Use of Laparoscopy in management of Urological Malignancies
Experimental study and clinical evaluation

Thesis Submitted in Partial Fulfillment
For the M.D. Degree in Urology

By

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Introduction

The era of endo-oncology has arrived!!

The start of the era of Laparoscopic surgery is considered to be in the 1980s due to revolution in video camera systems at that time.This started in 1987 when Mouret completed the first cholecystectomy laparoscopically which revealed the advantages of laparoscopic surgery, such as smaller incisions, decreased recovery time, less complication, less analgesic use and reduced hospital stay ***(Brandon et al., 1991).***

After that, Laparoscopic urologic surgery started to establish its role in the management of most of urologic diseases. Since the first laparoscopic nephrectomy was reported by Clayman et al. in 1990, ***(Clayman et al., 1991)*** breakthroughs have been made in laparoscopic surgery of the urinary system. Very quickly thereafter, a laparoscopic prostatectomy in 1992, ***(Schuessler et al., 1992)*** a laparoscopic partial nephrectomy in 1993**,** ***(Winfield et al., 1993)*** and an in vivo renal transplant in 1995 were completed and reported ***(Ratner et al., 1995).***

Why the delay?

Since that pioneering reports, the field of urologic laparoscopy has continued to expand and will be limited only by the imagination of interested urologists and the continuous improvement of instruments.

Reports from the literature have indicated that minimally invasive surgery (MIS); including laparoscopy and Robotic surgery can be applied to almost all open surgeries of the genitourinary system. But technical issues and the requirement of a high level of laparoscopic skill have limited the wide acceptance of the laparoscopic approach.

Based on the experience with urinary system laparoscopy accumulated in the past decade, laparoscopic surgery has developed from diagnosis to treatment, from simple resections to complicated reconstructive surgeries, and from treating benign disease to treating malignant disease ***(Gill, 2001)***.

Laparoscopic management of urologic malignancies had started by simple procedures as nephrectomy and pelvic lymph node dissection. Nowadays, laparoscopic and robotic surgeries represent a main line for management of most of urologic malignancies. Presently, there is no organ of the genitourinary system that has not been impacted by MIS ***(Fergany et al., 2001)***.

Is there any benefit from MIS for malignancies?

The benefits of laparoscopy compared to standard open surgery include less pain, less blood loss, faster healing time, smaller incisions, less scarring, less hospital stay and better magnified intraoperative visualization.

Additionally, reduced narcotic usage and the shorter hospitalization may lower the overall incidence of adverse events, especially in susceptible patients, such as the elderly. ***Laparoscopy for urologic malignancies*** continues to be an exciting and continually changing environment ***(Higashihara, 2002)***.

In this study we will focus on the application of laparoscopy in management of some urological malignancies including; solid renal tumors, transitional cell carcinoma of the urinary tract (kidney, ureter and bladder) and other bladder malignancies.

As a management of these types of malignancies; laparoscopic partial nephrectomy, laparoscopic radical nephrectomy, laparoscopic nephroureterectomy and laparoscopic radical cystectomy were performed.

Anatomical Considerations

A clear and confident understanding of surgical anatomy and anatomic interrelationships is a prerequisite for performing laparoscopic surgery. Anatomy is considered the map that should be followed till reaching the goal.

Anatomy of the Upper Urinary Tract

The upper urinary tract is contained within the retroperitoneum. ***The retroperitoneal space*** is bound by the diaphragm superiorly; posteriorly and laterally by the musculature of the body wall; anteriorly by the peritoneal envelope and inferiorly it is continuous with the pelvis. The kidneys and ureters lie within the retroperitoneum together with the adrenal glands, as well as vascular, lymphatic, and neural structures (Figure 1).

The anterior retroperitoneum also contains the duodenum, pancreas, and portions of the ascending and descending colon, all in close proximity to the upper urinary tract ***(Sampaio, 2000)***.

