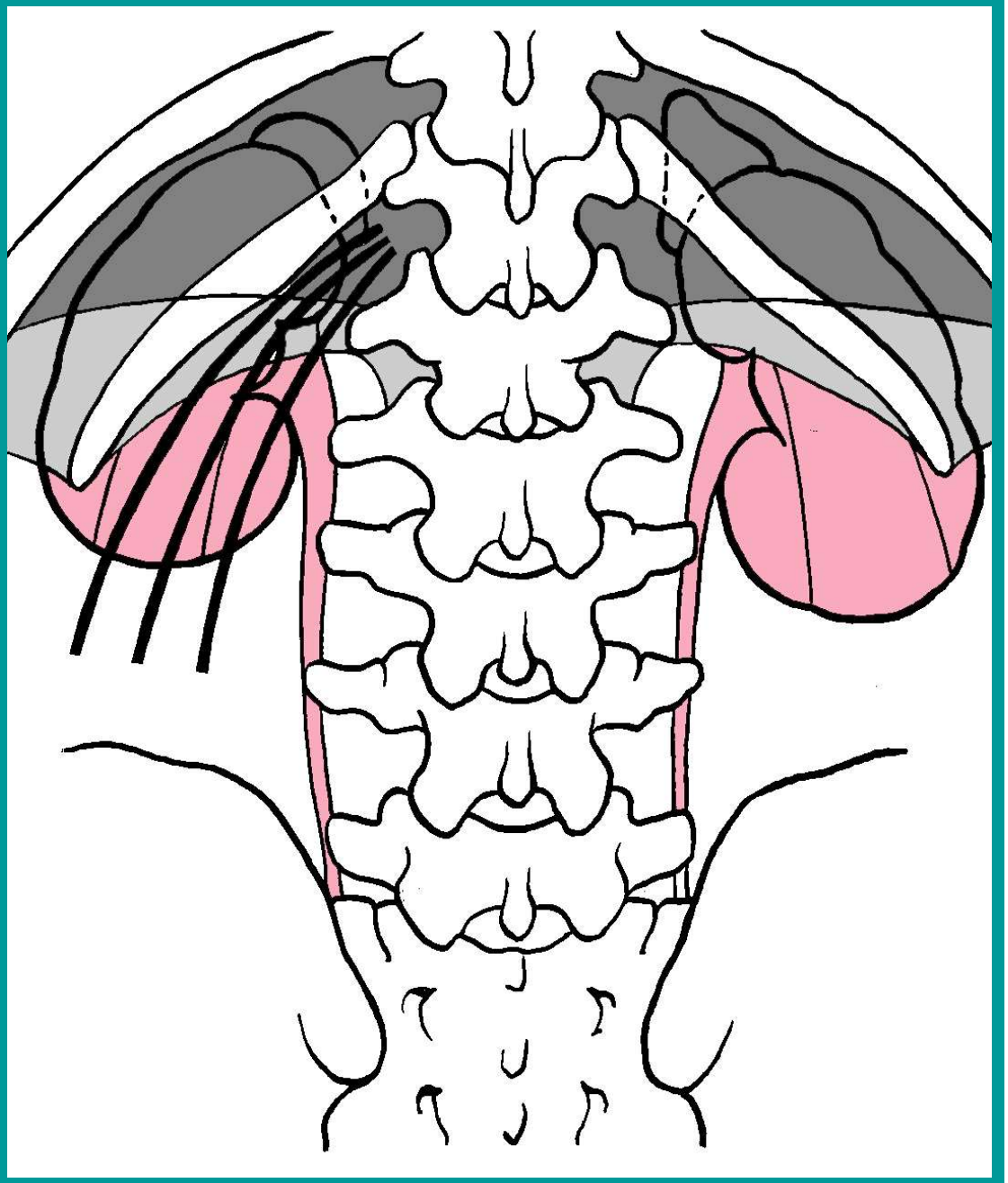




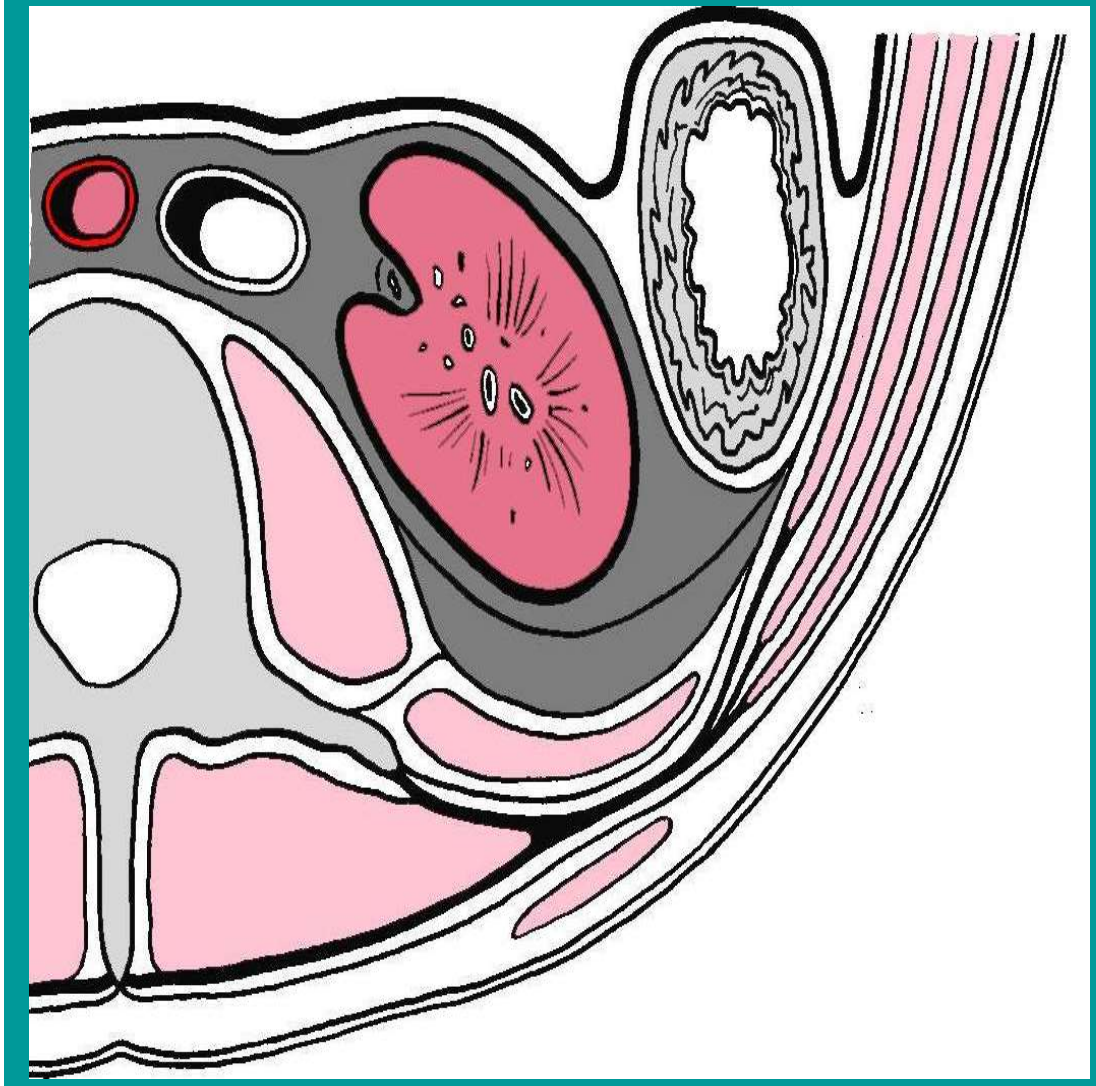
Position and syntopy of kidneys

Syntopie ledvin

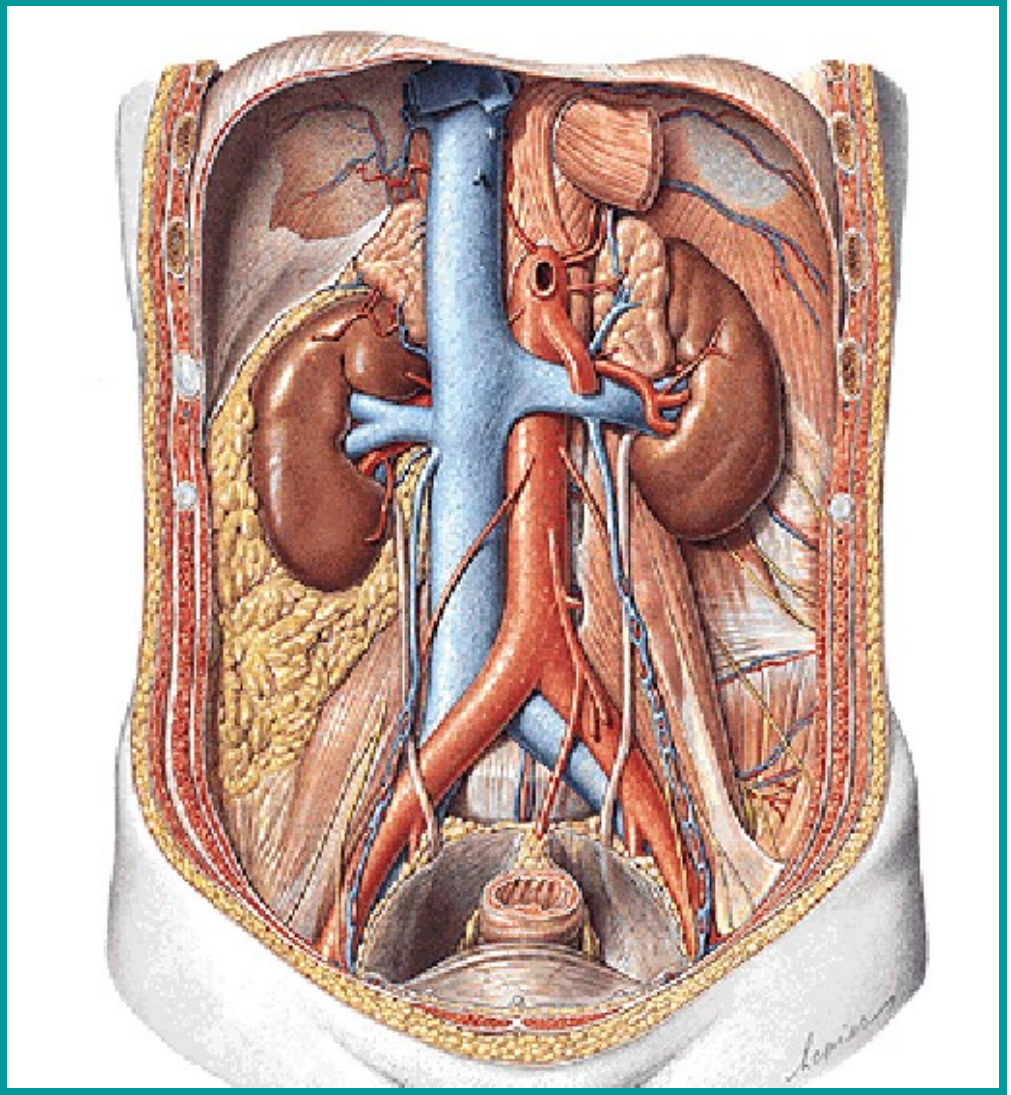




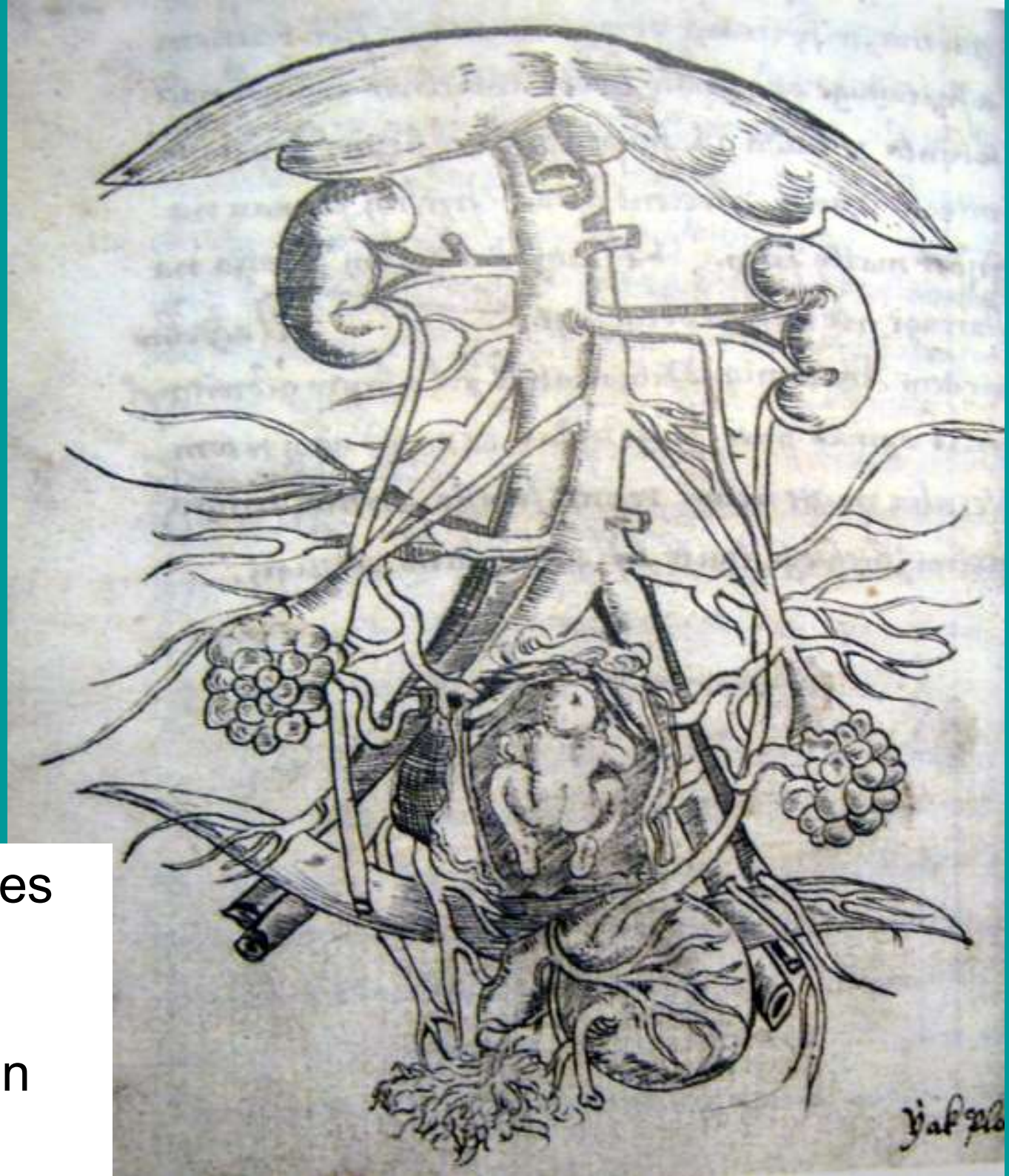
n.subcostalis, n. iliohypogastricus, n. ilioinguinalis,
diaphragma, m. iliopsoas, m. quadratus lumborum,
m. transversus abdominis, recessus costodiaphragmaticus



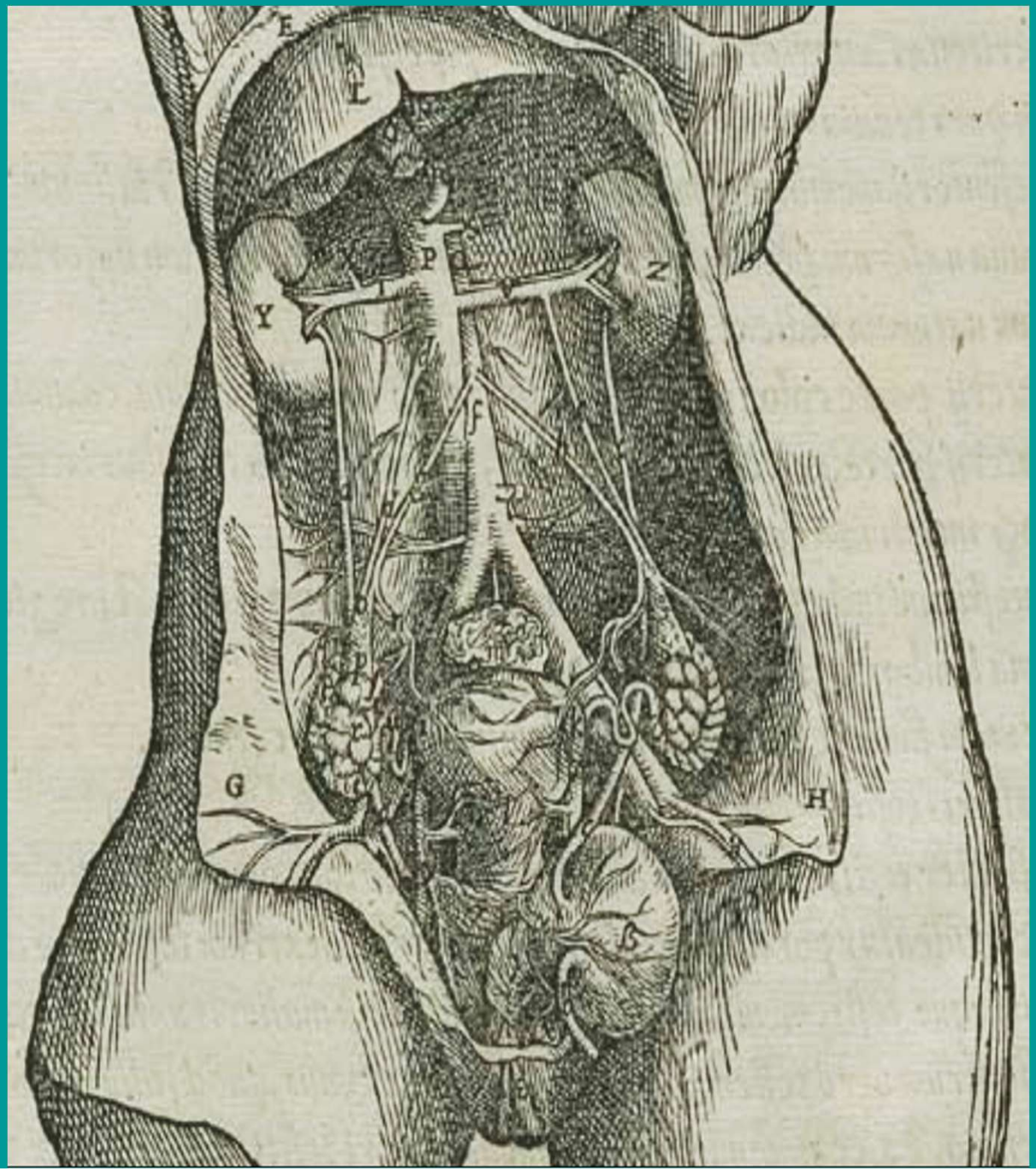
Capsula adiposa renis,
fascia renalis,
corpus adiposum pararenale



Asymmetrical entry of right and left gonadal veins (v. testicularis, v. ovarica)



Matouš Filomates Dačický:
Inside of a pregnant woman
1574

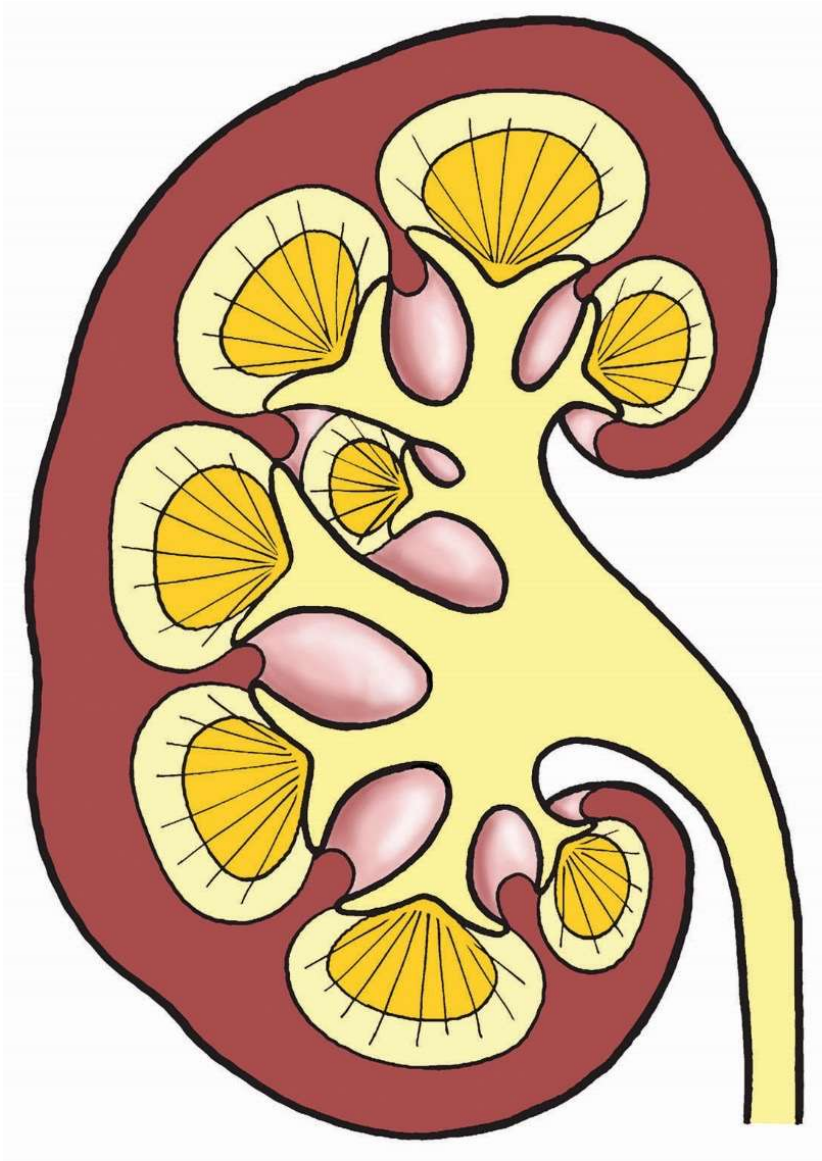


Vesalius A: De humanií corporis fabrica . Ioannis Oporini, Basel 1543, page 478. Female urinary and genital organs with blood vessels.

