

Applied Anatomy of the Genitourinary Tract

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Skeletal

Skeletal Anatomy

Ribs

Vertebral Bodies

Pelvis

Skeletal

Ribs

**Ribs 6-10 connected by cartilaginous
costal arch**

Ribs 11 and 12 not joined

Costal groove - intercostal vessels and nerve
└─→ **on inner inferior surface**

Netter 171, 231

Skeletal

Vertebral Bodies

T₁₁₋₁₂, L₁₋₅, Sacrum, Coccyx

Spinal Nerves

**Spinal nerves named for vertebral body just
above its foramen of exit**

**Spinal cord terminates at L₁₋₂
Nerves continue as cauda equina**

Skeletal

**Lumbar cord is at T₁₁ - L₁
vertebral levels**

**Sacral cord is at L₁₋₂ vertebral
levels**

Netter 149

Skeletal

Pelvis

Innominates - ilium
- ischium
- pubis } **- Paired**

Sacrum

Netter 231

Skeletal

Pelvic Foramina

Within bone - 1. Obturator foramen

Formed by ligaments - sacrotuberous

**(ischial tuberosity to
sacrum / coccyx)**

- **sacrospinous (ischial spine to lower sacrum)**

- ## **- 2. Greater sciatic foramen**

- ### - 3. Lesser sciatic foramen

Netter 331

Skeletal

Division of Pelvis

False pelvis - bowl shaped

- formed by iliac fossa
- in contact with intraperitoneal contents

True pelvis - entered directly through a low midline incision

Arcuate line of ilium - part of what divides true from false pelvis

Hinman 10.2

Musculature

Abdominal Wall

Skin and Sub Q

Musculature

Anterior abdominal wall

Anterolateral abdominal wall

Posterior abdominal wall

Pelvis

Musculature

Skin and Subcutaneous fascia

Camper's fascia - loose layer of fatty tissue beneath skin

Scarpa's fascia - deep to Camper's
- superior/lateral - blends with Camper's
- inferior - fuses with fascia of thigh
- medially - continuous with Colle's

Colle's fascia - continuous with Scarpa's and dartos
- till posterior edge of UG diaphragm

Dartos fascia - superficial layer of penis & scrotum
- continuous with Colle's and Scarpa's

Netter 354

Musculature

Anterior Abdominal Wall

Rectus Muscle - from pubic crest to ribs 5, 6, 7

Aponeurosis of ext. and int. oblique and transversus abdominus

Rectus Sheath
above arcuate line
anterior - ext/int oblique
posterior - int/transversus
below arcuate line - anterior all

Arcuate line = 2/3 distance from pubis to umbilicus

Netter 232, 233, 234

Musculature

Anteriolateral Abdominal Wall

External oblique - fibers run caudal/medial
- free inferior border is the inguinal ligament
- portion continues as external spermatic fascia

Internal oblique - upper fibers run cranially
- lower fibers run medially
- form part of conjoint tendon
- portion continues as cremaster muscle

Transversus abdominus - fibers run medially
- lowest fibers form conjoint tendon

Intercostals - external/internal
- connect ribs

Netter 232, 233, 234

Musculature

Posterior Abdominal Wall

Outer Layer - Latissimus dorsi
- External oblique

Middle layer - Internal oblique
- Serratus posterior inferior
- Sacrospinalis

Inner layer - Quadratus lumborum
- Iliacus

Innermost layer - Psoas
- Diaphragm

Hinman 8.5b

Musculature

Posterior Abdominal Wall - outer layer

Latissimus dorsi - Triangular shaped
- Covers most of lower back

External oblique

Petit's triangle - Lat. Dorsi, ext. obl., iliac crest

Netter 237

Musculature

Posterior Abdominal Wall - middle layer

Internal Oblique

Serratus Posterior Inferior

Sacrospinalis

Netter 237

Musculature

Posterior Abdominal Wall - inner and innermost layers

**Inner layer - Quadratus lumborum
- Iliacus**

**Innermost layer - Psoas
- Diaphragm**

Netter 246

Musculature

Layers of a Flank Incision

**Posteriorly - Latissimus dorsi
- ? Serratus posterior inferior**

**Anterolaterally - External oblique
- Internal oblique
(neurovascular bundle)
- Transversus abdominus (+/- rib)
- Transversalis fascia
- Thoracolumbar fascia
- Pararenal connective tissue/fat
- Gerota's fascia
- Perirenal fat
- Kidney**