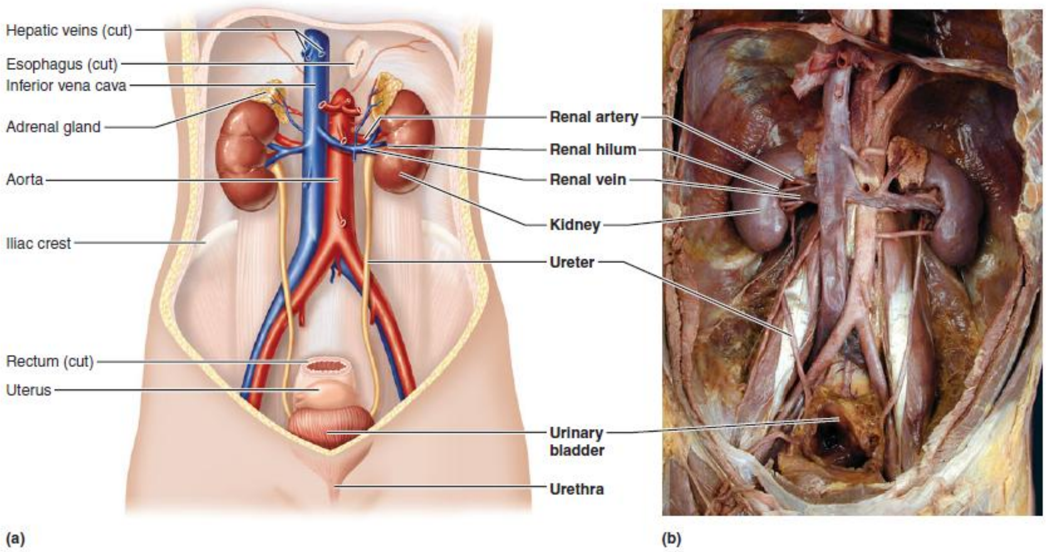

Figure 1: Organs of the Urinary system inside the retroperitoneum. (a) Anterior view in females. (b) Similar dissected view in males ***(Marieb et al., 2012)***.

In order to focus on the laparoscopic anatomy, these topics will be reviewed in the following order: organ (kidney and Ureter), type of approach (Transperitoneal vs. retroperitoneal), and anatomical caveats.

Kidney

General Anatomy:

The kidneys are paired organs lying retroperitoneal (behind the parietal peritoneum) in the superior lumbar region of the posterior abdominal wall. They extend from the level of the 11th or 12th thoracic vertebra superiorly to the 3rd lumbar vertebra inferiorly with the right slightly lower due to the presence of the liver.

The lateral surface of each kidney is convex; the medial surface is concave and has a vertical cleft called the renal **hilum,** where vessels, ureters, and nerves enter and leave the kidney (Figure 2). On the superior part of each kidney lies an adrenal (suprarenal) gland ***(Marieb et al., 2012).***

Several layers of supportive tissue surround each kidney (Figure 2). A thin, tough layer of dense connective tissue called the **fibrous capsule** adheres directly to the kidney's surface. Just external to the renal capsule is the **perirenal fat capsule**, and external to that is an envelope of **renal fascia.** The renal fascia contains an external layer of fat, the *pararenal fat*.

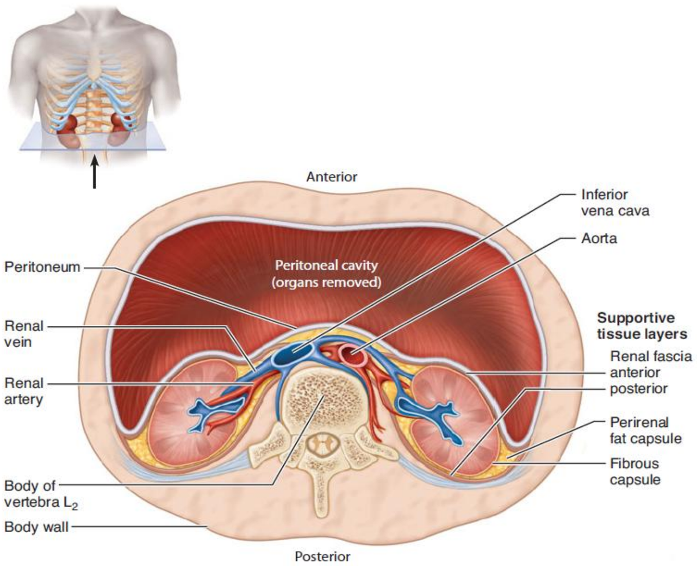

Figure 2: Cross section of the kidney viewed from the inferior direction showing the retroperitoneal position and its supportive tissue layers ***(Marieb et al., 2012).***

Relations of the kidney:

The superior poles of both kidneys related to its suprarenal gland (Figure 3). *The inferior poles* extend to within 2.5 cm of the iliac crests. In *the medial borders*, a deep vertical fissure opens anteromedially as the hilum, which is bounded by anterior and posterior lips and contains the renal vessels and nerves and the renal pelvis. The relative positions of the main hilar structures are the renal vein (anterior), the renal artery (intermediate) and the pelvis of the kidney (posterior).