Function of kidneys in fetal period

Metanephros functions from second half of prenatal period. Urine is excreted into amnionic fluid. The foetus swallows this and absorbs in the digestive tract. Excreted molecules thus enter bloodstream and via placenta into the maternal circulation and ultimately her kidneys. Thus placenta takes over the function of fetal kidneys.

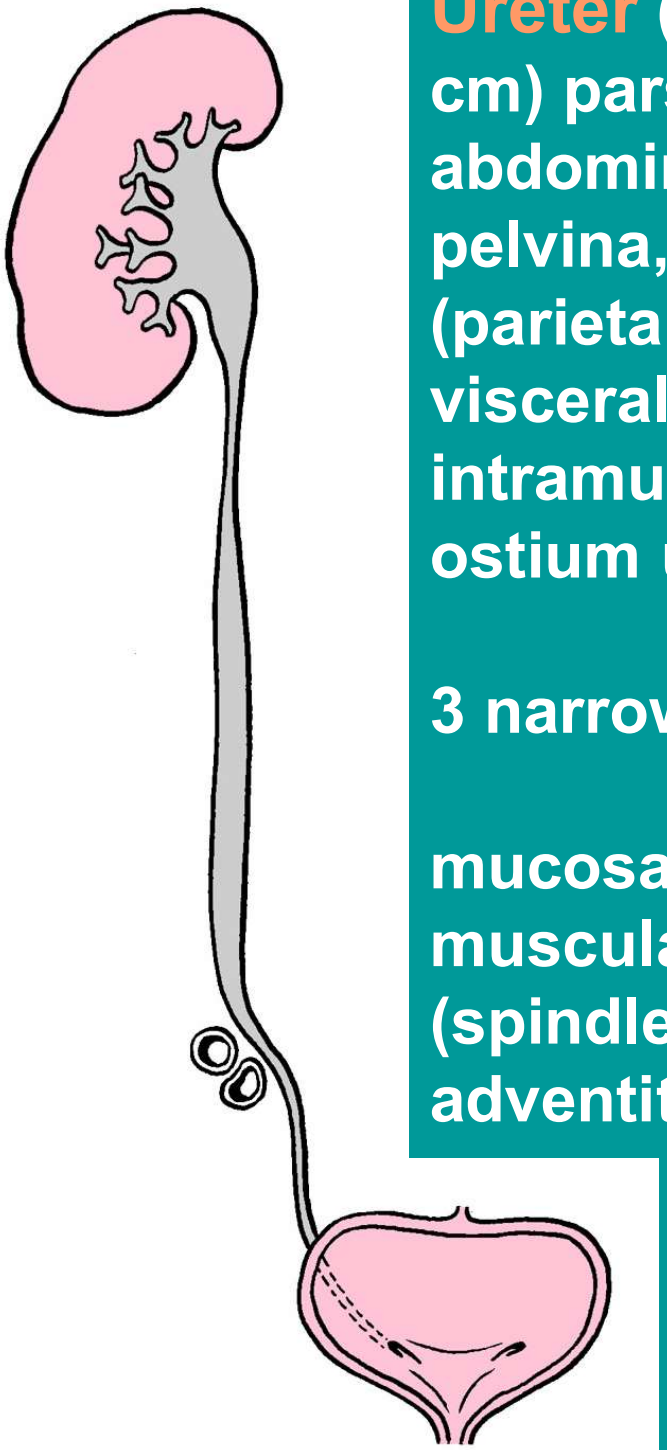
Agenesis of kidneys – oligohydramnion, poor lung development. Renal metabolic failure will happen only after birth.



Section of kidney

1 – cortex renalis včetně columnae renales (hnědě)
2 – pyramidy dřeně (žlutě s vyznačením zevní a vnitřní vrstvy)
4 – papilla renalis
6 – pelvis renalis
8 – columna renalis

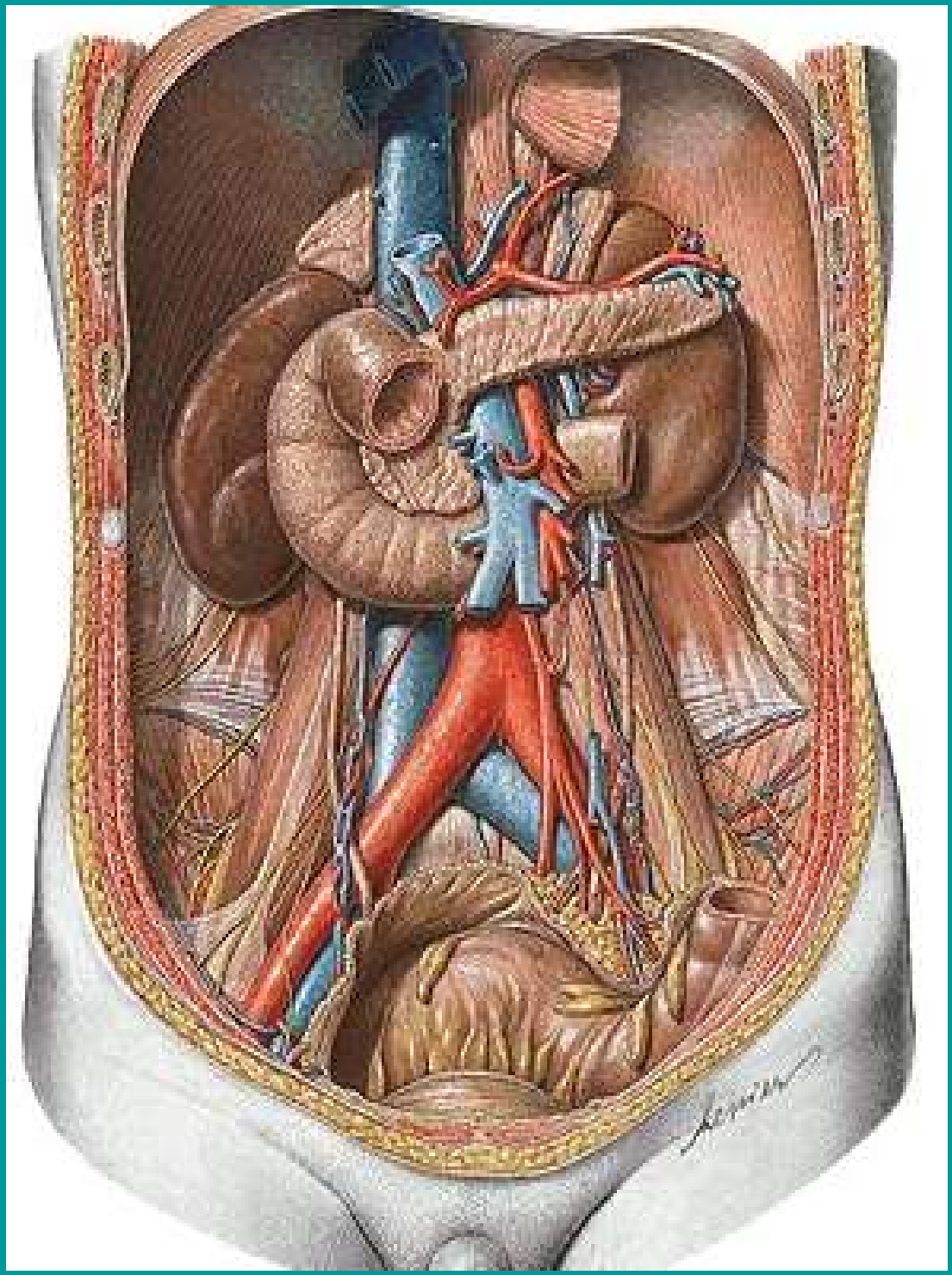
Pelvis renalis
typus ampullaris,
typus dendriticus
Calices renales
majores (2-3),
minores (7-14)
tunica mucosa,
muscularis,
adventitia

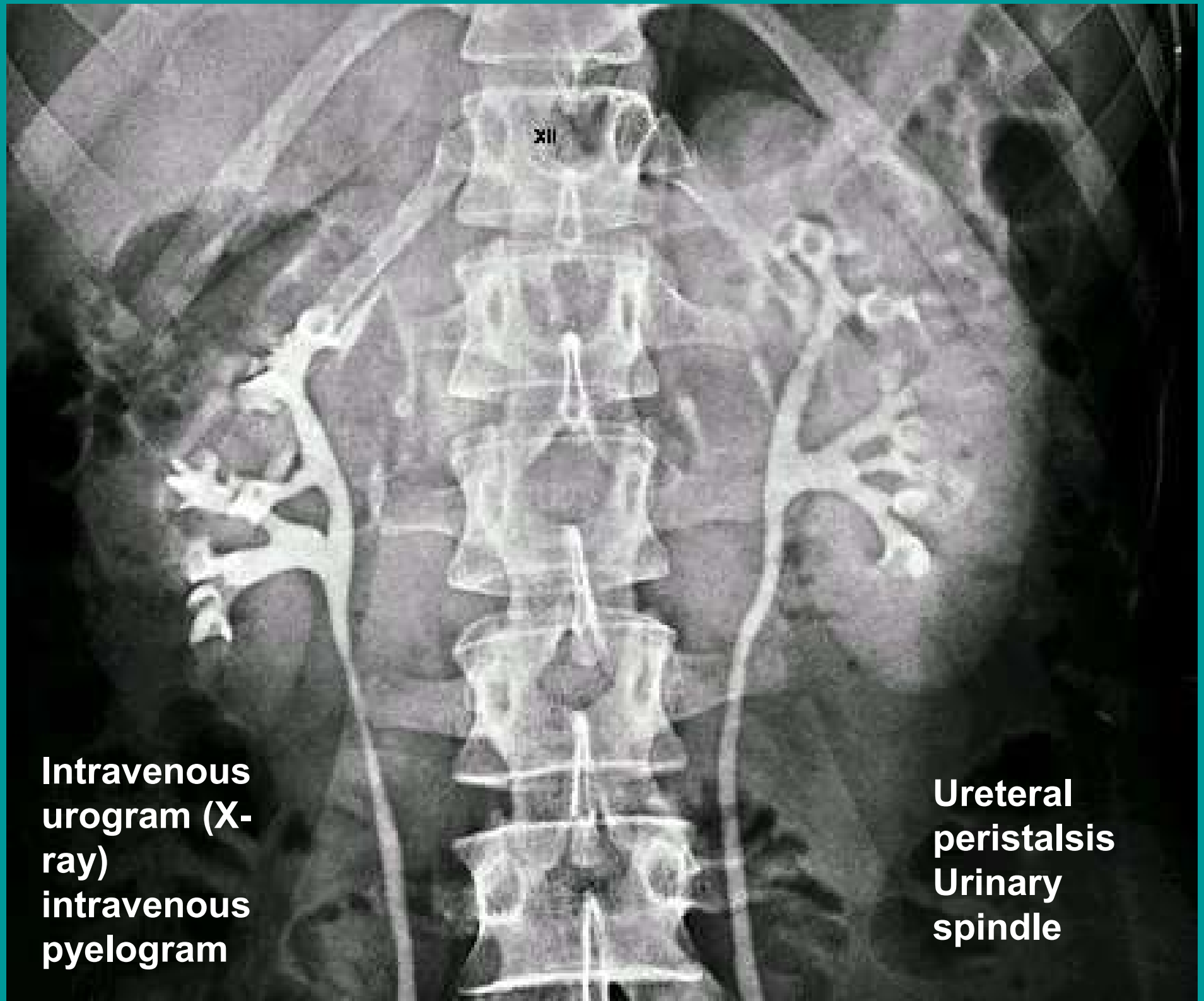


Ureter (25-30 cm) pars: abdominalis, pelvina, (parietalis, visceralis) intramuralis, ostium ureteris

3 narrowings

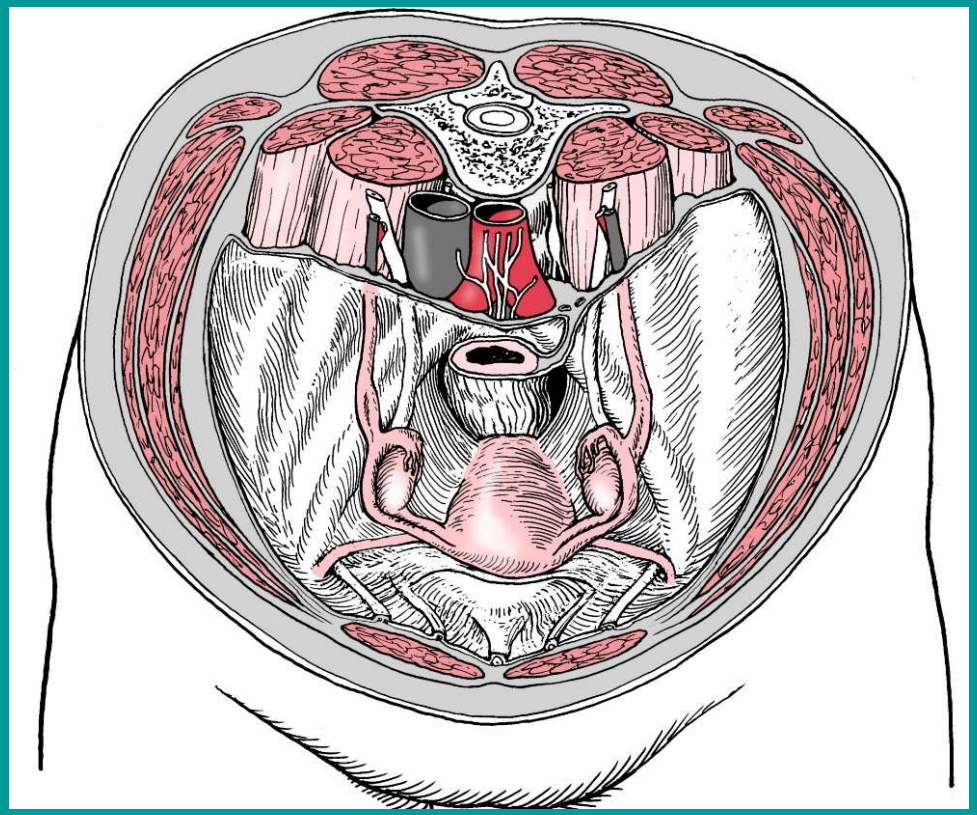
mucosa
muscularis
(spindles)
adventitia

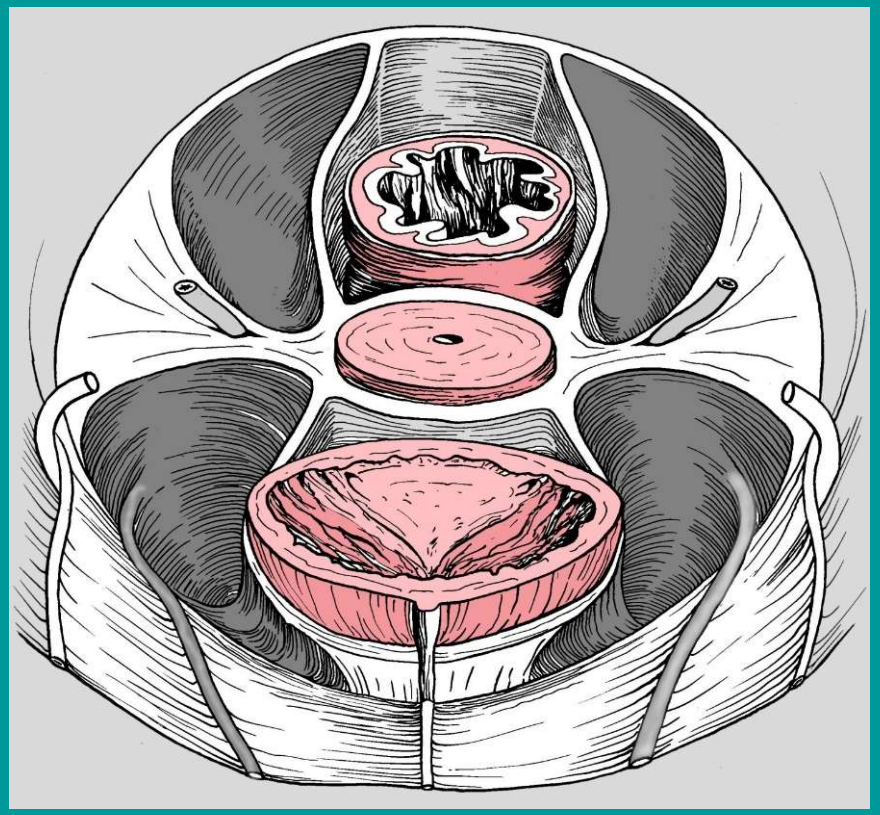




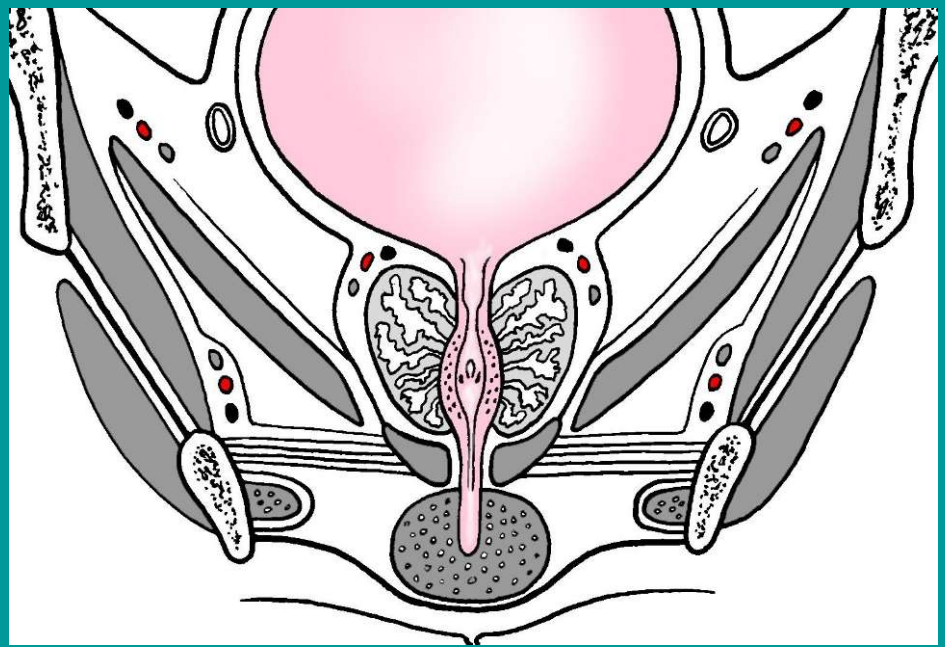
Intravenous urogram (X-ray) intravenous pyelogram