Netter 237, Hinman 8.5B

Musculature

Layers of Anterior Subcostal or Chevron Incision

External oblique

Internal oblique & rectus

Transversus abdominus

Transversalis fascia

Parietal peritoneum

Netter 235

Musculature

Stratum of Retroperitoneal Tissue

Outer Layer - Investment of body wall muscles (endopelvic fascia, transversalis fascia)

*** Intermediate - Investment of GU tract organs**

Inner - Investment of intestinal tract (Denonvillier' s fascia)

Musculature

Pelvic Musculature

Iliacus

Psoas

Obturator internus

Piriformis

Coccygeus

**Levator ani - puborectalis
pubococcygeus
iliococcygeus** } **Arise from arcus
tendineus and
pubis**

Netter 246, 333, 335

Obturator

Obturator Foramen

Has assumed importance with the advent of transobturator approaches to midurethral sling placement in women

Obturator

Obturator Foramen

Obturator internus muscle

Obturator membrane

Obturator externus muscle

**Obturator nerves and vessels in
superiolateral portion of foramen**

Adductors

**Adductor muscles encountered in
transobturator sling**

Adductor brevis

Adductor longus

Gracilis

Musculature

Perineum and UG Diaphragm

**Male and female almost the same
- only proportions change**

**Urogenital triangle - R and L ischial
tuberosities to symphysis pubis**

Musculature

Perineum

Superficial - superficial transverse
perineal muscles
- ischiocavernosus muscles
- bulbospongiosus muscles
- perineal body
- external anal sphincter
[Bartholin's glands (F)]

Netter 352, 356, 357

Musculature

Perineum

Deep - deep transverse perineal
muscles
- levator ani
- perineal body
- membranous urethra (M)/ext.
urethral sphincter (F)
[Cowpers glands (M)]

Netter 352, 356, 357

Vascular

Vascular Anatomy

Arterial - abdominal
- pelvic

Venous

Lymphatic

Vascular

Arterial - Abdominal Aortic Branches (1)

Inferior Phrenic - superior suprarenals (adrenal)

Celiac Trunk - common hepatic

- gastroduodenal
- right gastroepiploic (stomach & omentum) *(best for pedicle of omentum)
- splenic
- left gastroepiploic (stomach & omentum)
- left gastric

Middle Suprarenals - (adrenal)

Lumbar - 4 pairs

Netter 247, 282

Vascular

Abdominal Aortic Branches (2)

Superior Mesenteric - middle colic (transverse colon)

- right colic (ascending colon)
- intestinal arteries (jejunum & ileum)
- ileocolic (distal ileum, appendix, cecum)

Renal

- inferior suprarenals (adrenal)
- renal divisions (kidney)

Gonadal

- (testis/ovary)

Inferior mesenteric - left colic (descending colon)

- sigmoid (sigmoid)
- rectal (rectum)

[Bifurcation]

Netter 286, 287

Vascular

Arterial - Pelvis (1)

Common Iliacs

Divide at junction of L5 and sacrum

External iliac - inferior epigastric (medial)

- deep circumflex (lateral)
- passes beneath inguinal ligament
- becomes femoral artery

Internal iliac (Hypogastric) - most of pelvic arterial supply

Posterior - ilio-lumbar, lateral sacral

- superior gluteal (gluteal muscles)

* [If ligating hypogastrics - distal to posterior division]

Netter 372, 373

Vascular

Arterial - Pelvis (2)