Usually an arterial branch from the main renal artery runs over the superior margin of the renal pelvis to enter the hilum on the posterior aspect of the pelvis, and a renal venous tributary often leaves the hilum in the same plane. Above the hilum the medial border is related to the suprarenal gland and below to the origin of the ureter.

The convex *anterior surface* of the kidney actually faces anterolaterally and its relations differ on the right and left. Likewise the posterior surface of the kidneys in reality faces posteromedially. Its relations are similar on both sides of the body (Figure 3) ***(Healy & Borley, 2008).***

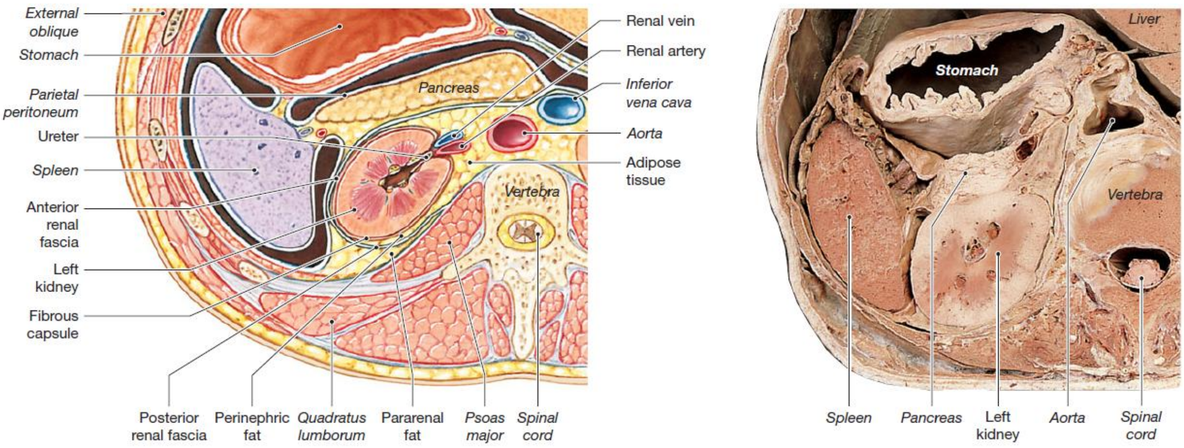

Figure 3: Diagrammatic cross section, as viewed from above, at the level of the kidney ***(Martini et al., 2012).***