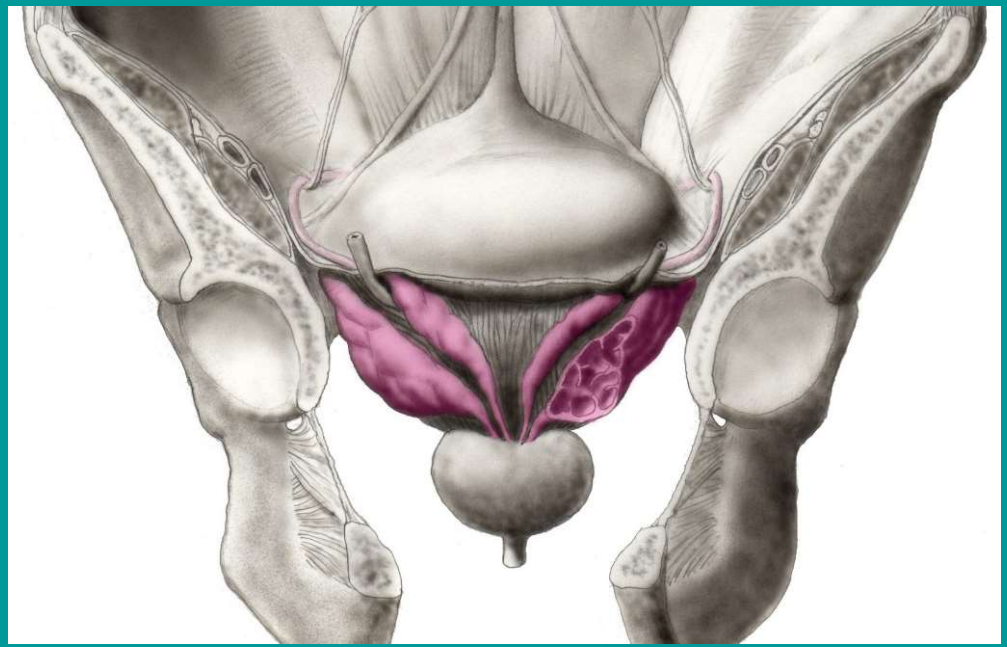
Ureteral peristalsis Urinary spindle

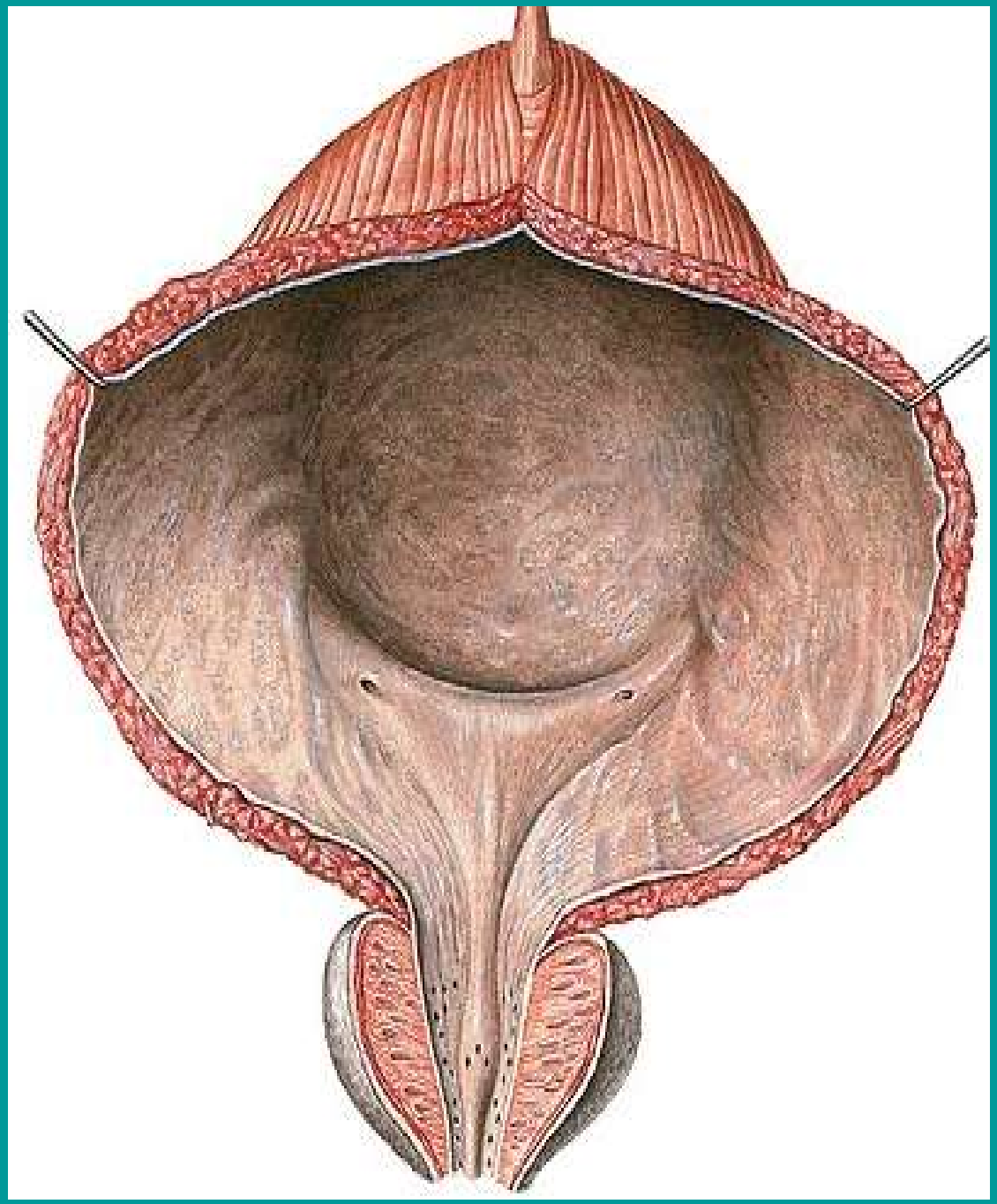




Syntopie pars pelvina ureteris u ženy a u muže







Vesica urinaria

apex, corpus, fundus,
cervix, uvula,
trigonum vesicae
ostium ureteris
ostium urethrae
internum,
plica interureterica
tunica serosa,
subserosa,
muscularis,
submucosa,
mucosa,
m. detrusor,
m. trigonalis

Bladder capacity:
30 – 80 ml (newborns), 300 ml (children), 600 – 1200 ml (adults)

Clinical notes

Palpation of bladder per rectum in male – interampular trigone, in female per vaginam area trigonalis vaginae.

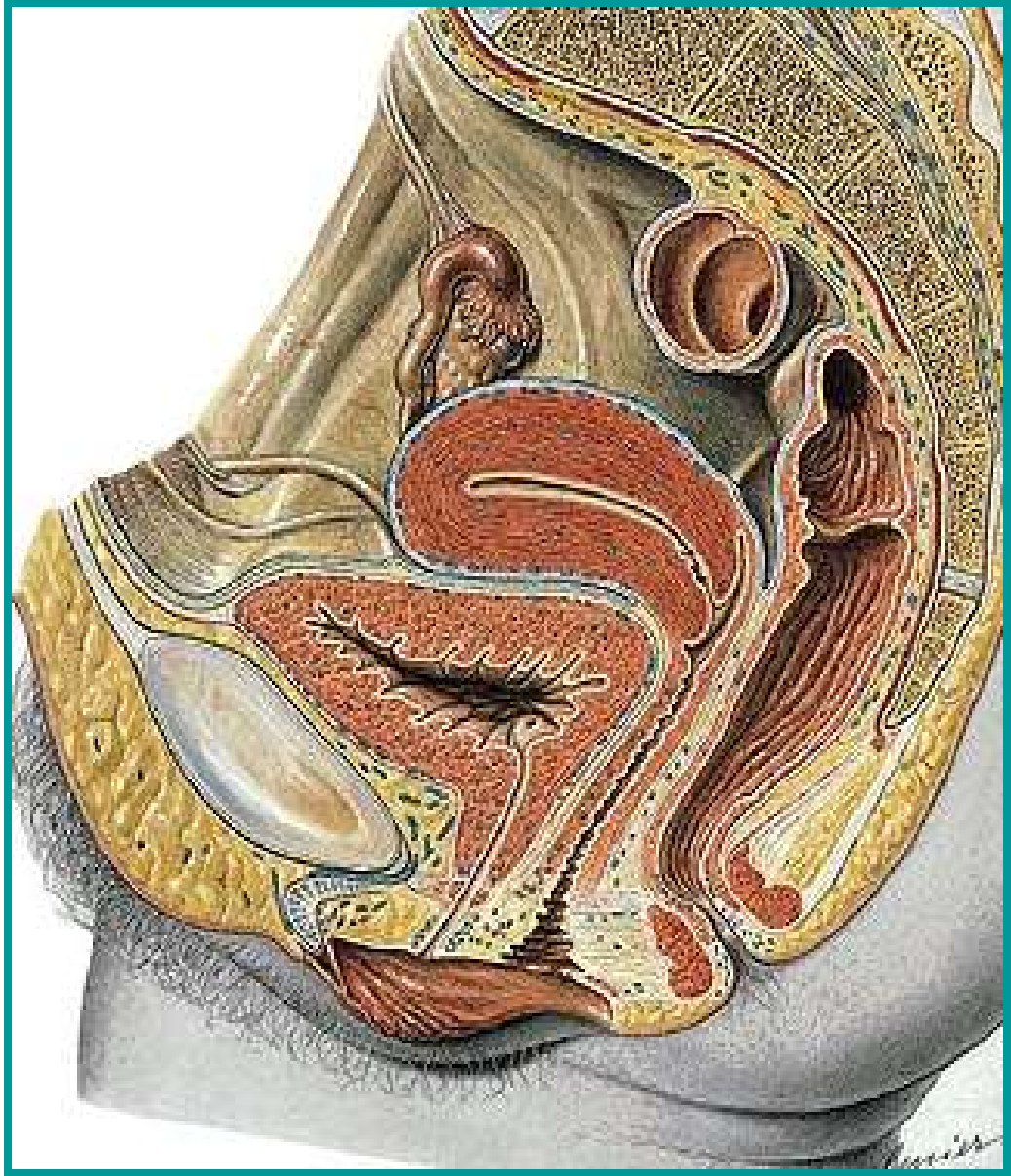
Cystoscopy

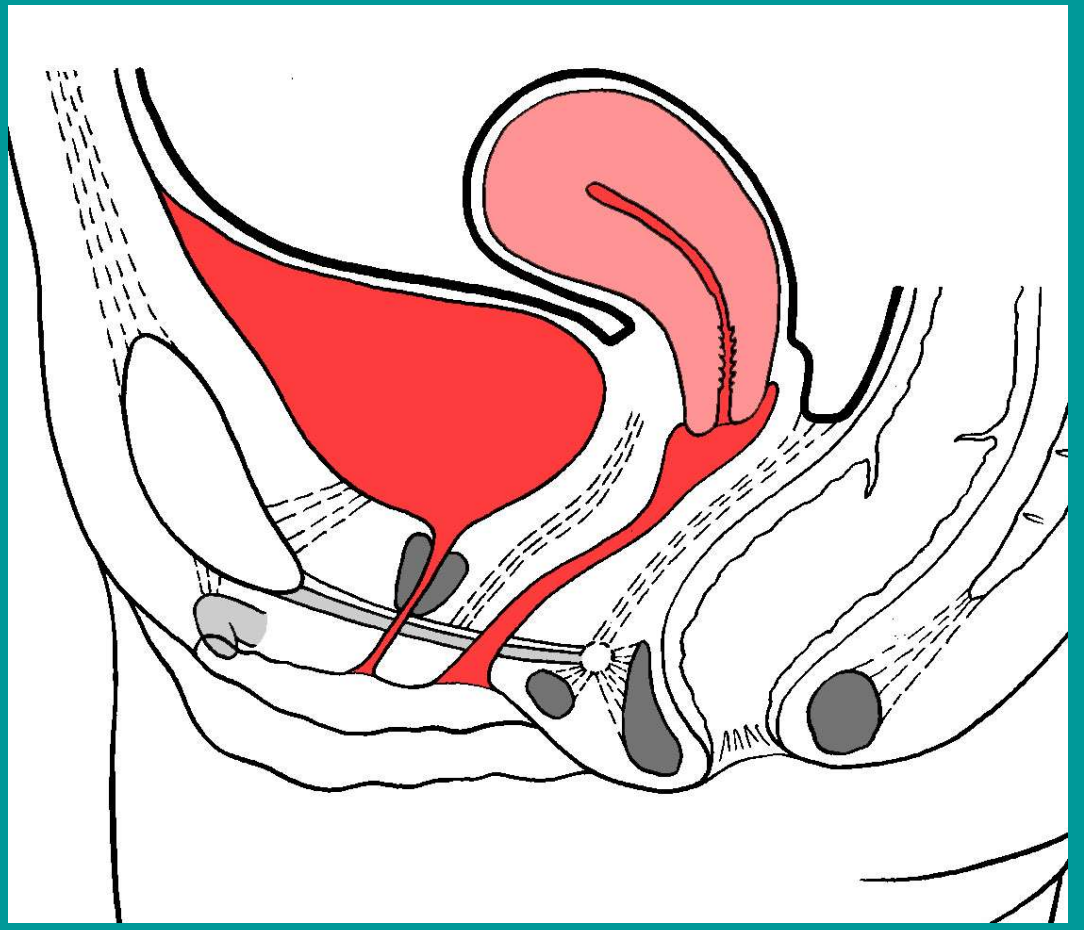
Ultrasound

X-ray – contrast

Urinary retention – catheter, or **suprapubic catherter** above pubic symphysis

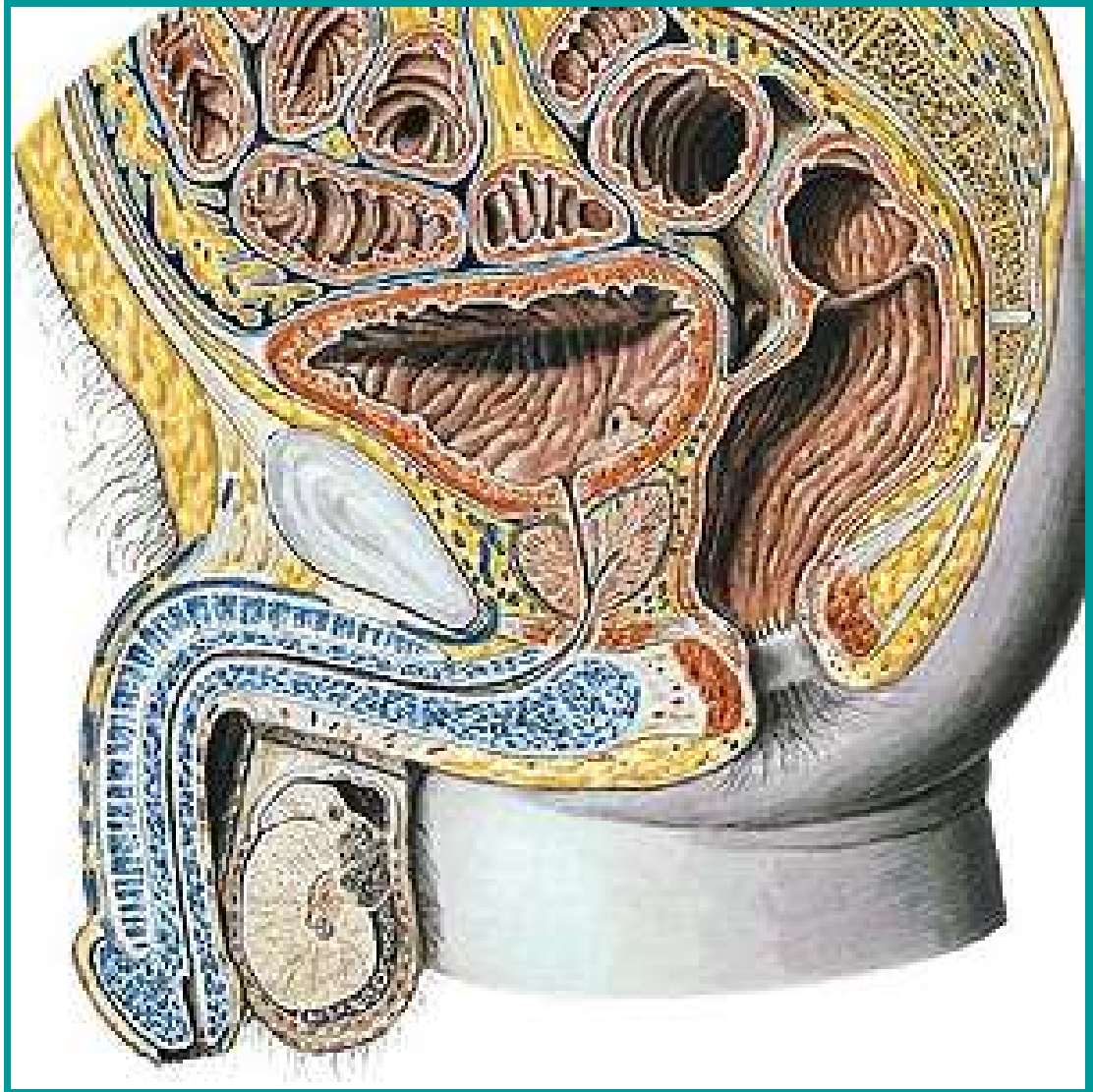
Syntopia vesicae urinariae

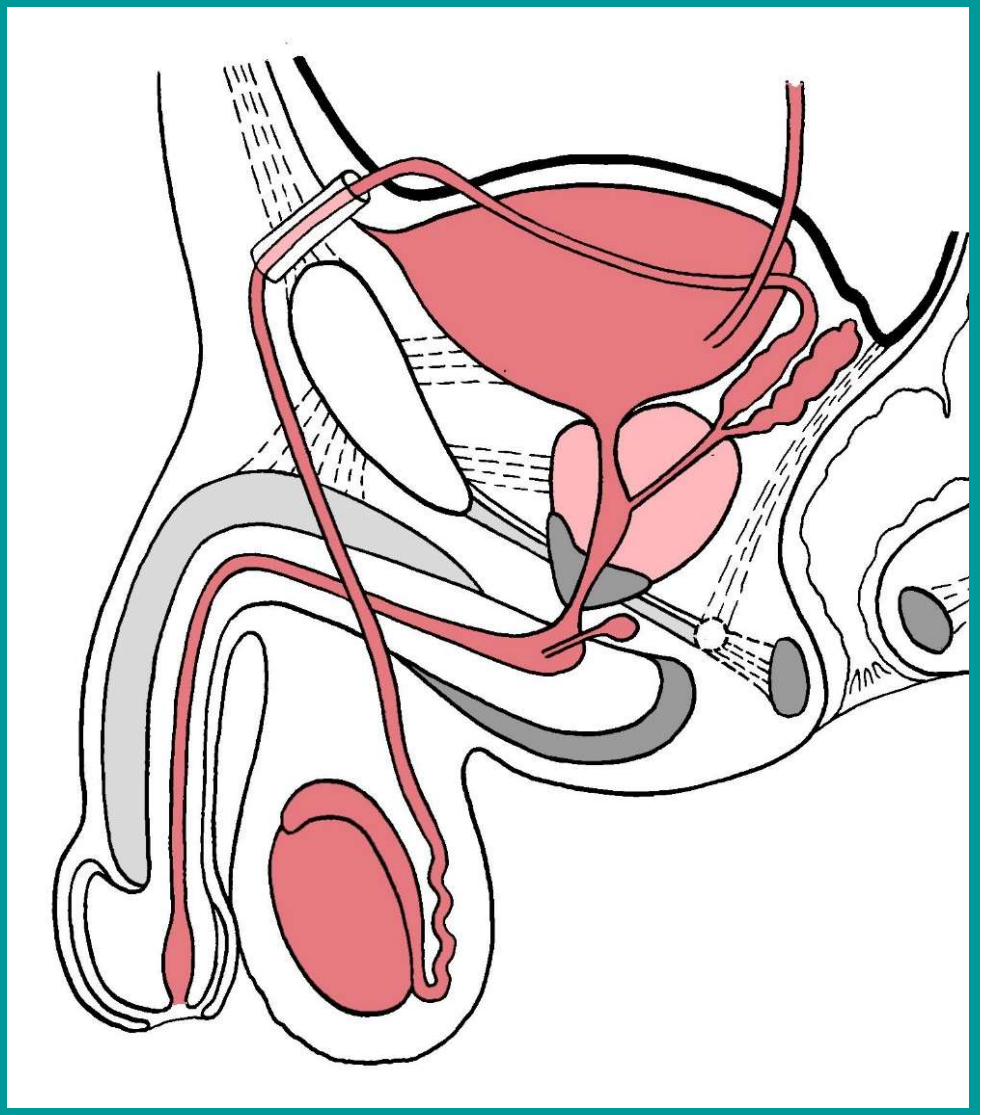




Fossa supravesicales, excavatio vesicouterina, excavatio rectovesicalis, paracystium, fascia vesicoumbilicalis, septum vesicovaginale, spatium prevesicale, spatium paravesicale

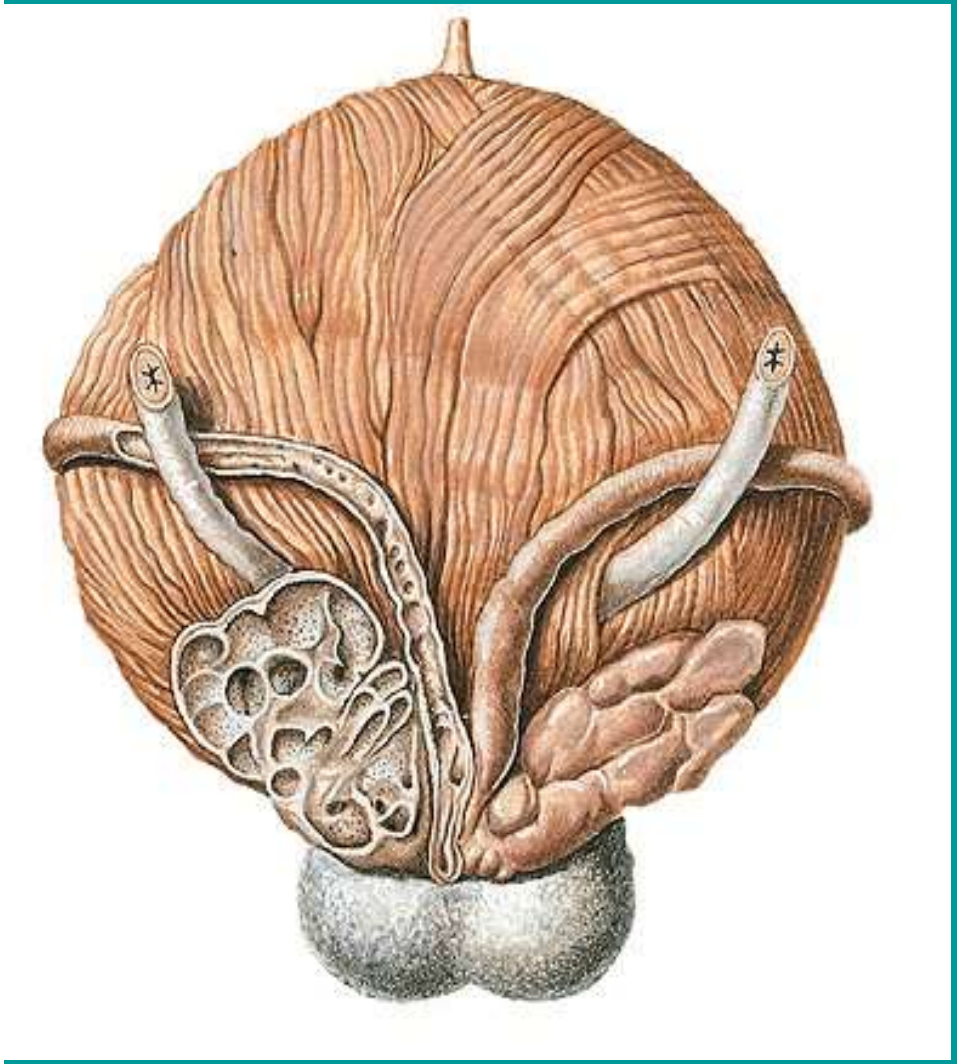
Syntopia vesicae urinariae



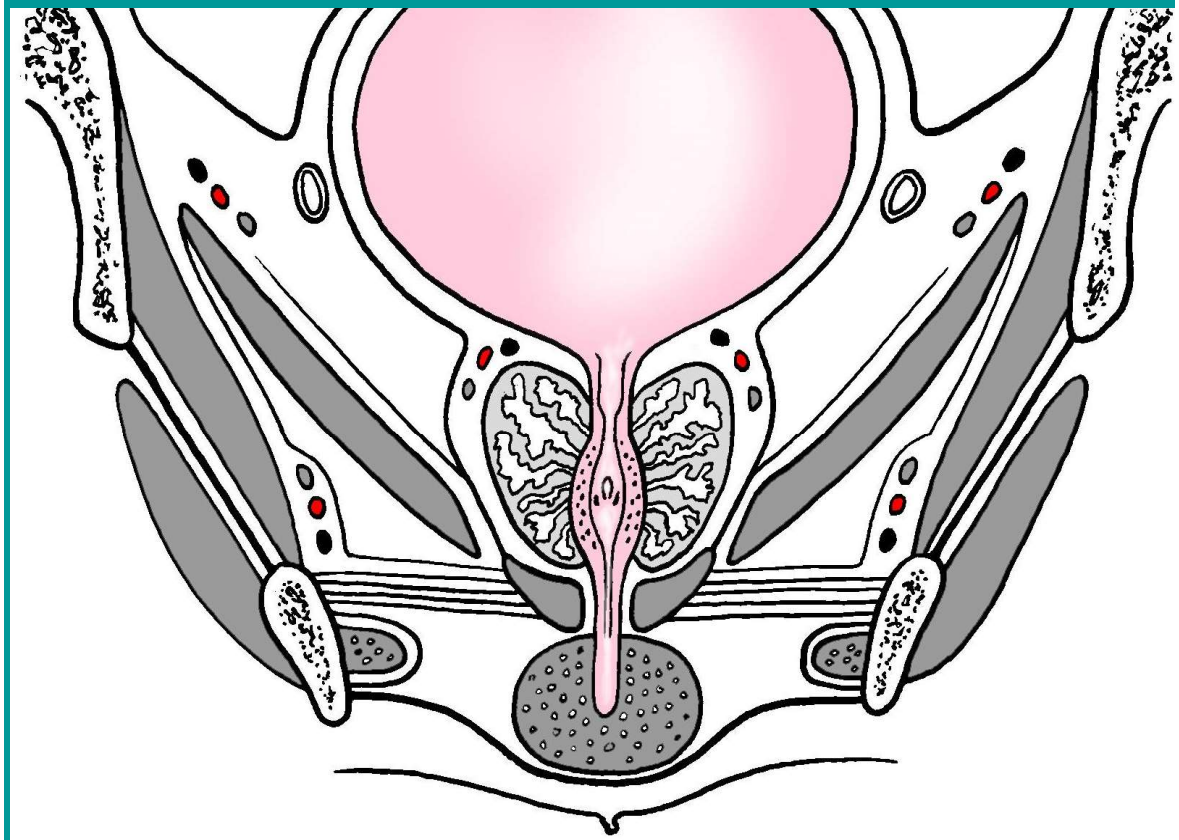


Excavatio rectovesicalis, septum rectovesicale, trigonum interampullare, lig. pubovesicale, rectovesicale