Internal Iliac - Anterior Division

- Obturator
- Umbilical
 - obliterated umbilical
 - superior vesical (bladder)
- (Vaginal/uterine [near ureter])*
- * - inferior vesical (bladder/prostate)
- * - internal pudendal - leaves pelvis through
Alcock's canal
 - penile
 - perineal

Netter 373, 374

Vascular

Veins

In most cases parallel arteries

**Exceptions - left gonadal and adrenal veins
empty into left renal vein**

**In many cases multiple veins (plexuses)
accompany single arteries**

Netter 248

Vascular

Lymphatics (1)

Retroperitoneal (testis/kidney)

- 1 - Left paraortic
- 2 - Interaortocaval
- 3 - Right paracaval

Left testis tumors metastasize to 1 and 2

Right testis tumors may metastasize to all

Hinman 3.4, Campbells 2-11, 2-12

Vascular

Lymphatics (2)

**Pelvic (prostate/bladder)
Internal/external iliac
Obturator**

**Inguinal (scrotum/penis)
Superficial - external to
fascia lata
Deep - along femoral vessels**

Netter 249

Neuro

Neuroanatomy

Somatic - Motor and Sensory

Thoracic

Lumbar

Sacral

Autonomic

Neuro

Thoracic

- Intercostals 6-12**
- Abdominal wall**

Neuro

Lumbar plexus

- **Iliohypogastric** - S - lower abdomen, pubis
 - M - lower abdominal wall
- **Ilioinguinal** - S - upper thigh, base of penis, upper scrotum
 - travels in inguinal canal
- **Lateral femoral cutaneous** - S - ant/lat upper leg
- **Genitofemoral** - S - cord, scrotum, ant. thigh
 - M - cremaster and dartos muscles
- **Femoral** - S - anter/med leg
 - M - psoas, iliac, knee extensors
- **Obturator** - M - thigh adductors
- **Sciatic** - S/M - posterior thigh and lower leg

Netter 462, 463 Hinman 4.11, 4.12

Neuro

Lumbar plexus - cautions !

- **Genitofemoral** - lies directly atop psoas - don't injure in psoas hitch
- **Femoral** - hidden by body of psoas proximally
 - may be injured by retractors
 - loss of knee extension and ant/med thigh sensation
- **Obturator** - may be injured during pelvic LAD
 - loss of thigh adduction
- **Sciatic** - passes posterior to sacrospinous ligament
 - may be injured during SSF
 - exaggerated lithotomy may stretch

Neuro

Sacral plexus

- **Sciatic** - see above
- **Posterior femoral cutaneous**
 - **perineal branch** - S - perineum & posterior scrotum
- **Pudendal nerve** - perineal
 - post. scrotal
 - dorsal nerve of penis/ clitoris
- **Nervi erigente** - to autonomic plexus (parasympathetic)

Netter 381

Neuro

Autonomic

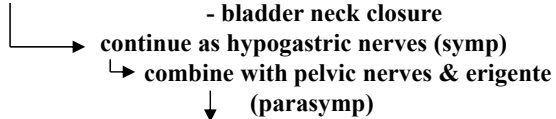
(much more detailed than current presentation)

Celiac & Superior mesenteric plexus

- adrenal/kidney/upper ureter

Superior hypogastric - largely sympathetic - lumbar roots

- seminal emission
- bladder neck closure



Inferior hypogastric (pelvic) plexus - lateral to rectum

Netter 322, 387

Neuro

Inferior hypogastric (pelvic) plexus

Midpoint at tip of seminal vesicles

Multiple prostatic/rectal/vesical blood vessels penetrate

Prostatic innervation

Neurovascular bundles - cavernous nerves

Inguinal Canal

Contains

- Males - spermatic cord plus
- Females - round ligament plus

3 Sides

- anterior - external oblique fascia
- posterior - transversus abd and transversalis fascia
- inferior - inguinal ligament