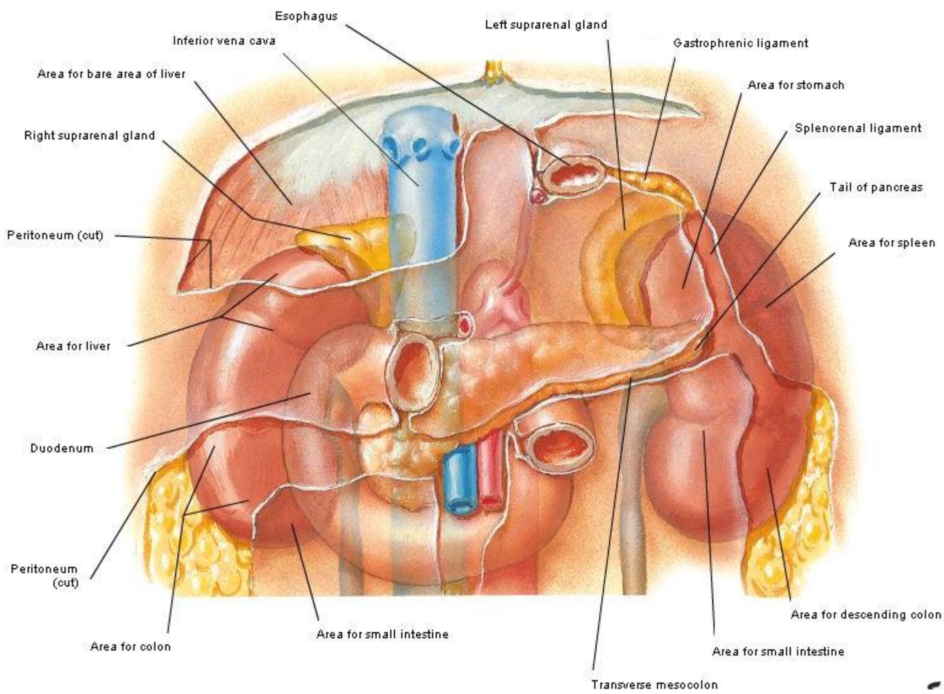

Figure 4: The Anterior relations of the Kidney ***(Netter, 2011).***

Anterior relations

The right suprarenal gland overlaps a small area of the upper part of the medial border of the superior pole. A large area below this is immediately related the right lobe of the liver separated by a layer of peritoneum (Figure 4). A narrow medial area is directly related to the retroperitoneal descending part of the duodenum. Inferiorly the anterior surface is directly in contact laterally with the retroperitoneal right colic flexure and medially with part of the intraperitoneal small intestine ***(Healy & Borley, 2008).***

A small medial area of the superior pole is related to the ***left*** suprarenal gland. The lateral half of the anterior surface is related to the spleen but separated by a layer of peritoneum. A central quadrilateral area lies in direct contact with the retroperitoneal pancreas and the splenic vessels. Above this a small variable triangular region, between the suprarenal and splenic areas, is in contact with the stomach separated by a layer of peritoneum. Below the pancreatic and splenic areas, a narrow lateral strip which extends to the lateral border of the kidney is directly related to the retroperitoneal left colic flexure and the beginning of the descending colon. An extensive medial area is related to intraperitoneal loops of jejunum. The gastric area is covered with the peritoneum of the lesser sac (omental bursa) and the splenic and jejunal areas are covered by the peritoneum of the greater sac. Behind the peritoneum covering the jejunal area, branches of the left colic vessels are related to the kidney ***(Healy & Borley, 2008).***

Posterior relations

The posteromedial surface of the kidneys is embedded in fat and devoid of peritoneum. The right and left kidneys are related to similar structures. Superiorly are the diaphragm and the medial and lateral arcuate ligaments (Figure 5). More inferiorly, moving in a medial to lateral direction, are psoas major, quadratus lumborum and the aponeurotic tendon of transversus abdominis, the subcostal vessels and the subcostal, iliohypogastric, and ilioinguinal nerves. The upper pole of the right kidney is level with the 12th rib, and that of the left with the 11th and 12th ribs (Figure 6). The diaphragm separates the kidney from the pleura, which descends to form the costodiaphragmatic recess: diaphragmatic muscle is sometimes defective or absent in a triangle immediately above the lateral arcuate ligament, and this allows perirenal adipose tissue to contact the diaphragmatic pleura ***(Healy & Borley, 2008).***