Trigonum interampullare



Syntopy of urinary bladder in frontal section of pelvis at the level of prostate



Urethra feminina

(4 cm)

Ostium urethrae internum (accipiens, evacuans),

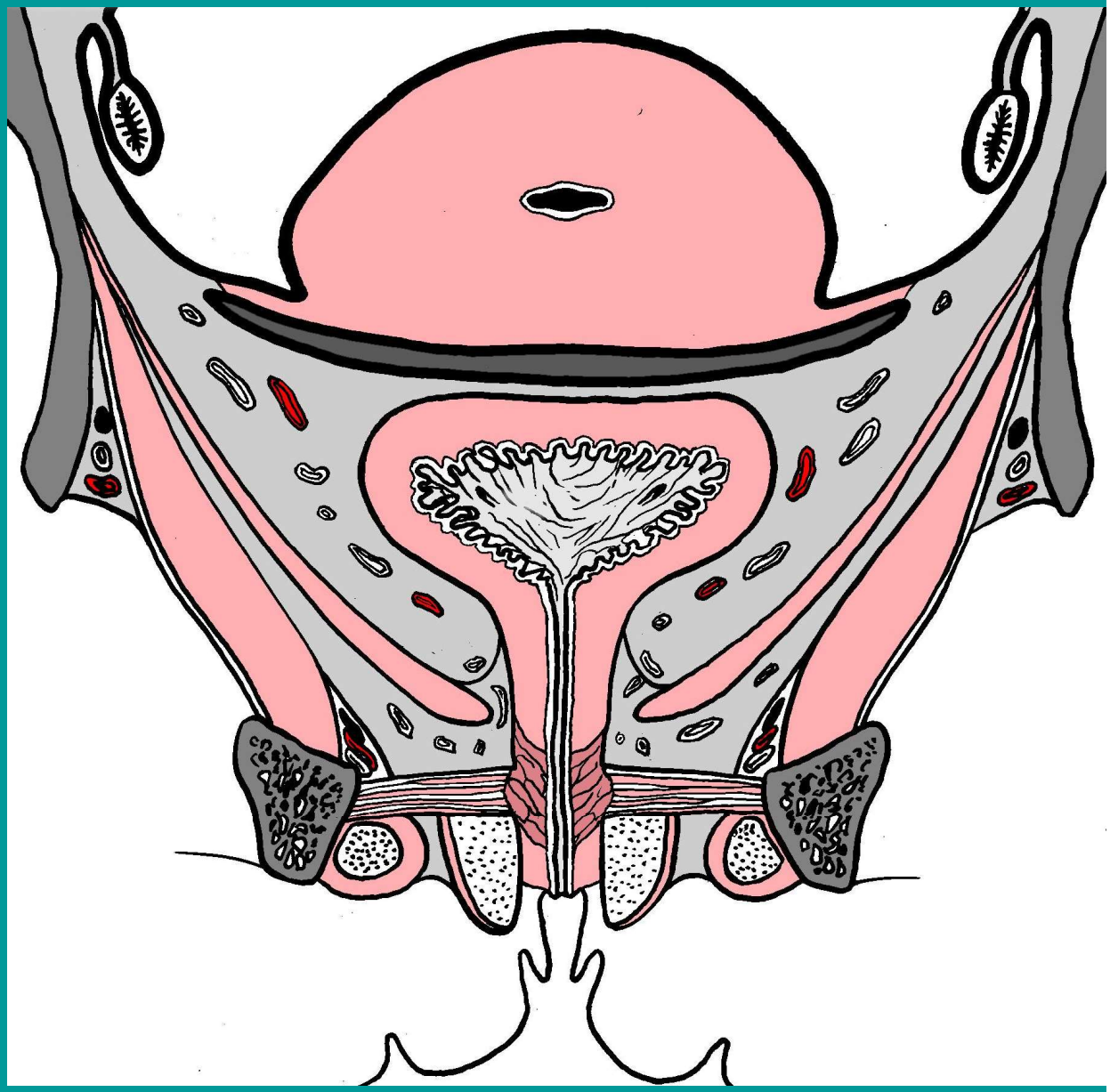
Pars intramuralis, pelvina, perinealis

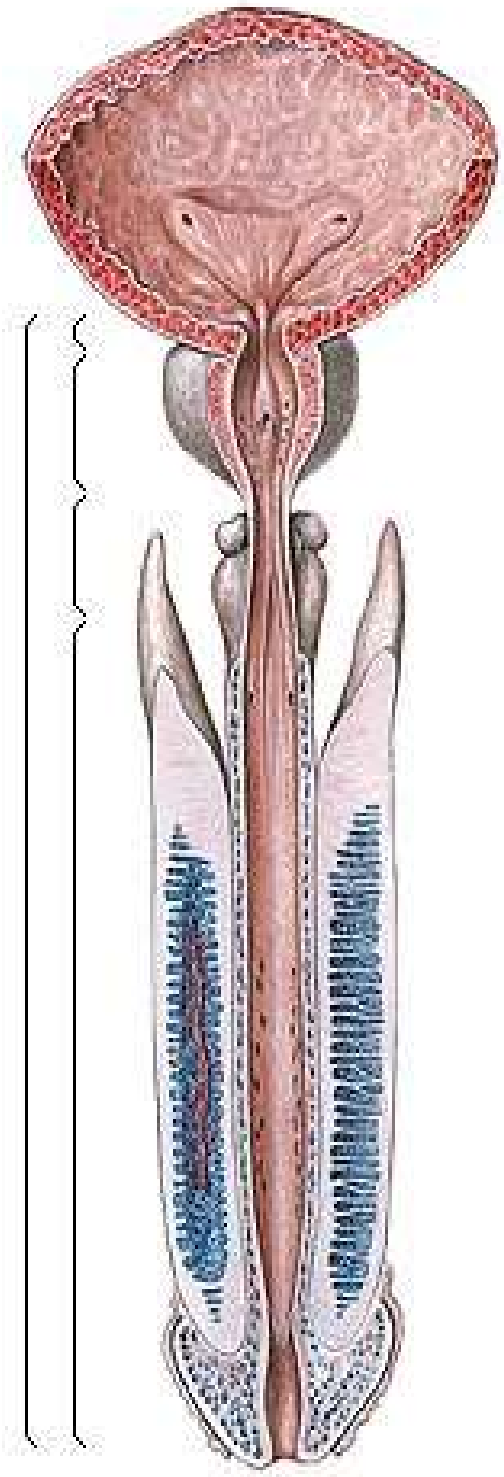
Ostium urethrae externum

M. sphincter urtehrae externus,

glandulae urethrales

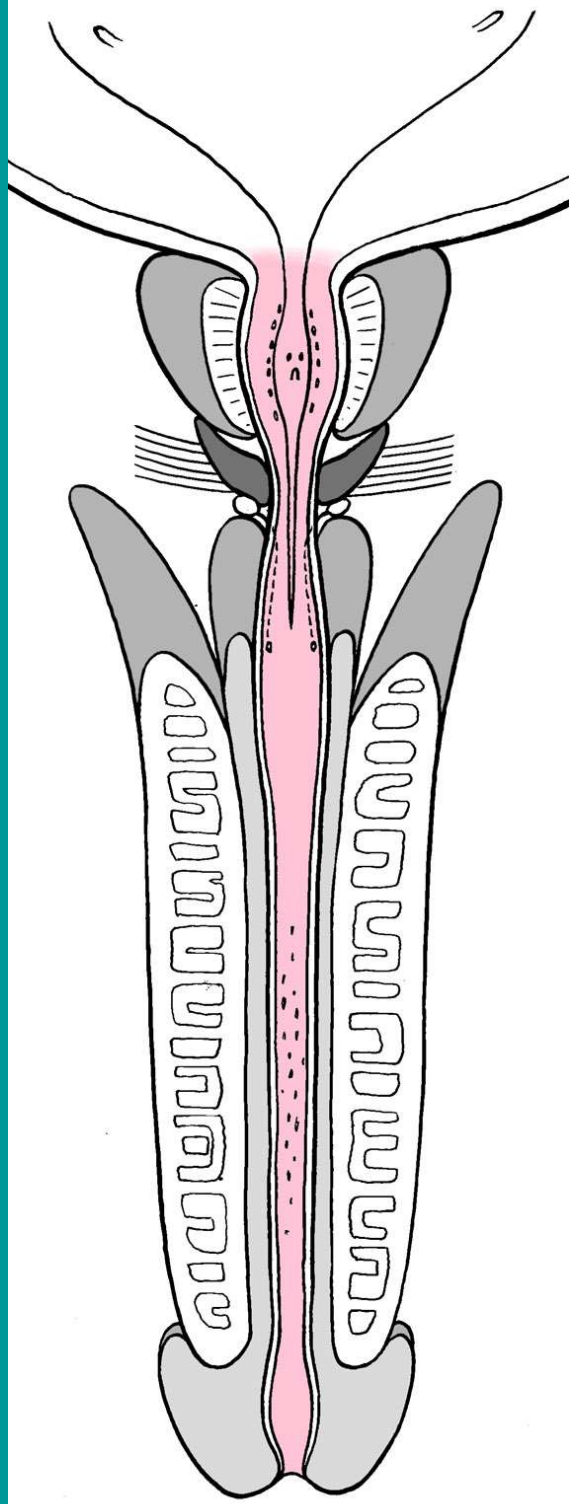
ductus paraurethrales





Urethra masculina

orificium urethrae internum,
ostium accipiens, evacuans
sphincter urethrae internus,
uvula vesicae
pars intramuralis, prostatica,
spongiosa, glandis
curvatura subpubica,
praepubica
colliculus seminalis,
sinus prostaticus,
sphincter urtehrae externus,
glandulae urethrales,
lacunae urethrales,
orificium urethrae externum
fossa navicularis



Urethra masculina

sphincter urethrae internus,
uvula vesicae
pars intramuralis, prostatica,
spongiosa, glandis

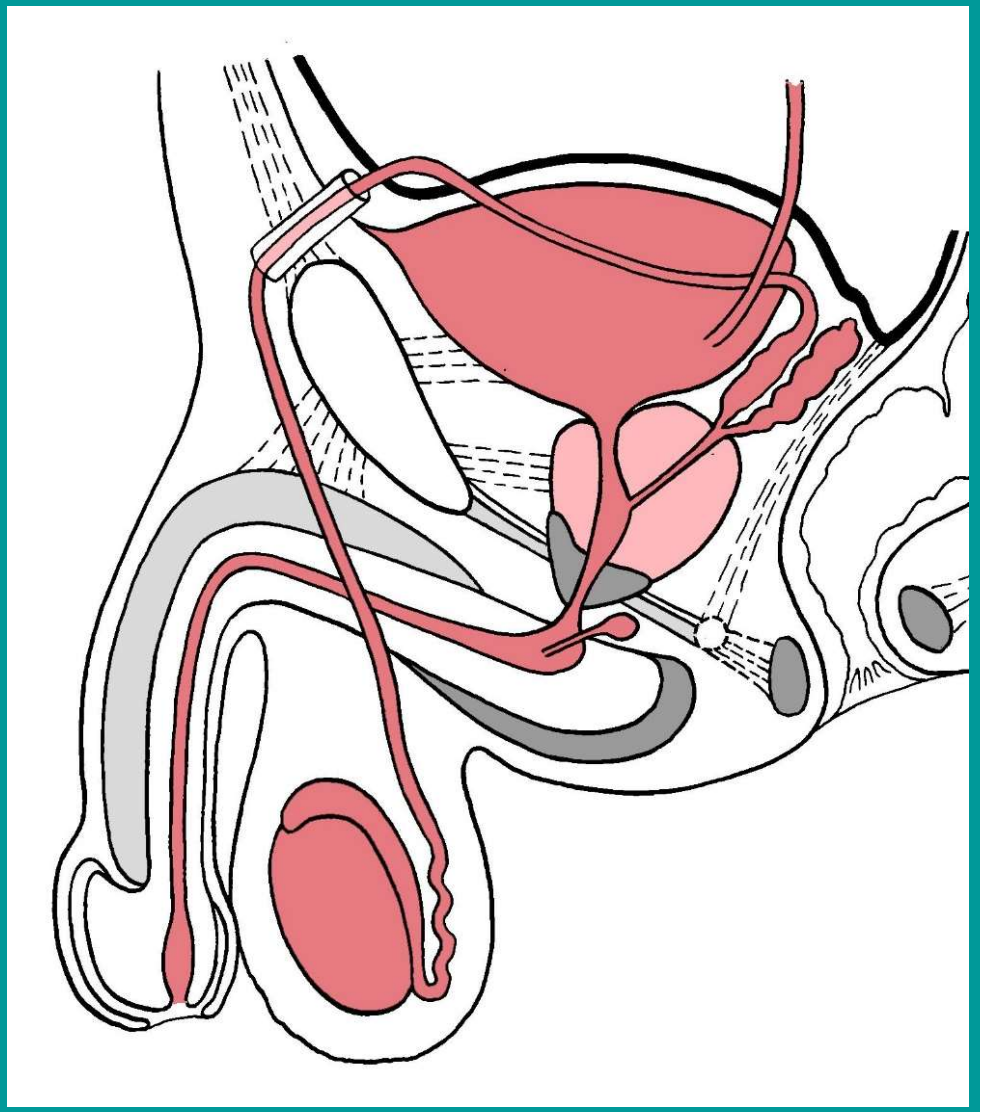
curvatura subpubica,
praepubica

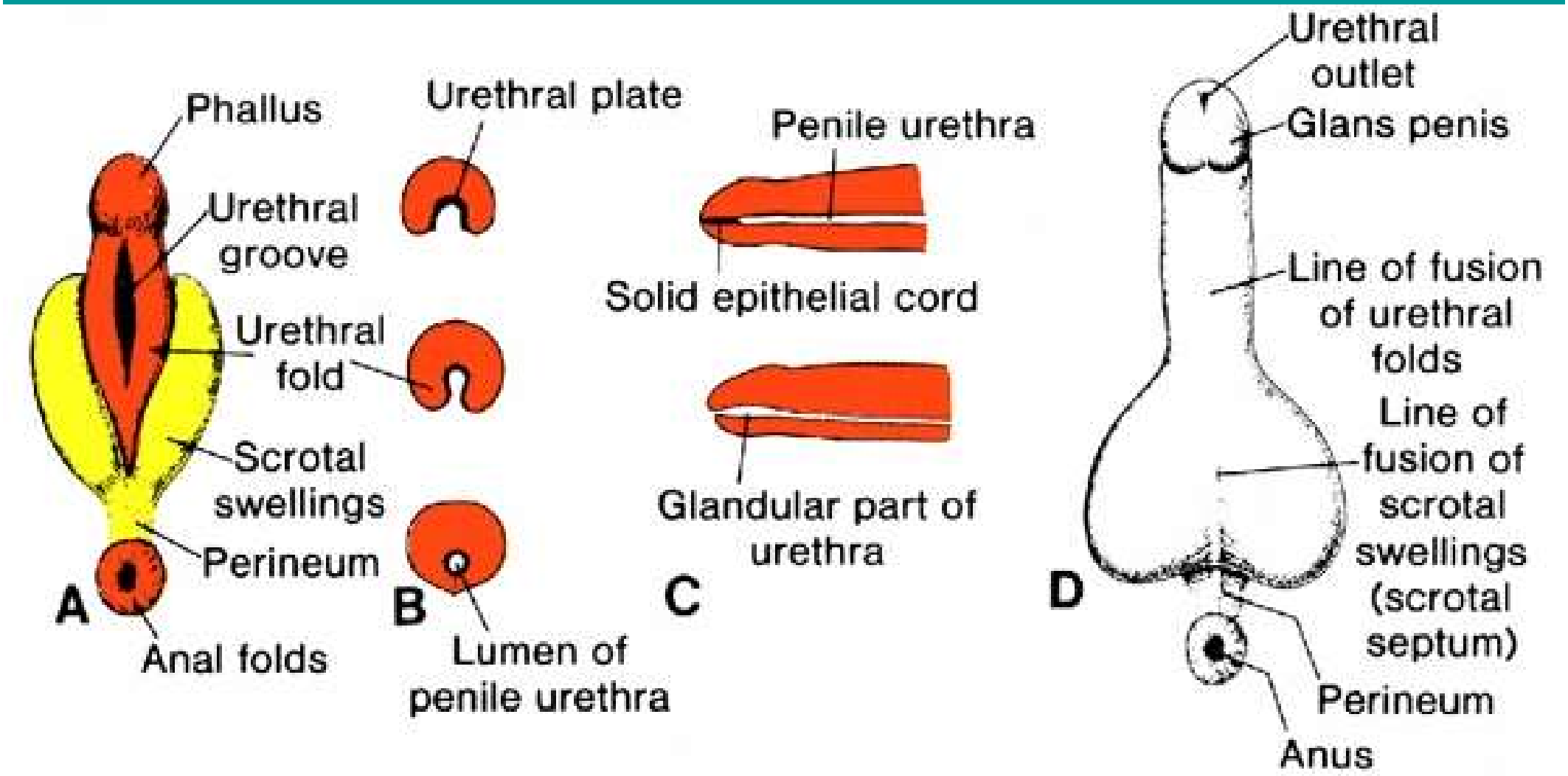
colliculus seminalis,

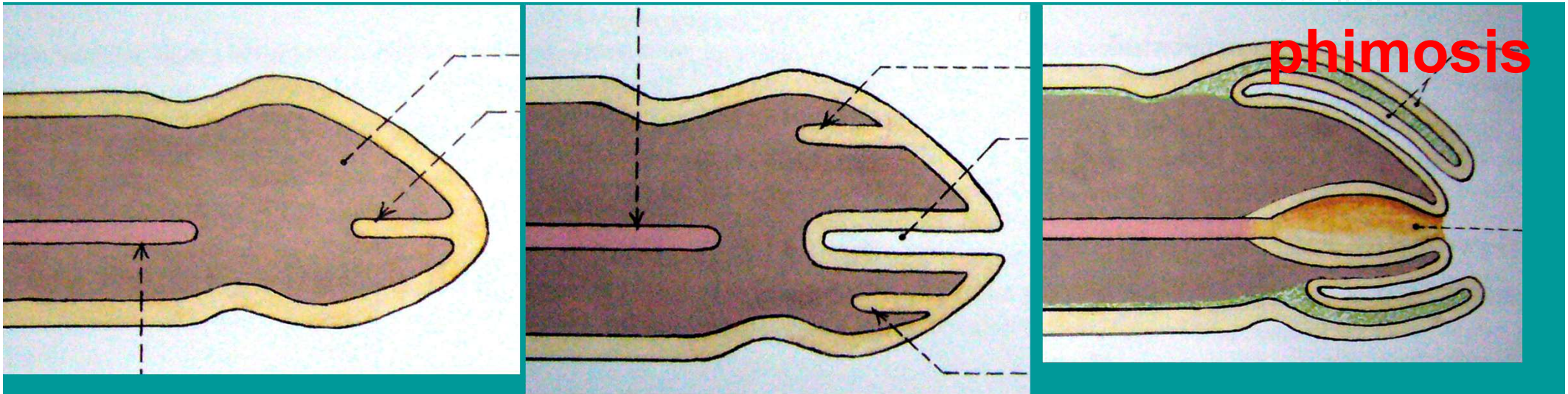
sphincter urtehrae externus,
glandulae urethrales,