Hesselbach's triangle

- borders - inferior epigastrics
- margin of rectus muscle
- inguinal ligament

Indirect hernia - lateral to triangle

Direct hernia - through triangle

Netter 243

Femoral triangle

Base - inguinal ligament

Lateral - sartorius

Medial - adductor longus

Floor - iliopsoas and pectineal muscles

Femoral triangle - contents - (NAV)

Lateral - femoral nerve
↓
Medial - femoral artery
femoral vein

- covered by fascia lata
- opening in fascia lata - fossa ovalis through which superficial vessels and saphenous vein emerge
- sentinel node (Cabana) jxn. of saph vein and super. ext. pudendal vein (penile Ca)
- fascia lata divides deep and superficial nodes

Netter 466, 244

Adrenal

Adrenal

Arterial supply - superior - inferior phrenic
- medial - from aorta
- inferior - from renals

Venous drainage - left - to left renal vein
- right - short vein to IVC

2 distinct sections - adrenal cortex (G, F, R)
- adrenal medulla

Within Gerota's fascia

Kidney

Kidneys - Anatomic Relations

Anterior

Right

Adrenal

Left

Adrenal Liver

Spleen Duodenum

Stomach Colon

Pancreas

Jejunum

Colon

Posterior

Left

Diaphragm

abdominus fascia

Quadratus lumborum, Psoas

Left

Rib 11

Right

Right &

Rib 12,

Transversus

Campbells 2-25

Kidney

Gerota's Fascia

1. Intermediate stratum
2. Perinephric fat is within
3. Anterior = Toldt's; Posterior = Zuckerkindl's

Laterally/Superiorly - Fused

Medially - Fused over great vessels but contiguous with contralateral side

Inferiorly - open potential space

Kidney

Renal Pedicle - VAP

Anterior



Posterior

Vein

Artery

Pelvis

- At L 1-3

- Below take off of SMA

Kidney

Renal Vasculature

- **Main renal artery**
- **Segmental arteries (5)**
 - **Interlobar arteries**
 - **Arcuate arteries**
 - **Interlobular arteries**
 - **Afferent arteriole**

Netter 315

Kidney

Segmental Branches - end arteries

Posterior (1st branch) - prior to hilum

Apical
Upper
Middle
Lower

} **Anterior**

Avascular plane - separates anterior
branches from posterior
- posterior to convex border

Hinman 12.34

Kidney

Veins in Kidney

- **Accompany arteries**
- **Intercommunicate**
- Right renal vein - short to IVC**
- Left renal vein - receives adrenal and gonadal V.**
 - **crosses anterior to aorta,**
 - posterior to SMA**

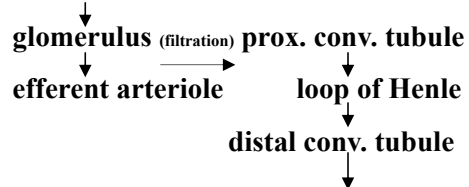
Kidney

Microanatomy

Cortex - nephrons

Medulla - collecting ducts

Nephron - afferent arteriole (from interlobular)



collecting tubule

Netter 317

Kidney

Renal Collecting System

- typically 7-9 **papillae** (tip of pyramid)
- each papilla cupped by a **minor calyx**
(may have more than one papilla per minor calyx)
- minor calyces connected by necks, **infundibulae**, to form 2 or 3 **major calyces**
- major calyces coalesce to form **renal pelvis**

Netter 313

Ureter

Ureters 22 - 30 cm long

Relations

Psoas in retroperitoneum

Crosses iliac vessels near iliac bifurcation

Pelvis

Females

- * behind ovary
- * behind uterine artery (* sites of injury at hysterectomy)
- * cervix
- * vaginal wall