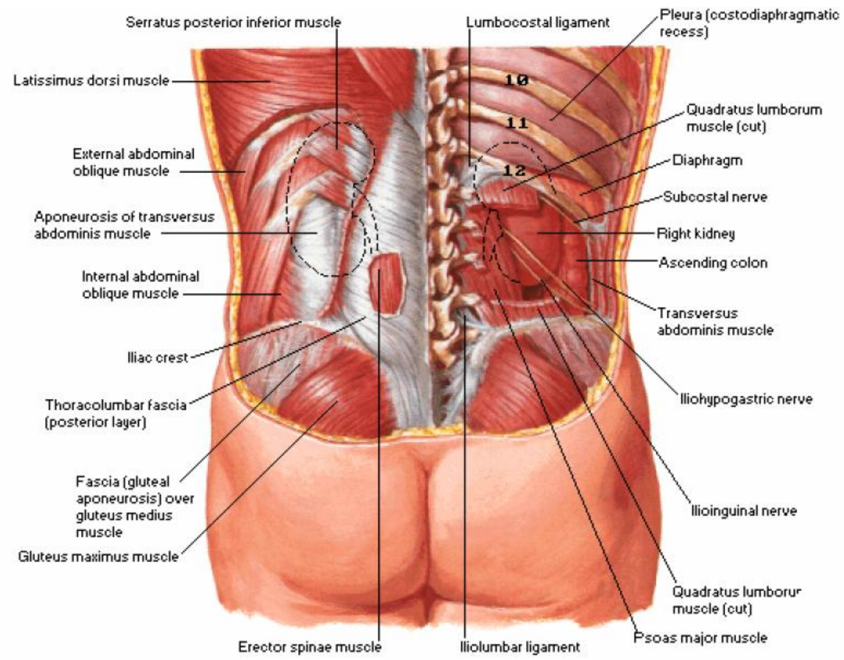

Figure 5: The Posterior relations of the Kidney ***(Netter, 2011).***

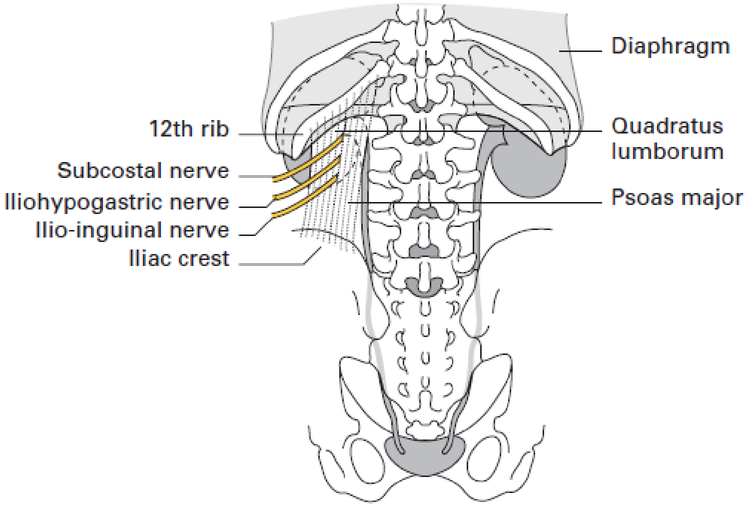

Figure 6: The posterior relations of the Kidney ***(Ellis, 2006).***

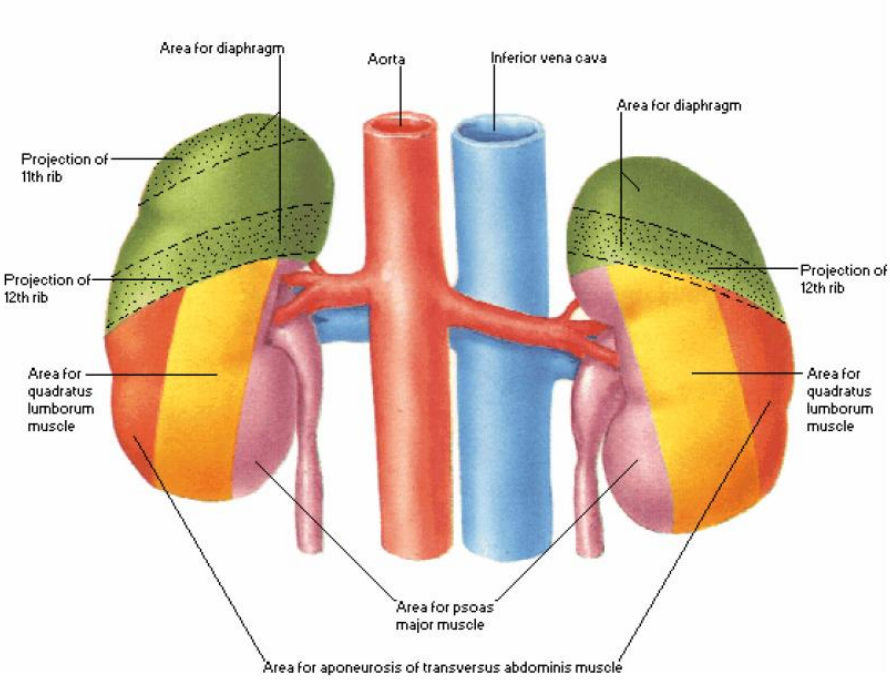

Figure 7: The posterior relations of the Kidney ***(Netter, 2011).***

Vasculature of the Kidney:

Under normal resting conditions, the kidneys receive 20–25 percent of the total cardiac output. In normal individuals, about 1200 ml of blood flows through the kidneys each minute.