orificium urethrae externum

fossa navicularis




Phallus
Urethral groove
Urethral fold
Scrotal swellings
Perineum
Anal folds
A
Urethral plate
B
Lumen of penile urethra
Penile urethra
Solid epithelial cord
Glandular part of urethra
C
Urethral outlet
Glans penis
Line of fusion of urethral folds
Line of fusion of scrotal swellings (scrotal septum)
Perineum
Anus
D


phimosis

lacuna magna

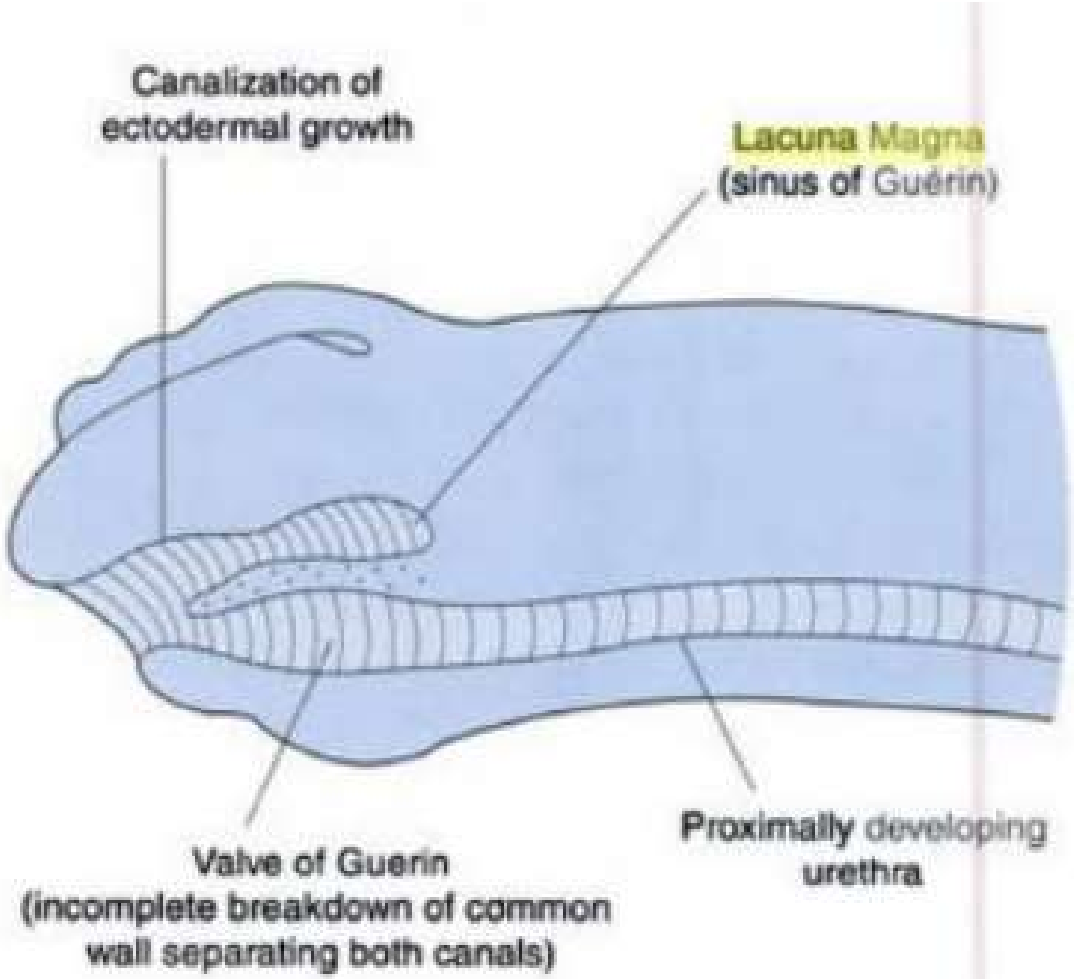
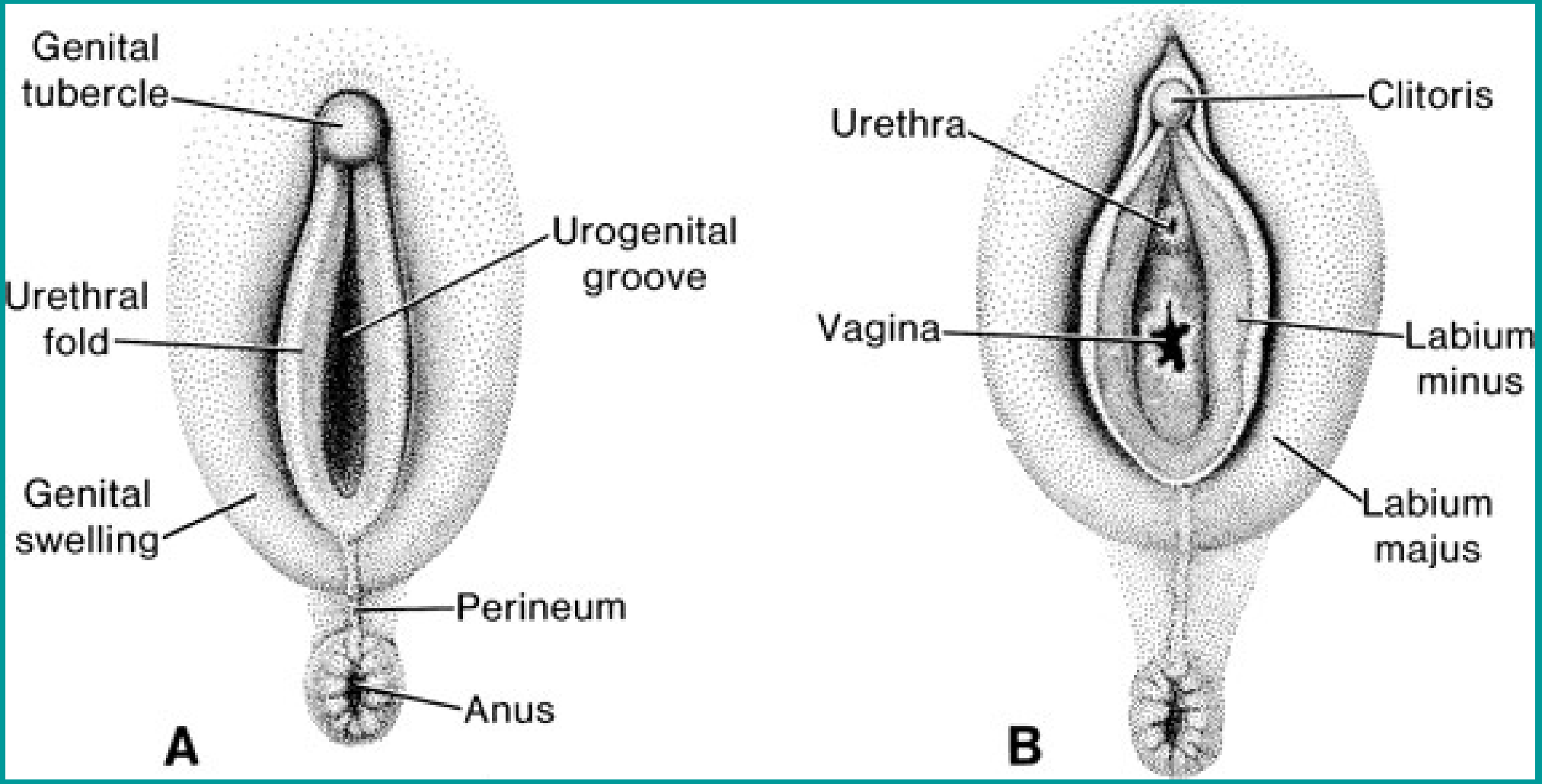
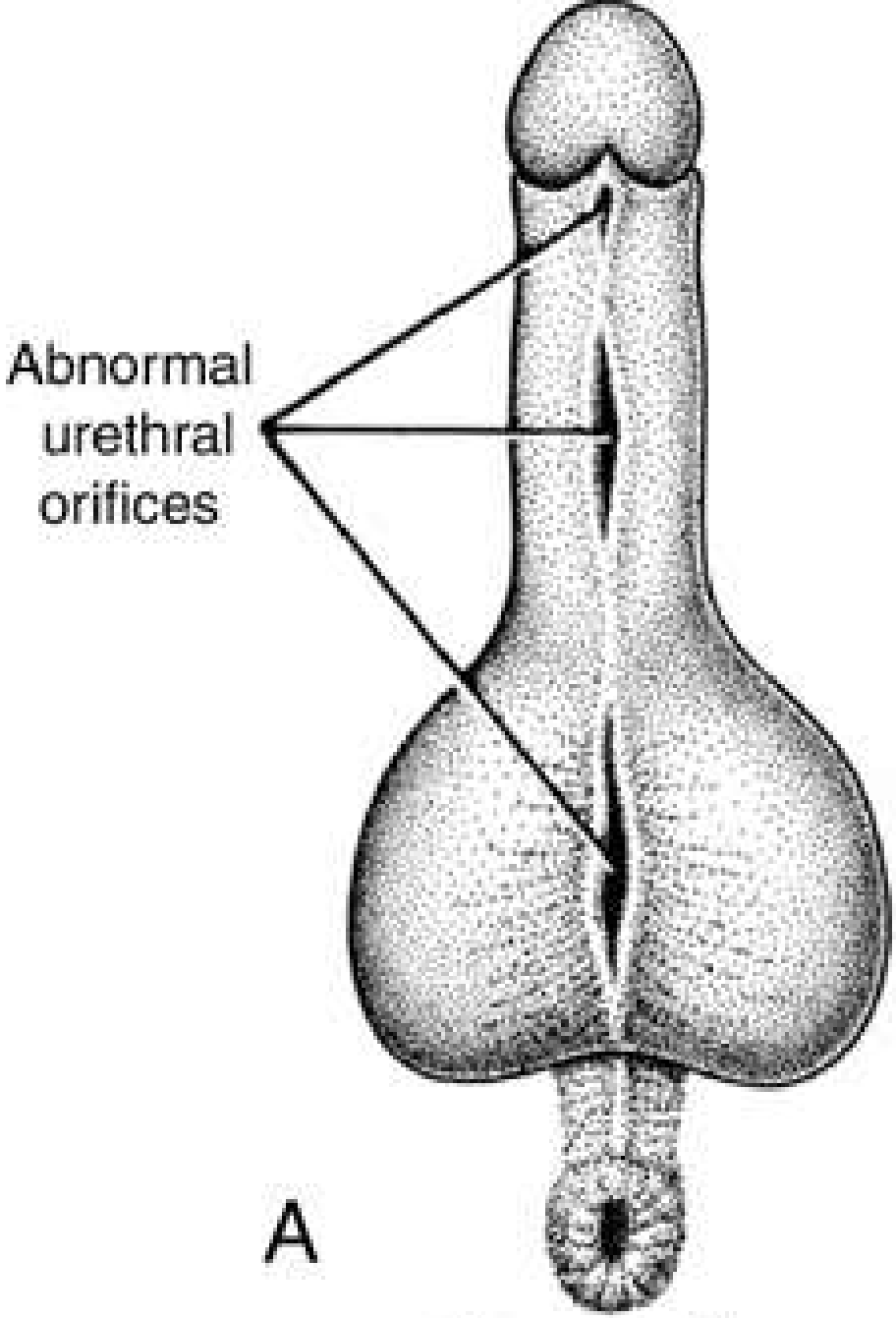


Figure 28.27 Embryologic formation of fossa navicularis and lacuna magna. (From Seskin and Glassberg, 1994, with permission, and adapted from Stephens, 1983b.)

catheterisation…

Lacuna magna or false dorsal dimple Archives - Penis Doctor
https://www.goldjournal.net/article/S0090-4295(11)00505-X/fulltext


Genital tubercle
Urogenital groove
Urethral fold
Genital swelling
Perineum
Anus
A
Urethra
Clitoris
Vagina
Labium minus
Labium majus
B



Hypospadias

M. sphincter urethrae externus

lies at and above the diaphragma urogenitale
is around the urethra
has slow muscle fibres – tone

caudal fibres go to sides of vagina
cranial fibres go to prostate apex
M. sphincter urethrovaginalis a m. compressor urethrae

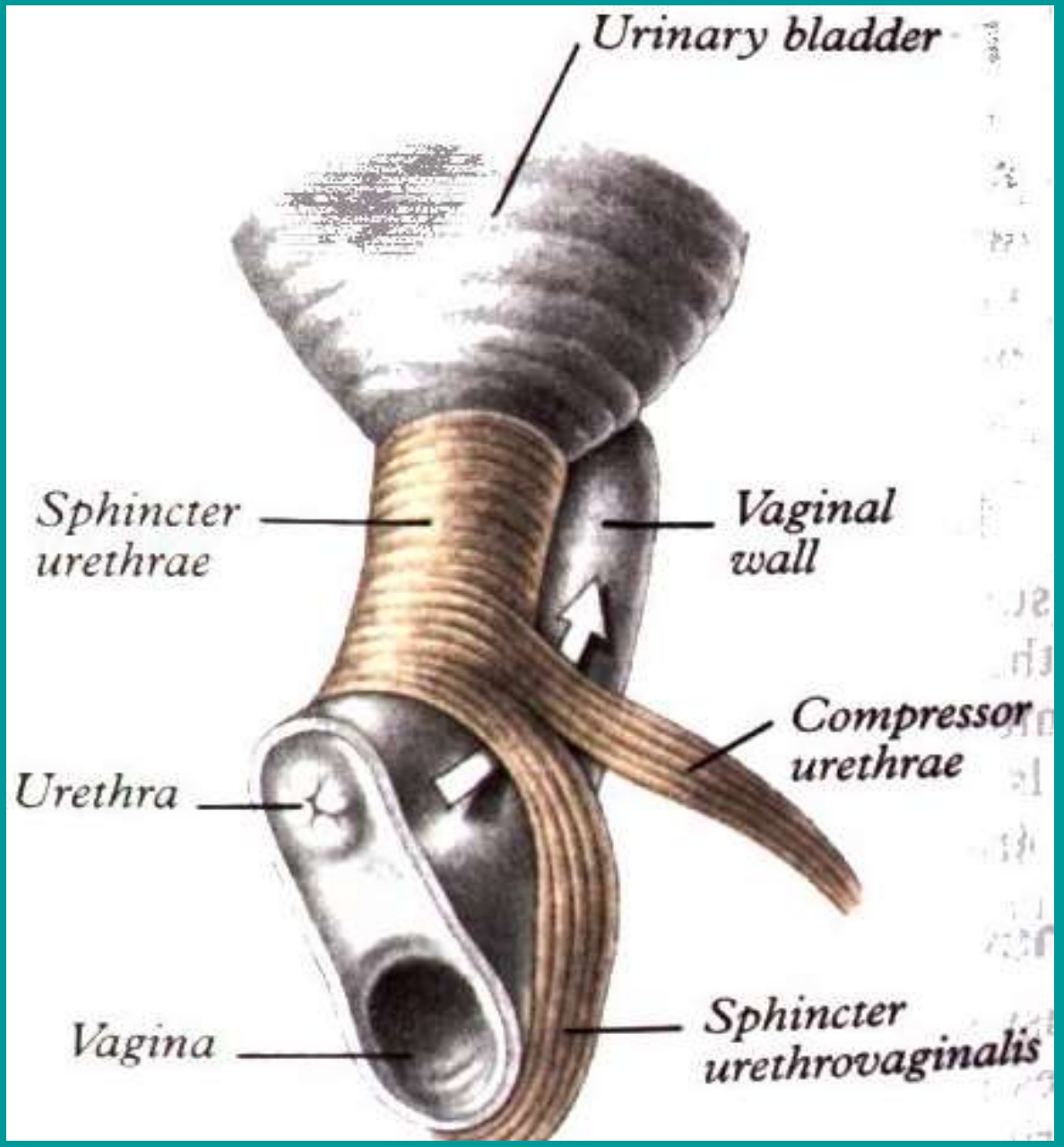
Innervation via pudendal nerve (Alcock canal) from motoneurons of Onuf's nucleus in S2 and S3

Striated muscle sphincters of urethra

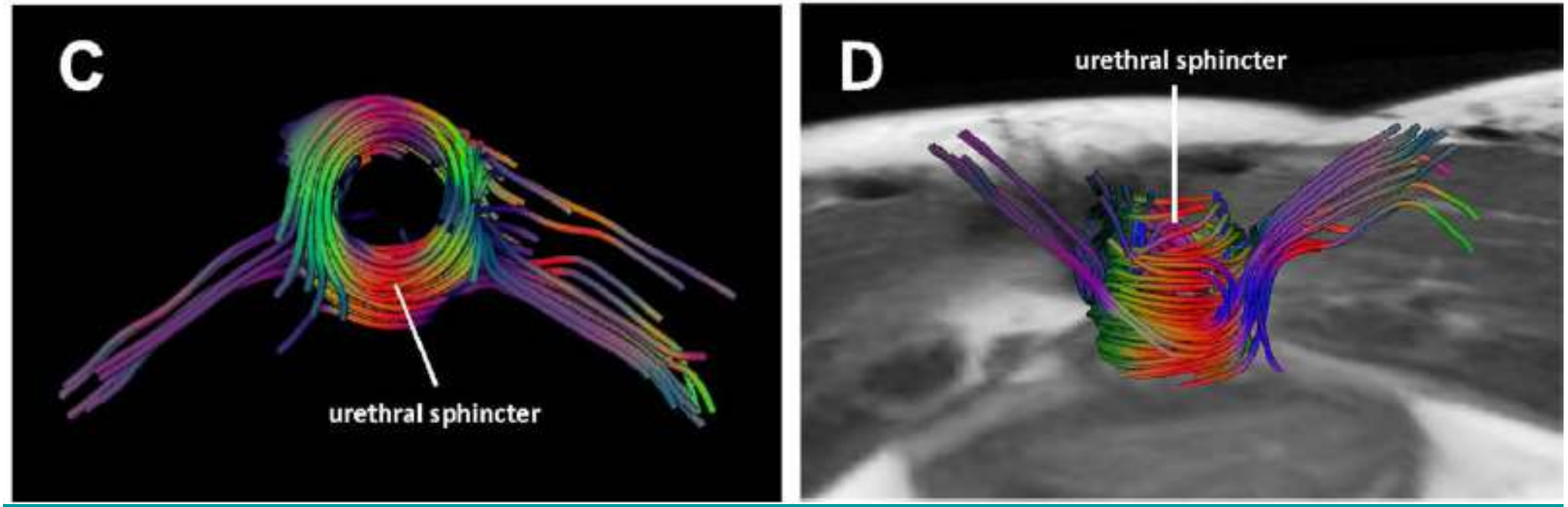
M. sphincter urethrae externus

M. sphincter urethrovaginalis

M. compressor urethrae



Fiber tractography MRI representing the urethral sphincter complex from cranial (C) and posterior view (D).



Neurol. Prax. 2005, roč. 6 (3): 352 – 7.

Continetia urinae

No visible m. sphincter urethrae internus

Pelvic floor muscles, connective tissue of endopelvic fascia (hamaka theory) fixing vagina and bladder.

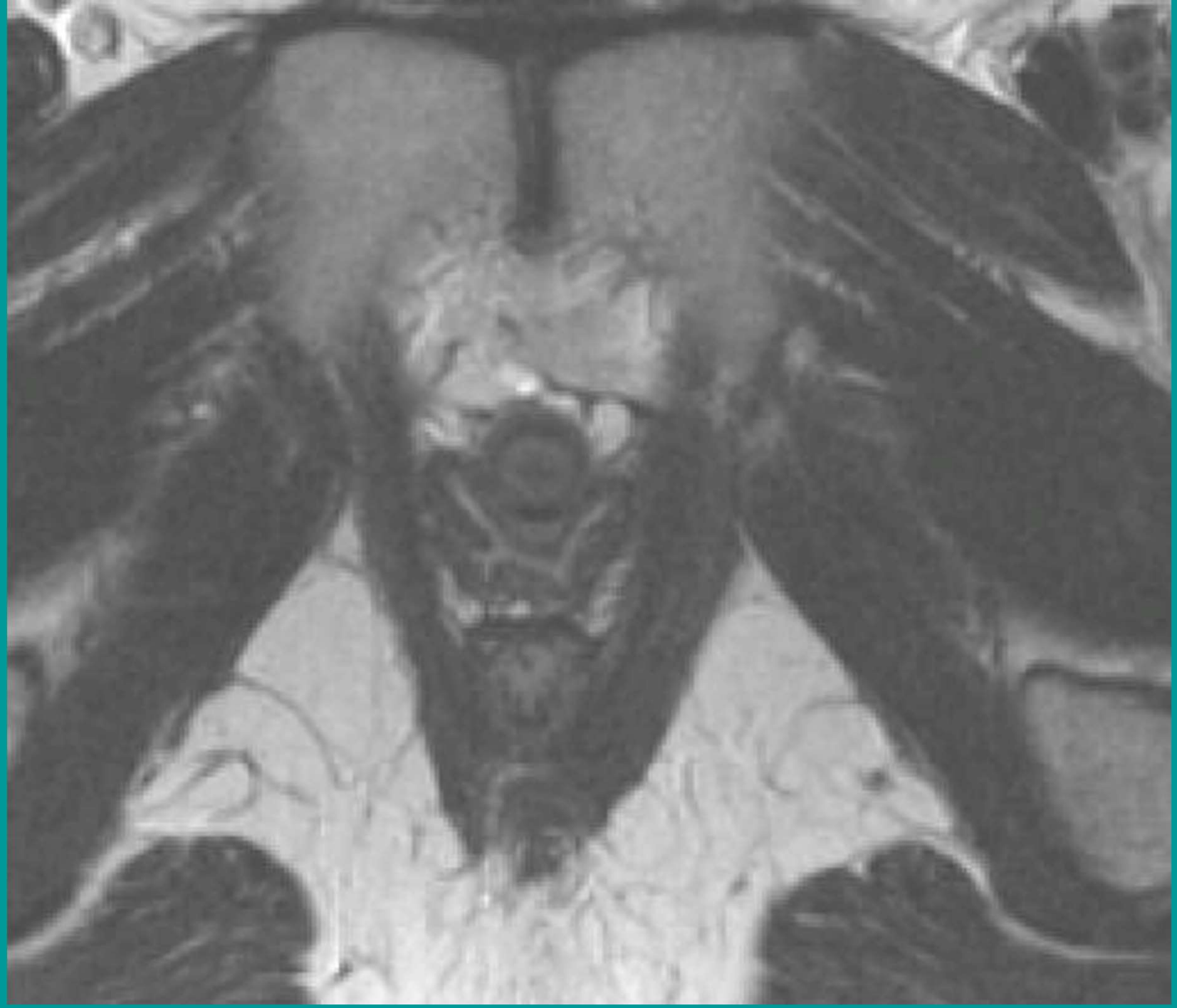
Mechanism of micturition

Pelvic floor musculature relaxes, bladder “sags” down. Its neck becomes wider like a funnel, and ostium accipiens widens and lower down ostium evacuans forms the actual entry to urethra.