Males

behind vas
deferens

Netter 320

Ureter

Ureters - blood supply

Multiple feeding branches

**renal artery } gonads
upper ureteral } supply is medial aorta**

**iliacs
(uterine) } lower ureteral supply is lateral
vesical arteries }**

**After reaching ureter -longitudinal anastomosing
plexuses**

Campbells 2-46

Ureter

Ureteral Caliber

3 areas of narrowing *

*** UPJ - 2mm**

Abdominal - 10mm

*** Iliacs - 4mm**

Pelvic - 4-6mm

*** UVJ - 3-4mm**

Campbells 2-47

Bladder

Bladder - Innervation

Sympathetic - T₁₀ - L₂

- hypogastric N. (trigone, BN)

Parasympathetic - S₂₋₄

- pelvic N. - (bladder body)

Somatic - S₂

- pudendal N. (external sphincter)

Hinman 13.35, 13.36

Bladder

Bladder - Vasculature

Superior vesical pedicle - superior vesical artery
(from internal iliac)
(obliterated umbilical artery)
from same branch

Inferior vesical pedicle - inferior vesical artery
(usually from internal iliac
or internal pudendal)

Hinman 13.33

Bladder

Bladder - relations

- Adults - pelvic organ children - more abdominal
- Covered superiorly by peritoneum
- Posterior - males - rectum; females - vagina
- Anterior - potential space to pubis - space of Retzius
- 3 muscular layers - outer longitudinal
 - middle circular
 - inner longitudinal
- trigone - ureteric musculature to vesical neck

Netter 342

Prostate

Prostate

- Vitals -**
- Weight - 18 grams
 - Length - 3-4 cm
 - Width - 4 cm
 - Depth - 2 cm
- Relations**
- Anterior-space of Retzius/puboprostatic ligaments
 - Anterolateral-endopelvic fascia
 - Lateral-fatty tissue/levator ani/NVB
 - Posterior-Denonvilliers fascia/rectum
 - Superior-bladder/seminal vesicles
 - Inferior-urogenital diaphragm

Netter 358

Prostate

Prostate - Zonal Anatomy

Transitional zone - 5 - 10% of normal vol.

- gives rise to BPH
- 20% of CAP

Central zone - 20% of normal volume

- surrounds ejaculatory ducts
- 1-5 % of CAP

Peripheral zone - 75 % of normal volume

- 70 % of CAP

Primarily
proximal
to veru.

Campbells 3-28

Prostate

Prostate - Vascular

Arterial - inferior vesical

- prostatic branch
- urethral branches
- perpendicular to urethra near BN
- turn parallel to urethra
- supply BPH adenoma
- capsular branches
- part of NVB
- gives off rami to prostate

Venous

- prostatic plexus (Santorini's)
- inflow from deep dorsal vein of penis
- drains primarily to internal iliac
- communicates with vertebral veins -

(Batson's plexus)

Netter 374

Prostate

Prostate - Neural/Lymphatic

Innervation - via inferior hypogastric plexus

- both sympathetic (hypogastric)
and parasympathetic (pelvic)

Lymphatic drainage - primary - internal iliac
chain

Prostate

Seminal Vesicals

5 cm in length

**Fuses with ampulla of vas to form
ejaculatory ducts**

Vasa Deferentia

Arises from tail of epididymis
Posterior to cord vessels
Leaves internal ring and runs extraperitoneally
Passes above ureter
Dilated terminal vas = Ampulla

Blood supply - vesiculodeferential artery
- a branch of superior vesical
Innervation - from inferior hypogastric (pelvic)
plexus - mostly sympathetic

Netter 358

Urethra

Urethra

Male

Prostatic	}	posterior
Membranous		
Bulbar	}	anterior
Penile		
Glanular		

Anterior urethra - within corpus spongiosum
- openings of multiple small glands

Urethra

Urethra

Blood supply - dual supply

- internal pudendal artery
 - common penile A
 - bulbourethral artery
 - dorsal artery - terminates at glans
 - circumflex branches

Campbell's 3-38

Urethra

Urethra - Female

- 4 cm long
- Many small glands
 - distally grouped to form Skene's glands
- Mucosa/submucosa form cushion to increase closure pressure
- Anterior to vaginal tissues