Detrusor then pushes urine into urethra.

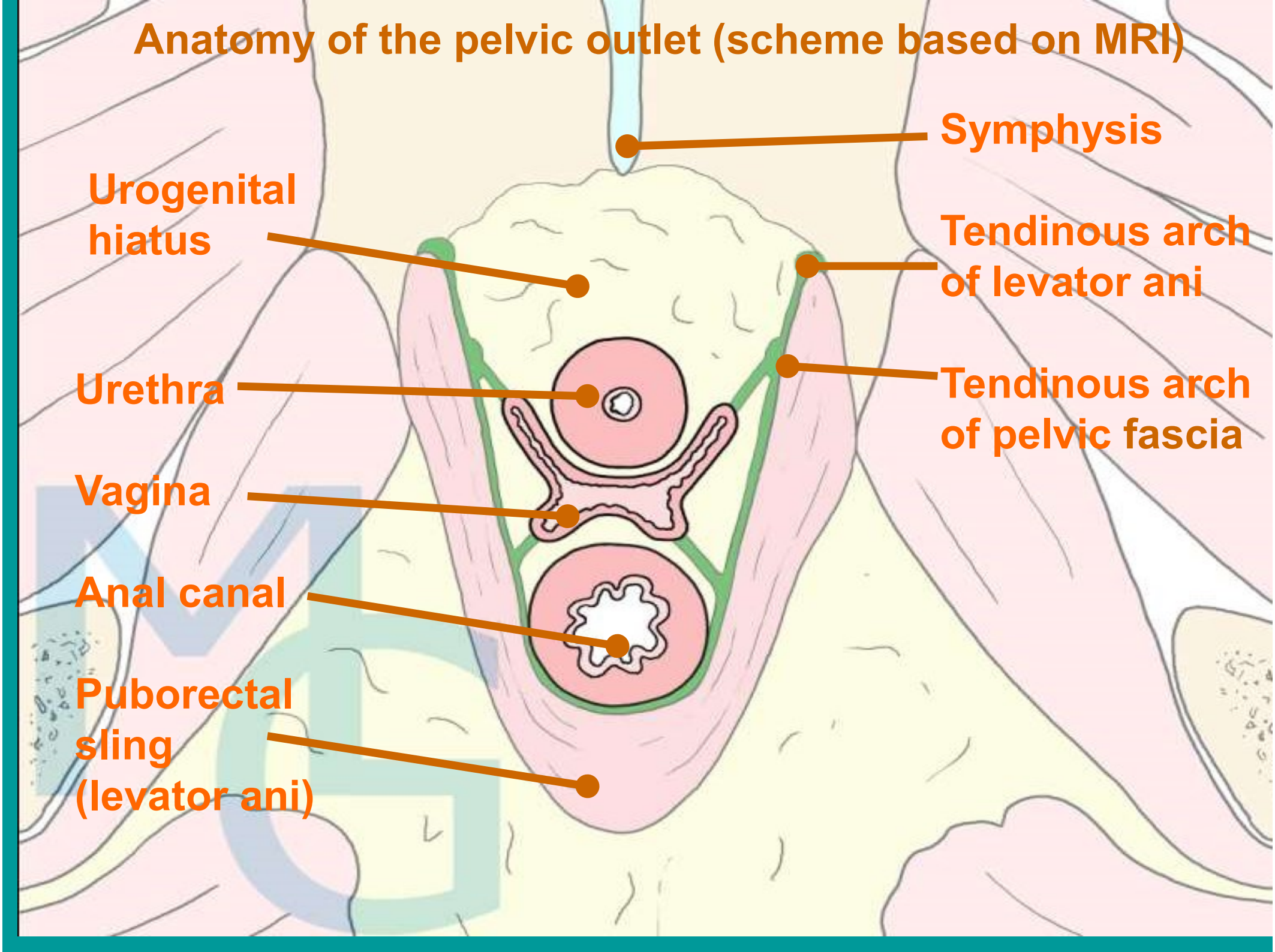
Musculature around ureters contracts to prevent reflux.

Striated sphincter urethrae relaxes and urine flows.



MRI of female pelvis at the level of hiatus urogenitalis
(level 2 according to DeLancey)

Anatomy of the pelvic outlet (scheme based on MRI)

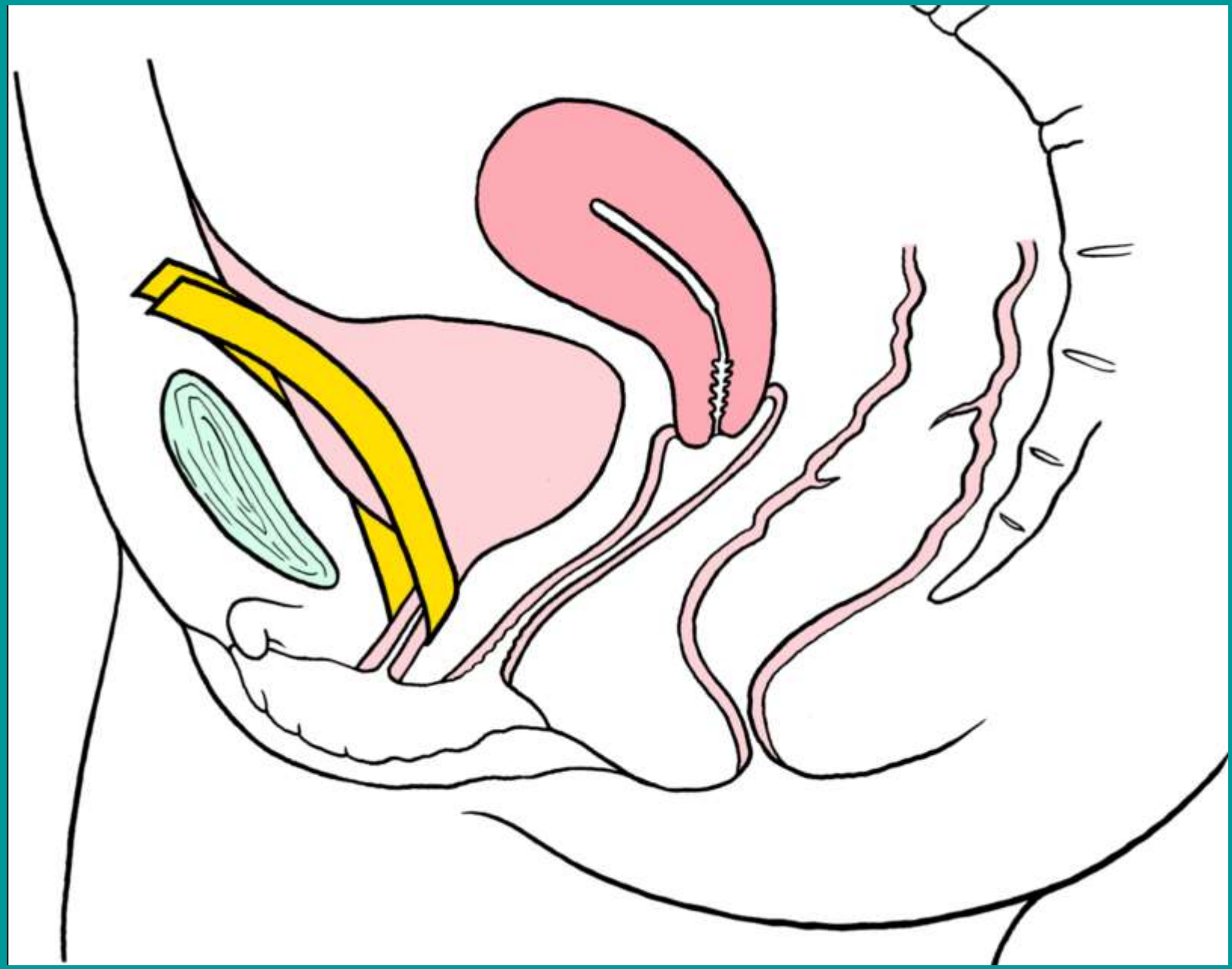


Urinary continence - female

hamaka theory (De Lancey, 1994) the main factor of continence is support of the underside of bladder and urethra by the anterior vaginal wall fixed in pelvis by endopelvic fascia from the sides of the pelvis.

Increased intraabdominal pressure (com)presses urethra to the hamaka.

tension-free tape: urethral suspension for urine incontinence



Int Urogynecol J Pelvic Floor Dysfunct. 2009 Jun;20(6):681-8. .

Anatomical relationship and fixation of tension-free vaginal tape Secur.

Hubka P, Mašata J, Naňka O, Grim M, Martan A, Zvárová J
First Faculty of Medicine and General Teaching Hospital, Department of Gynaecology and Obstetrics, Charles University in Prague, Apolinarska 18, 12000, Prague, Czech Republic. petr.hubka@vfn.cz

OBJECTIVE: The objective is to describe the anatomical localisation of tension-free vaginal tape Secur (TVT-S) in the H-position regarding possible injury of vessels and fixation site. METHODS: We placed TVT-S inserters bilaterally in 14 embalmed and five fresh frozen female bodies. After dissection, we measured distances from the obturator bundle (obturator nerve and obturator vessels). RESULTS: In embalmed bodies, the mean distance of TVT-S from the obturator bundle was 3.05 cm (standard deviation (SD) 1.18 cm) on the left, 3.07 cm (SD 1.17 cm) on the right. Perforation of the fascia of obturator internus muscle occurred in 46.4%. In fresh frozen bodies, results were fundamentally similar. Injury of variable vessels can occur. CONCLUSION: There is a minimal risk of injury to the obturator bundle during TVT-S; however, there is a significant risk of inserting the TVT-S inserter into the obturator fossa. The position of TVT-S does not change significantly after legs mal-positioning.

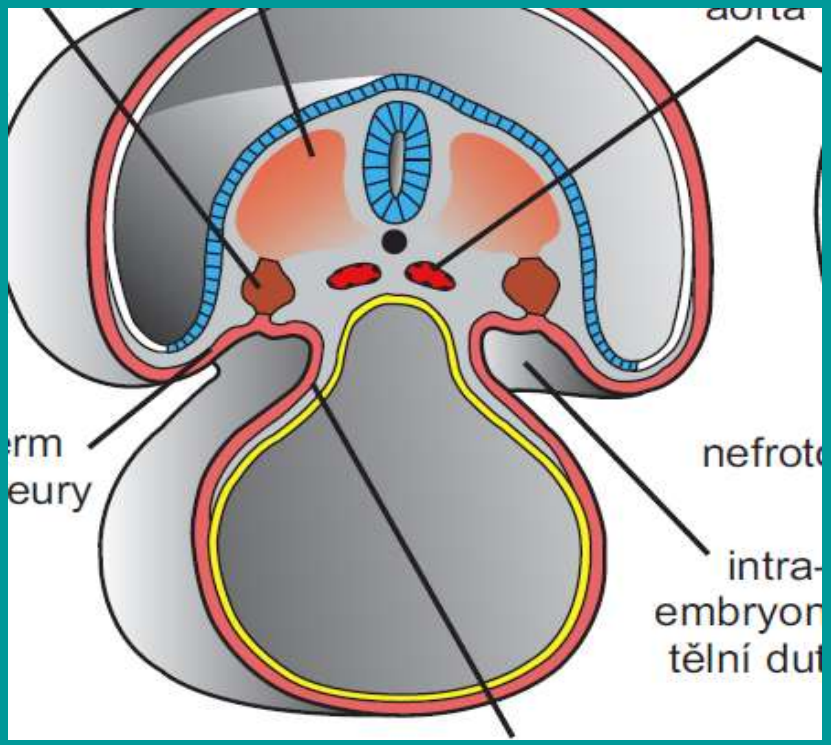
Development of the urinary system

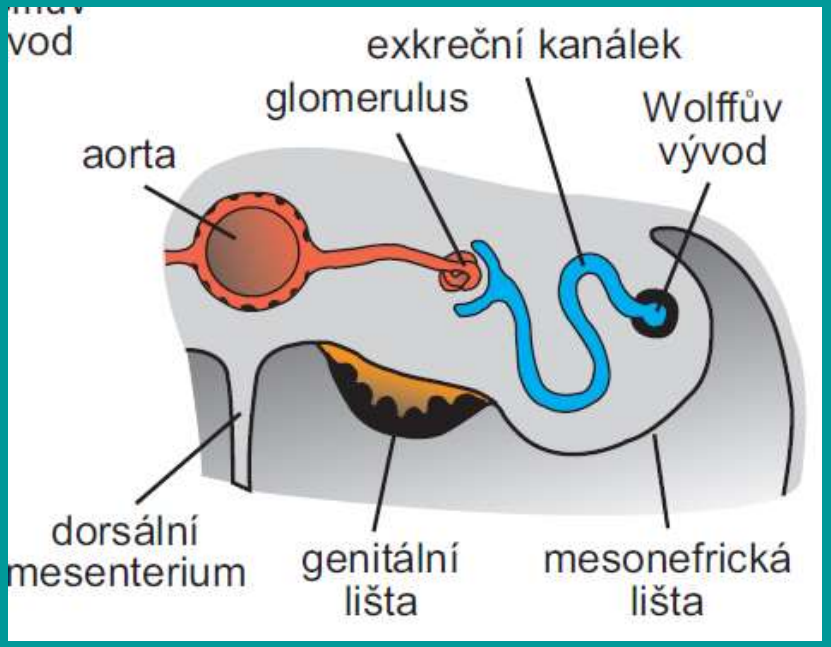
Development of urinary system

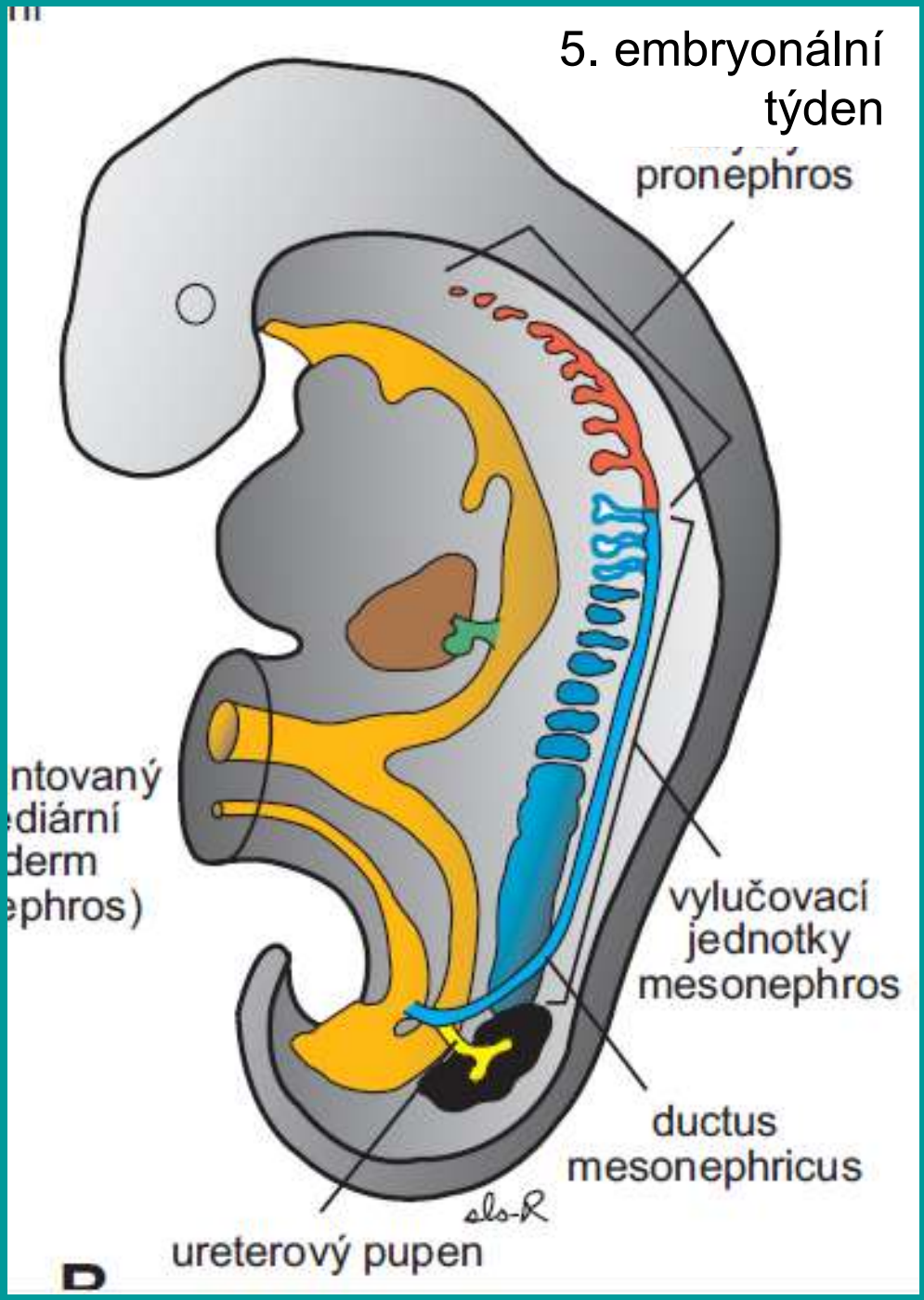
předledvina, **pronephros**
prvoledvina, **mesonephros**
definitivní ledvina, **metanephros**
nephrogenesis: **interaction of ureteric bud and nephrogenic blastema** (its mesenchymo-epithelial transformation)

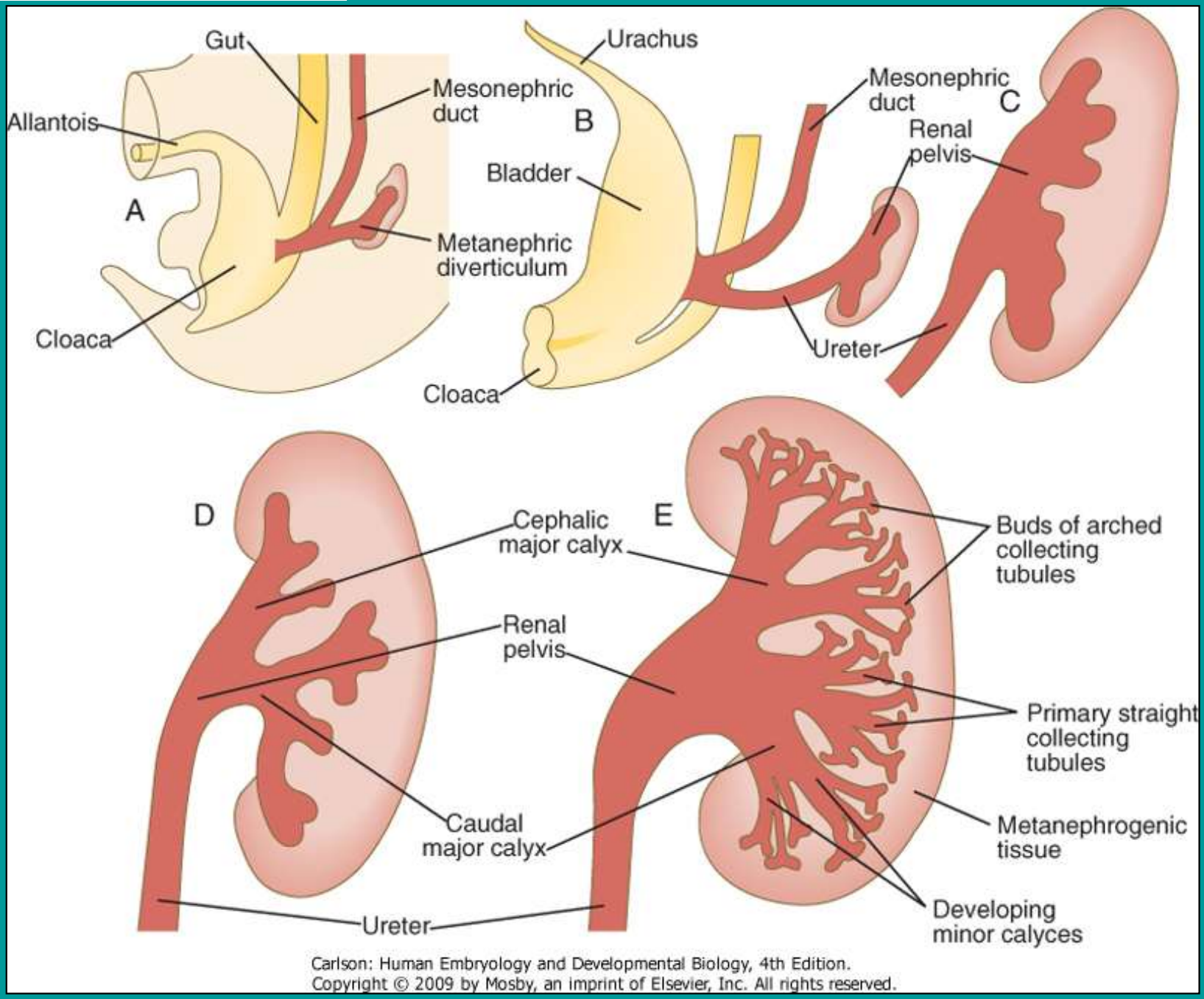
development of calices, pelvis and ureters
ascent and rotation of kidneys
development of blood supply
development of the bladder and urethra