Female pelvic floor

Female pelvic floor

Prevents abdominal/pelvic organs from falling out
Controls storage and evacuation of feces
Allows conception and parturition

Two components

Viscerofascial layer – connective tissue
endopelvic fascia
Muscular layer – levator ani muscle

Female pelvic floor

Viscerofascial layer

Cardinal ligaments —→ apex

Uterosacral ligaments —→ apex

Pubocervical fascia —→ bladder/pelvic side walls

Prerectal fascia —→ rectum/pelvic side walls

Pubovisceral muscles

Levator ani - from pubis to coccyx – sling like

Pubococcygeous – connects immobile structures
-little contribution to support

Puborectalis – attached to lateral vaginal walls
-penetrates rectal wall

Ileococcygeous – horizontal sheet

Female pelvic floor

Pelvic floor prolapse

Cystocele – bladder prolapse

Enterocoele – apical prolapse
frequently with bowel

Rectocele – rectal prolapse

Penis

Penis

Paired Corpora Cavernosa

- Attached proximally (via crura) to pubic arch
- Distal 3/4 closely apposed
- Distally evaginate glans

Corpus Spongiosum

- Encloses urethra
- Terminates to join glans

Netter 356

Penis

Penis

Corpora Cavernosa

- Enclosed by tunica albuginea
- Filled with erectile tissue - vascular spaces
- Divided by septum
 - distally vascular spaces communicate
- Buck's fascia surrounds corporal bodies
 - dorsal nerves/arteries/vein within Buck's
- dartos fascia surrounds Buck's

Corpus Spongiosum

- Enclosed by tunica albuginea and Buck's
- Minimal vascular communication with corpora cavernosa

Netter 355

Penis

Penis - Arterial Supply

- Internal pudendal artery
 - penile artery (via *Alcock's canal*)
 - cavernosal arteries - corp. cavernosa
 - bulbourethral - spongiosum
 - dorsal artery - cavernosal branches
 - circumflex
 - glans
 - femoral artery
 - external pudendal arteries
 - superficial penile arteries (supplies shaft skin)

Campbell 3-38

Penis

Penis - Venous Return

Superficial - superficial veins join

- superficial dorsal vein
 - saphenous vein

Intermediate - glans, c. spong. distal 2/3 c. cavern

- retrocoronal plexus
- circumflex veins
 - deep dorsal vein
 - prostatic plexus

Deep - prox 1/3 c. cavern, bulb

- cavernous v. → internal pudendal
- bulbar v. → prostatic plexus
- crural v. → both of above

Hinman 16.31

Penis

Penis - Innervation

Somatic

Pudendal nerve (via Alcock's canal)

————→ **dorsal nerve of penis**

Autonomic

Inferior hypogastric (pelvic) plexus

————→ **cavernous nerves**

Testis

Testis and Epididymis

4 - 5 cm in length

Volume - 30 cc

Covered by tunica albuginea

Arterial supply -testicular artery (from aorta)

- vasal artery (from sup. vesical A.)

Venous return - pampiniform plexus

└──→ **gonadal vein**

right —→ IVC

left —→ renal vein

Netter 362

Testis

Testis and Epididymis

Seminiferous tubules

- rete testis

- efferent ductules

- convoluted epididymal duct

- ductus deferens

Cranial portion of epididymis - globus major/head

Caudal portion of epididymis - globus minor/tail

Netter 362

Testis

Scrotal Layers

(Testis)

Tunica albuginea

Tunica Vaginalis (visceral)

Tunica Vaginalis (parietal)

Internal spermatic fascia

Cremasteric muscle and fascia

External spermatic fascia

Dartos muscle

Scrotal skin

Netter 362

Scrotal Blood Supply

Laterally – inferior external pudendal artery – off of femoral artery (external iliac)

Medially – superficial perineal artery – branch of internal pudendal artery (internal iliac)