Excretory sytem develops from intermediate mesoderm

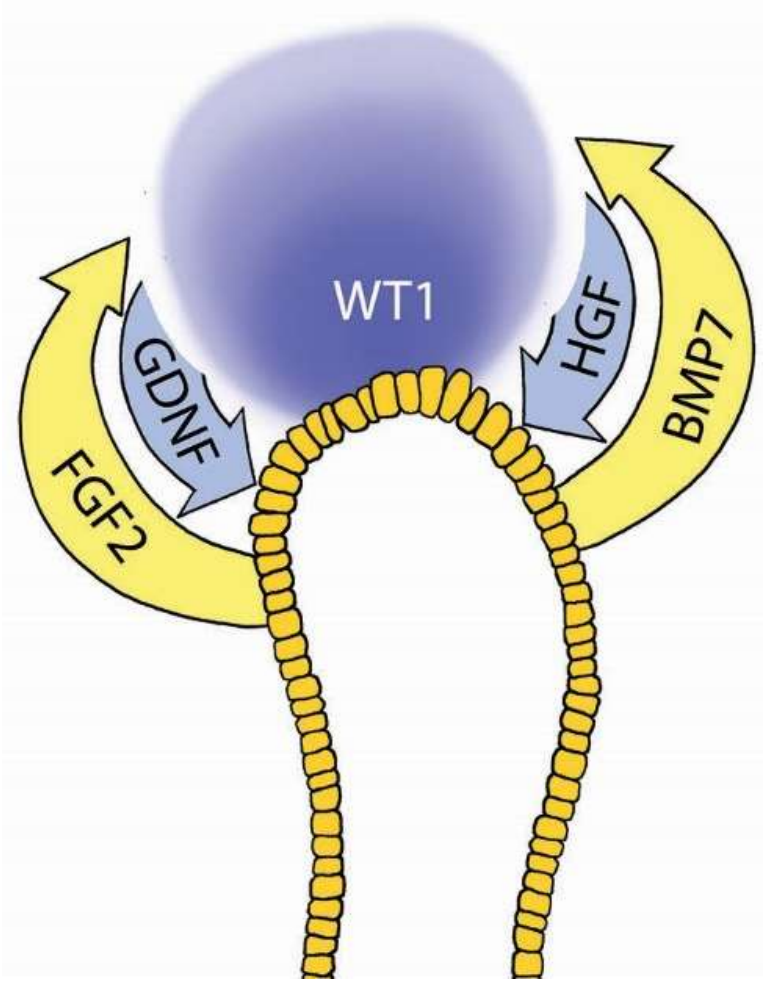




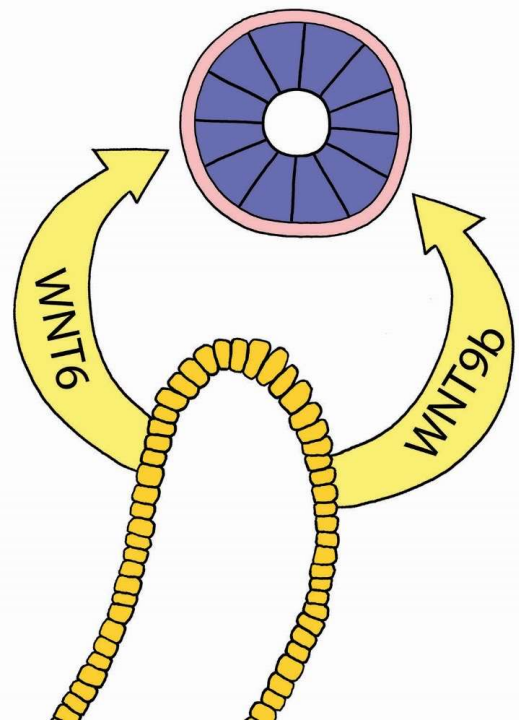




Development of the renal pelvic and calyces



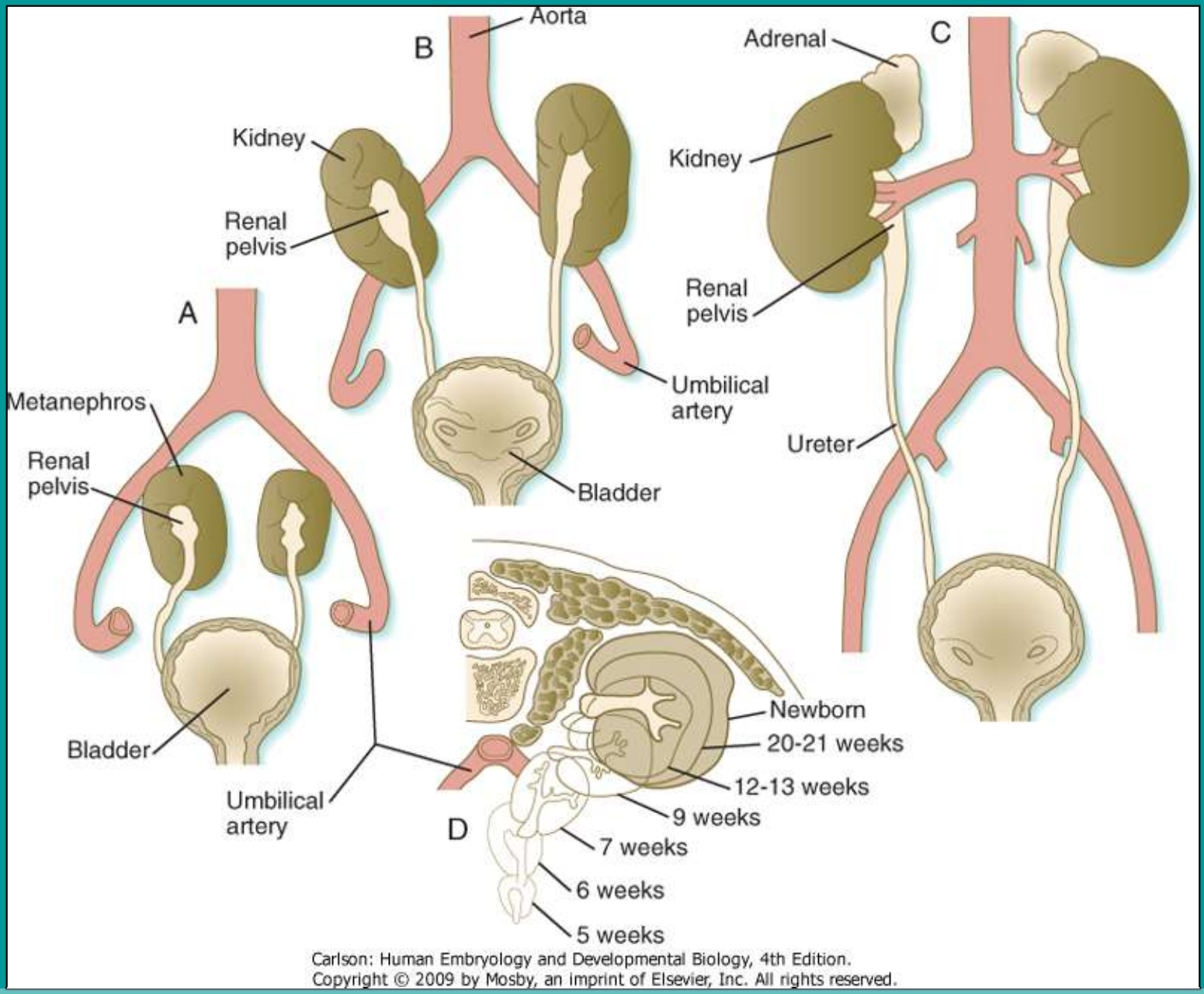
Genová exprese v průběhu nefrogenese za interakce ureterového pupenu (žlutě) a metanefrogenního blastému (modře) v časném stadiu. Jsou znázorněny signální dráhy a uvedeny názvy molekul, které navozují expresi genů řídících diferenciaci ledviny.



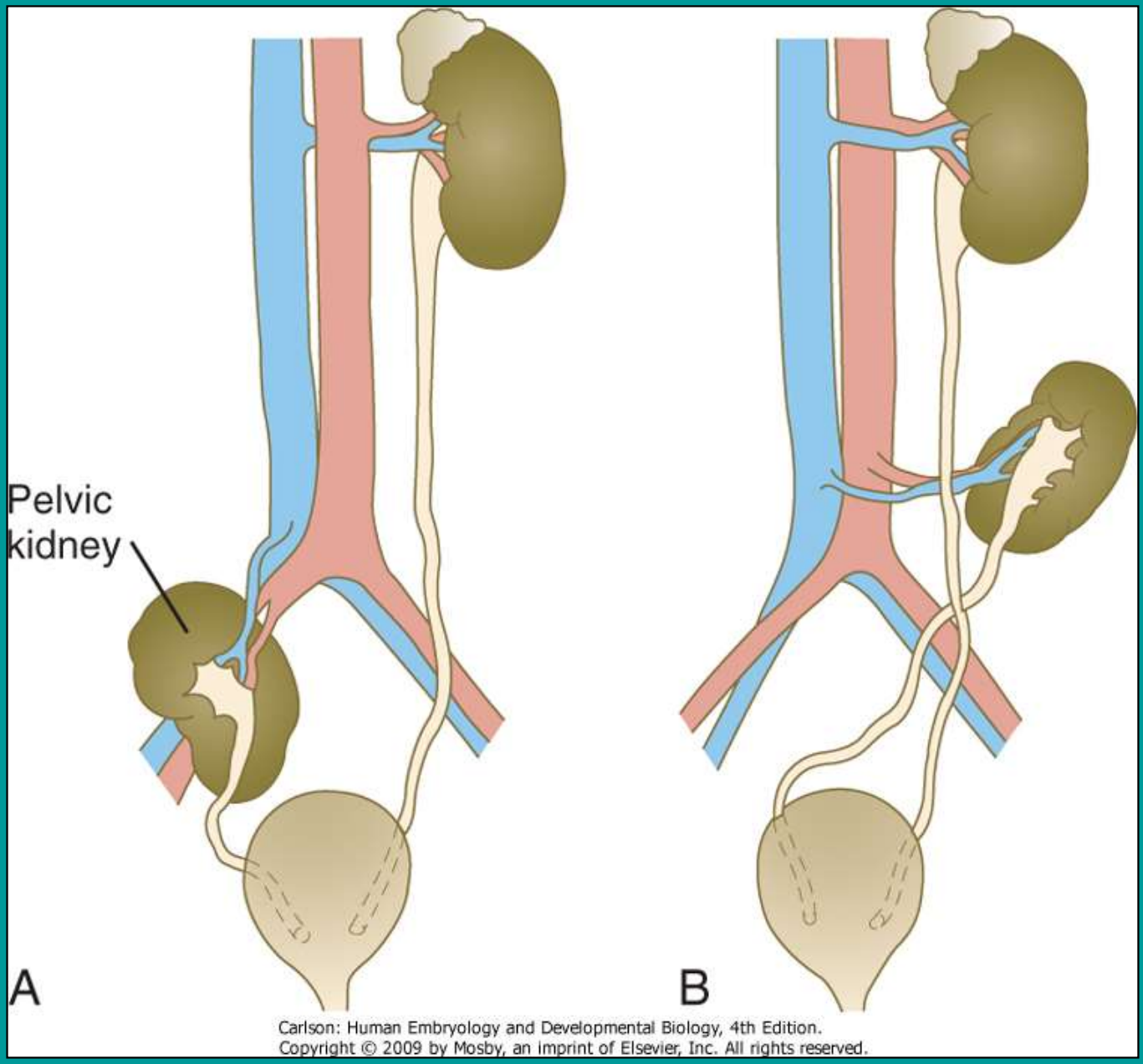
V pozdějším stadiu vývoje nefrogenese produkuje ureterový pupen (1) další signální molekuly WNT9b a WNT6, které stimulují proliferaci buněk metanefrogenního blastému a navozují jeho přeměnu z mesenchymu v epithel kanálků budoucích nefronů (3). Buňky kanálků syntetizují molekuly buněčné adhese syndecan a E-cadherin, nezbytné pro vývoj kanálků.

Abbreviation	Growth Factor	Renal Development	Expression Location
BMP4	Bone Morphogenetic Protein 4	prevents ectopic ureteric bud outgrowth and extra ureteric bud divisions	mesenchymal cells surrounding mesonephric duct and stromal mesenchyme surrounding steric bud stalks
BMP7	Bone Morphogenetic Protein 7	survival of metanephric mesenchyme	metanephric mesenchyme
Fgf8	Fibroblast Growth Factor 8	transition of the induced cap mesenchyme into RVs	cap mesenchyme
GDNF	Glial-cell derived neurotrophic factor	induces steric bud outgrowth from mesonephric duct, interacts with Ret	metanephric mesenchyme
VEGF	Vascular endothelial growth factor	promotes endothelial cell proliferation, differentiation	s-shaped body
Wnt4	Wingless-Type MMTV Integration Site Family, Member 4	mesenchymal-to-epithelial transition	cap metanephric mesenchyme, pre-tubular aggregate, nephron progenitors
Wnt5a	Wingless-Type MMTV Integration Site Family, Member 5a	nephrogenesis induction, ectopic bud formation	steric bud, metanephric mesenchyme
Wnt9b	Wingless-type MMTV integration site family, Member 9B	renewal and differentiation of nephron progenitors and normal ureteric bud branching, mesenchymal-to-epithelial transition	steric bud stalk epithelial cells

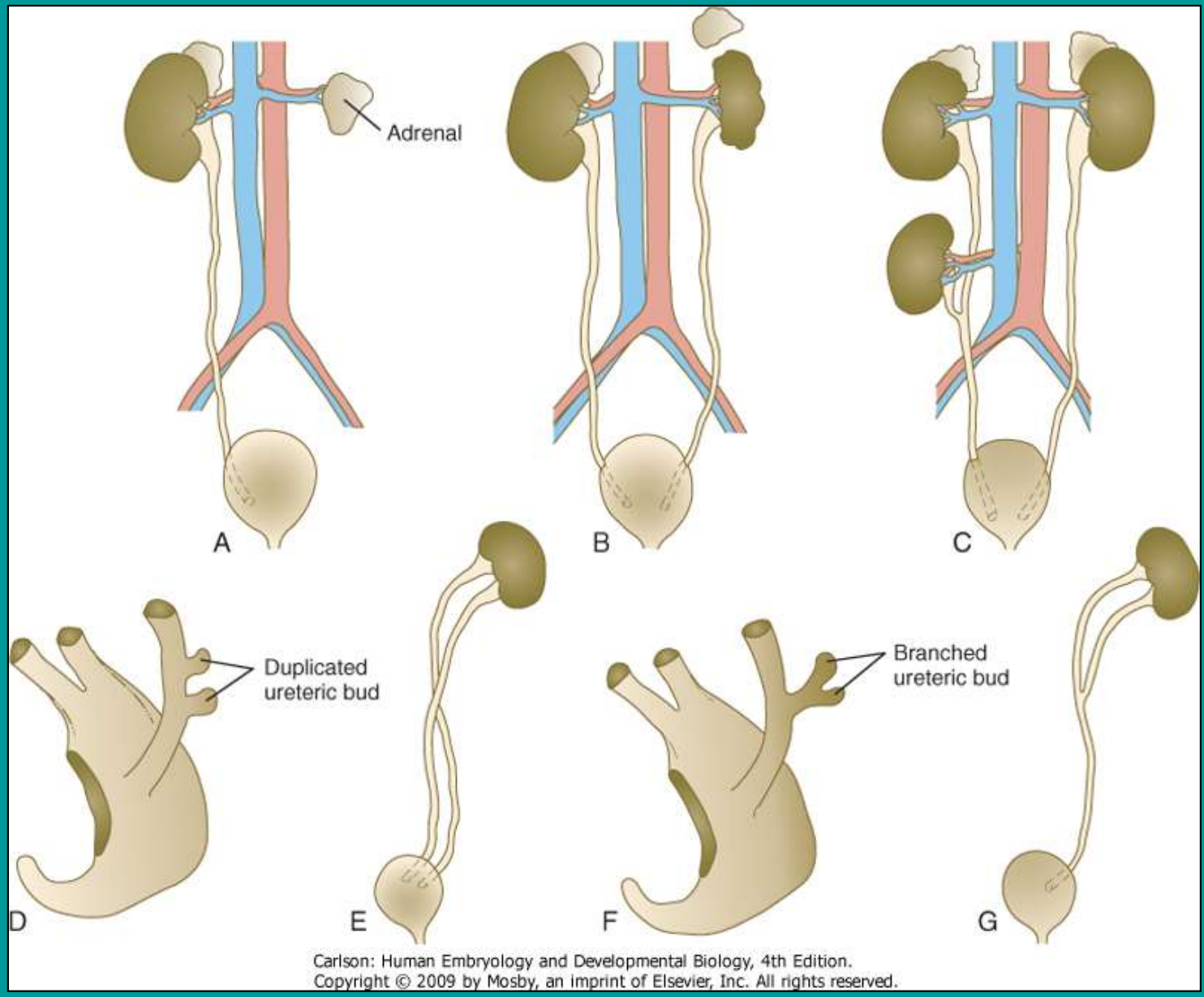
- **Foxd1** - (Brain Factor-2) transcription factor that is a renal stroma specific gene.
  Links: Renal System - Molecular | OMIM Foxd1



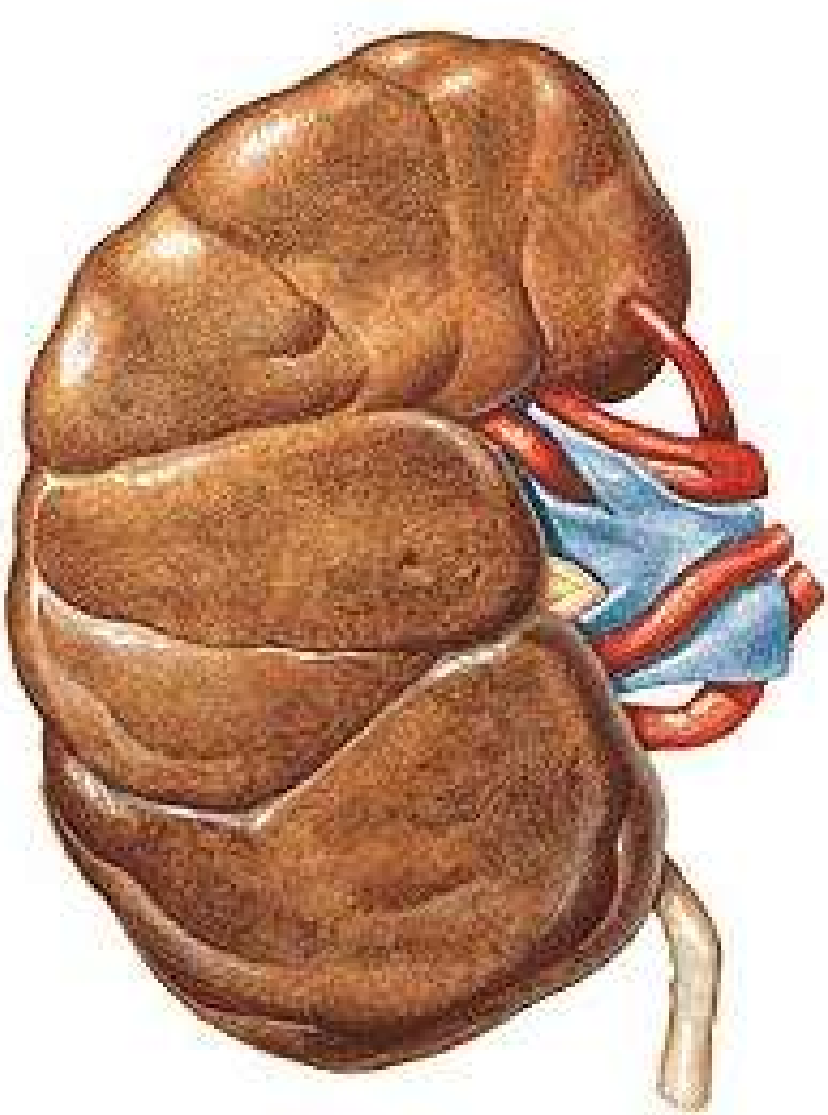
A-C: Migration of kidney from pelvis to lumbar region.
D: Rotation.

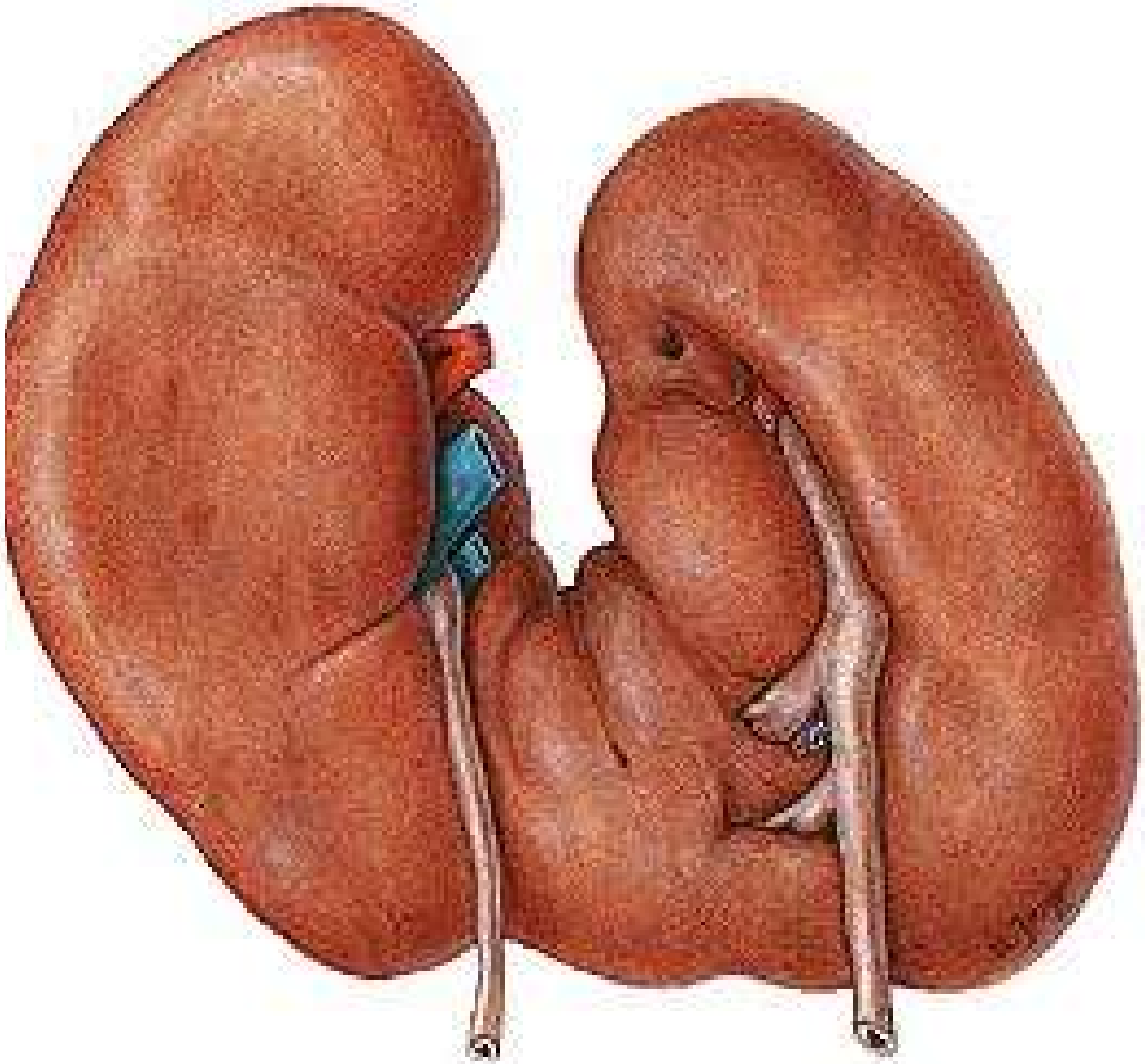


Renal migration defects. A Pelvic kidney. B Crossed ectopia.



Other developmental abnormalities.





Renculisation

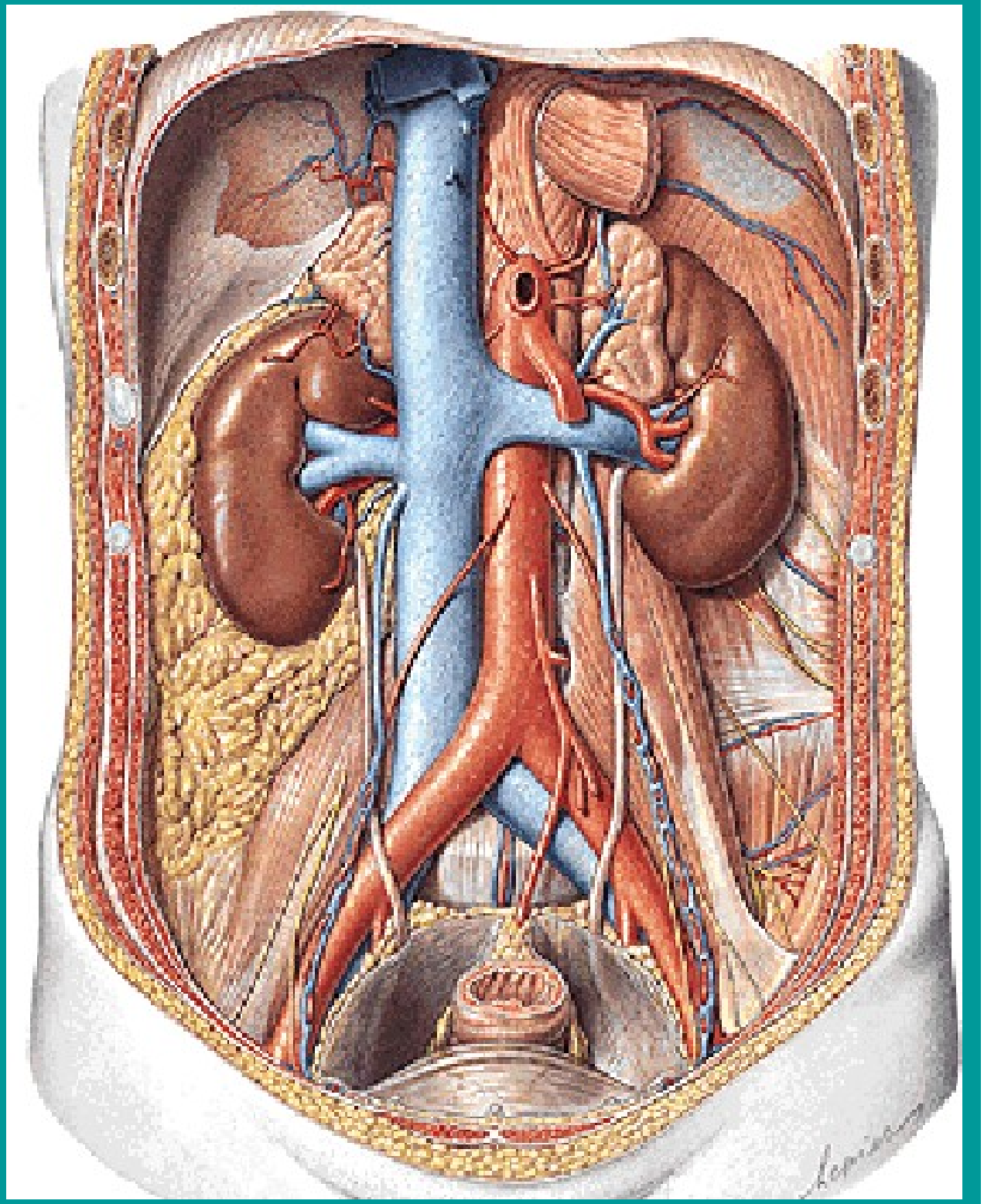
Horseshoe kidney

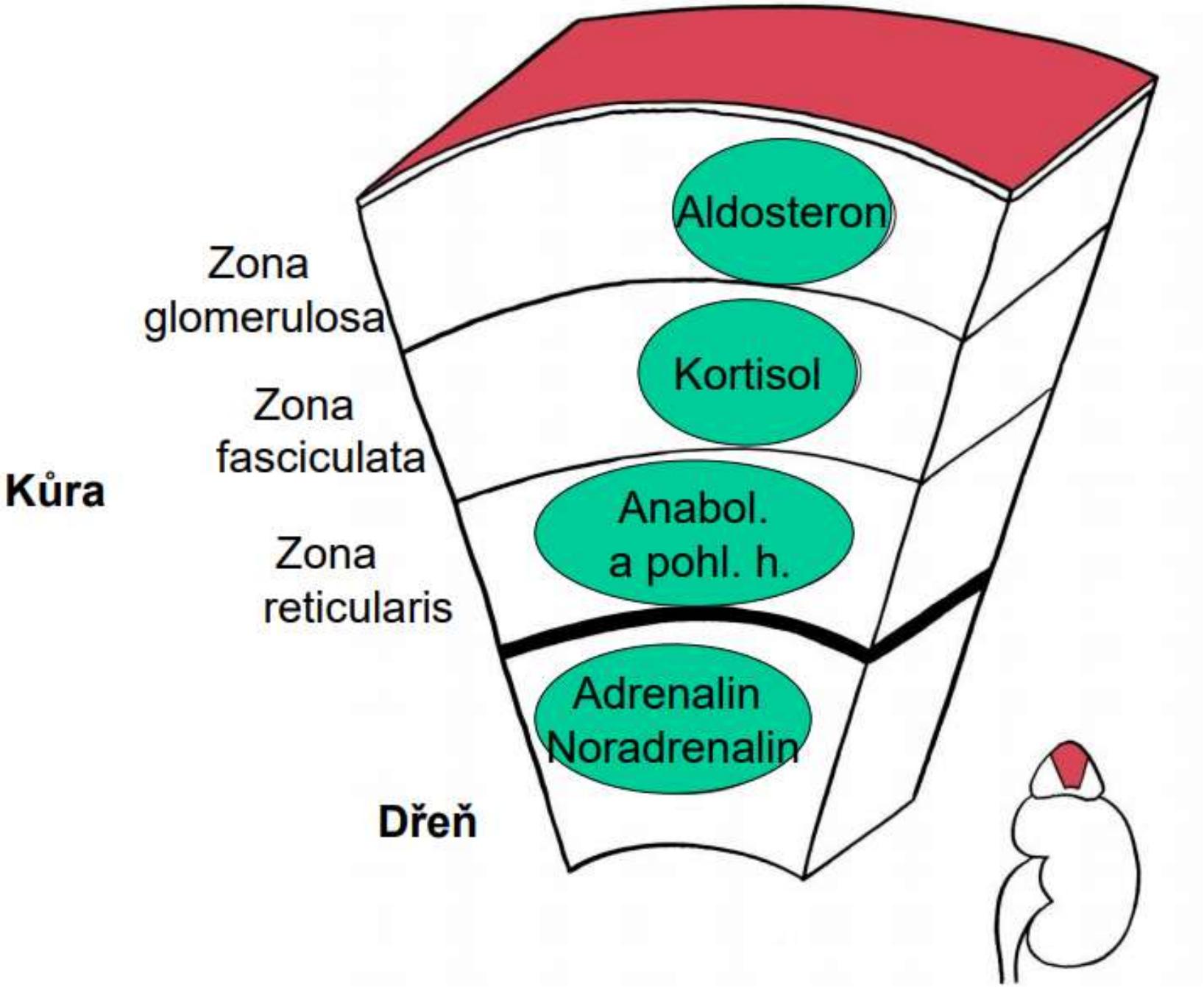
Suprarenal glands
Glandulae suprarenales

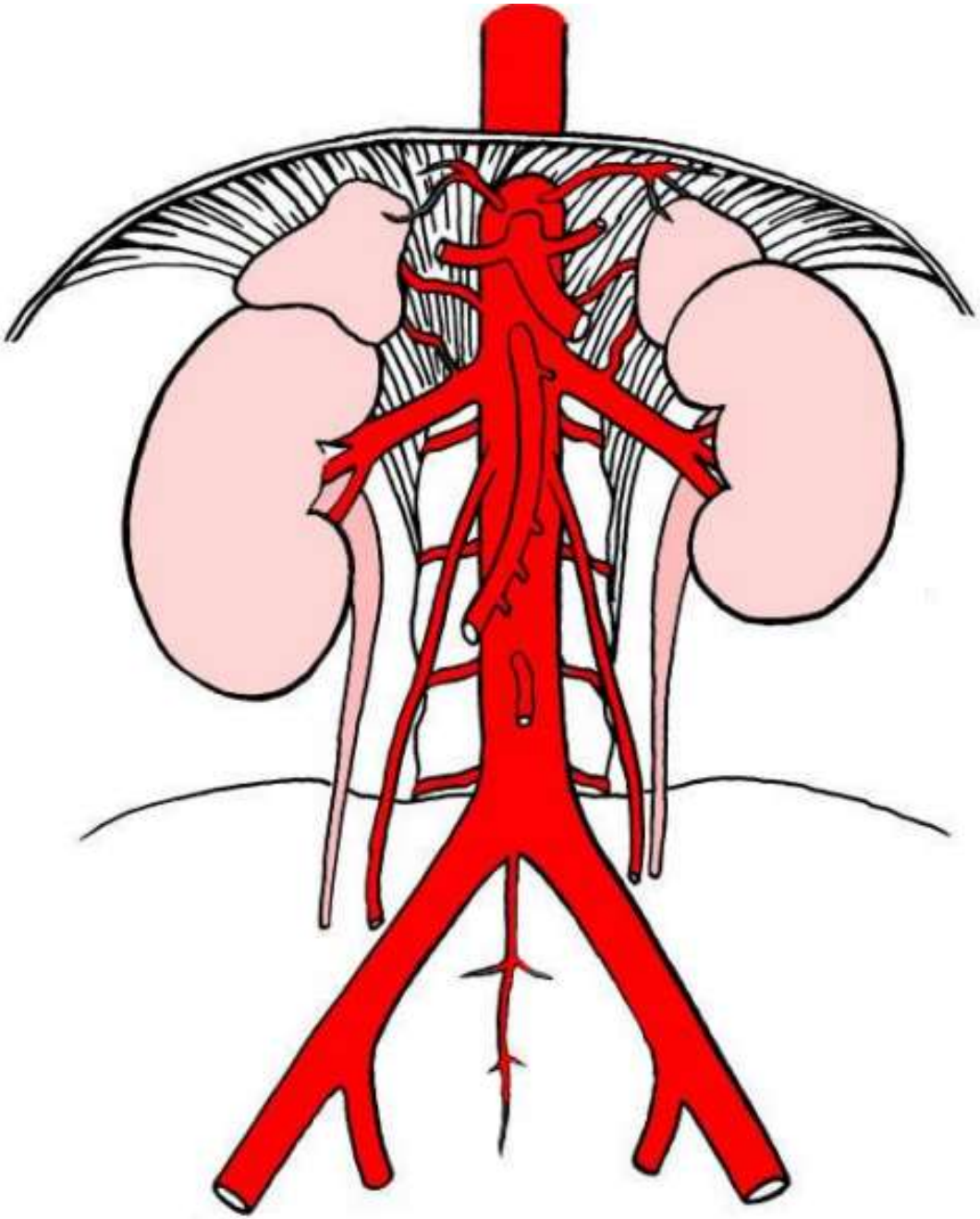
Endocrine 6-12g

Sits on superior pole of kidneys at level of Th11, below and in front of the diaphragm

Cortex (mesoderm) and medulla (neural crest)




Aldosteron
Zona glomerulosa
Kortisol
Zona fasciculata
Kůra
Anabol. a pohl. h.
Zona reticularis
Adrenalin Noradrenalin
Dřeň



Cévní zásobení

Tepny:

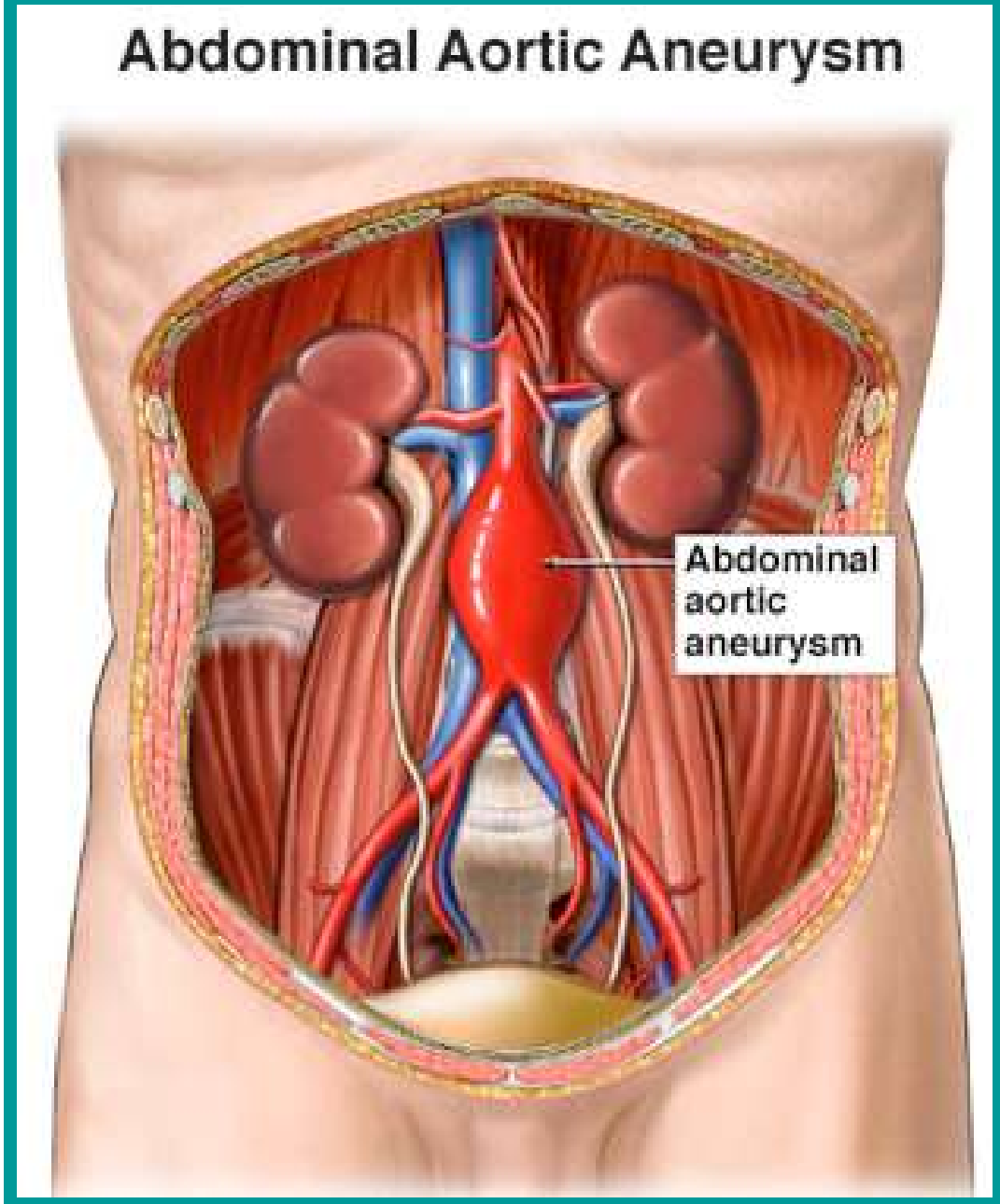
a. suprarenalis superior z a. phrenica inf.

a. suprarenalis media z aorty abdominalis

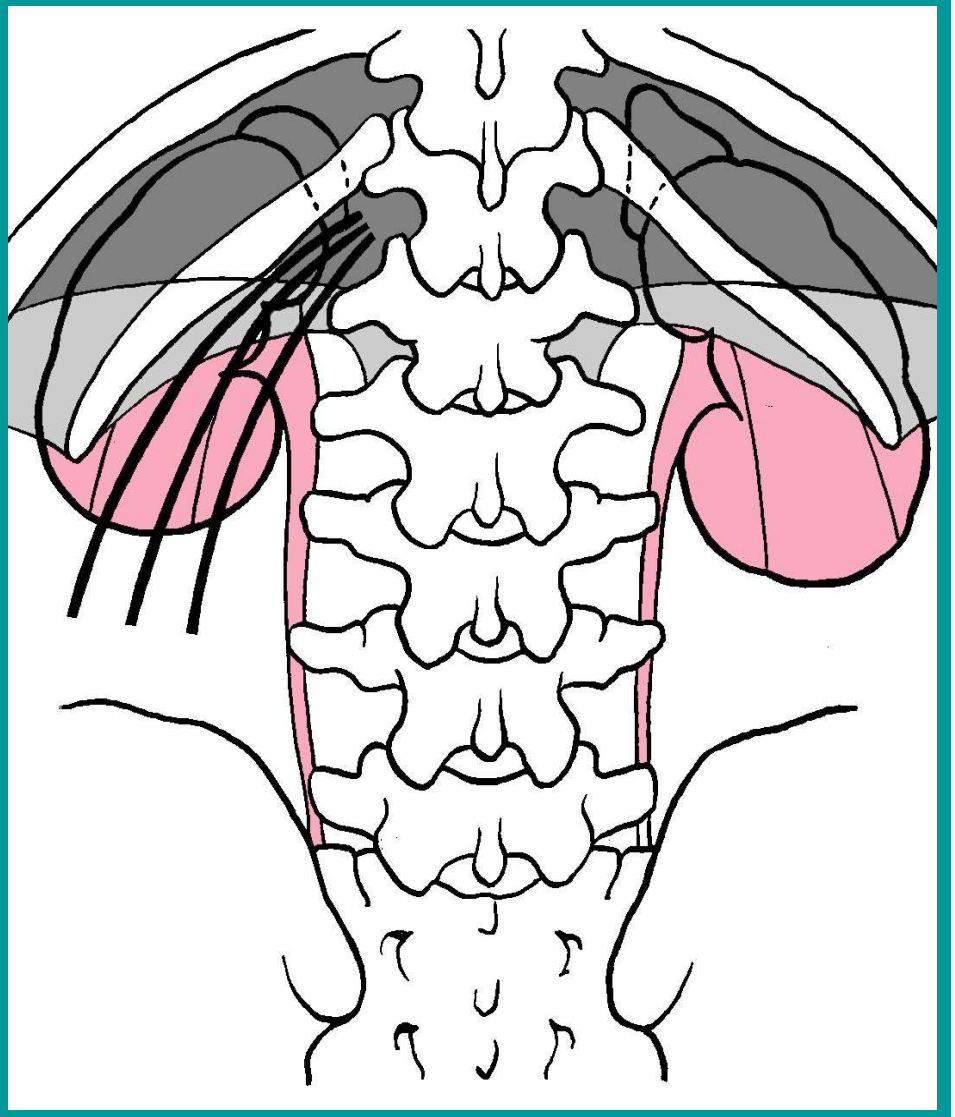
a. suprarenalis interior z a. renalis

Žíly:

v. centralis vystupuje z hilu, jako v. suprarenalis se vlévá vpravo do v. cava inf., vlevo do v. renalis



Aneurysm treatment in New Jersey | Heart and Vascular Care (rwjbh.org)



n.subcostalis, n. iliohypogastricus, n. ilioinguinalis,
diaphragma, m. ilio**psoas**, m. quadratus lumborum,
m. transversus abdominis, recessus costodiaphragmaticus

pvala@lf1.cuni.cz

Illustrations:

Gray´s Anatomy,

Sobottův atlas anatomie člověka, Grada, 2007

Grim, Druga: Základy anatomie, 5. díl

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Lecture of doc. Naňky

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