Each kidney receives blood from a **renal artery** that originates along the lateral surface of the abdominal aorta nearly at the level of the superior mesenteric artery ***(Martini et al, 2012).***

As the renal artery arises from the abdominal artery and enters the kidney at the renal sinus, it branches into the **segmental arteries (Figure 8)**. Five arterial segments have been identified. The apical, superior (anterior) , inferior , middle (anterior) and posterior. This is the pattern most commonly seen, and although there can be considerable variation it is the pattern that clinicians most frequently encounter when performing partial nephrectomy ***(Novick, 1998).*** Whatever pattern is present, it must be emphasized that vascular segments are supplied by virtual end arteries. In contrast, larger intrarenal veins have no segmental organization and anastomose freely.

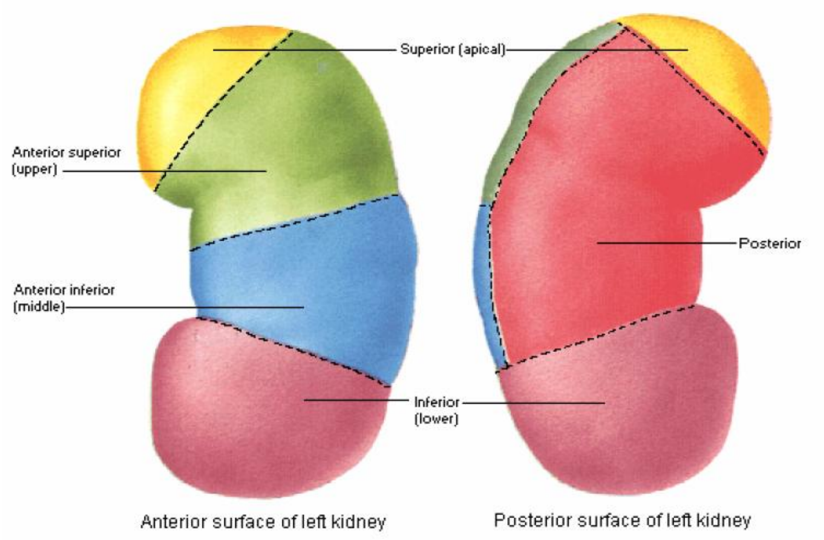

Figure 8: The Segmental arterial supply of the Kidney ***(Netter, 2011).***

There is relatively avascular longitudinal zone (the ‘bloodless' line of Brödel) along the convex renal border, which was proposed as the most suitable site for surgical incision ***(Brodel, 1911).*** However, many vessels cross this zone, and it is far from ‘bloodless': planned radial or intersegmental incisions are preferable. This is important when undertaking partial nephrectomy for renal cell cancers. In this surgery the branches of the renal artery are defined so that the surgeon may safely excise the renal substance containing the tumour while not compromising the vascular supply to the remaining renal tissue ***(Novick, 1998).***

Segmental arteries further divide into a series of **interlobar arteries** that radiate outward, penetrating the fibrous capsule and extending through the renal columns between the renal pyramids into the cortex. The interlobar arteries supply blood to the **arcuate arteries** that parallel the boundary between the cortex and medulla of the kidney. Each arcuate artery gives rise to a number of **cortical radiate arteries,** or interlobular arteries, which supply portions of the adjacent renal lobe. Numerous **afferent arterioles** branch from each cortical radiate artery to supply individual nephrons ***(Martini et al, 2012).***

From the nephrons, blood enters a network of venules and small veins that converge on the **cortical radiate veins,** or interlobular veins**.** In a mirror image of the arterial distribution, the interlobular veins deliver blood to **arcuate veins** that empty into **interlobar veins.** The interlobar veins merge to form the **renal vein**; there are no segmental veins **(Figure 9)** ***(Martini et al., 2012).***

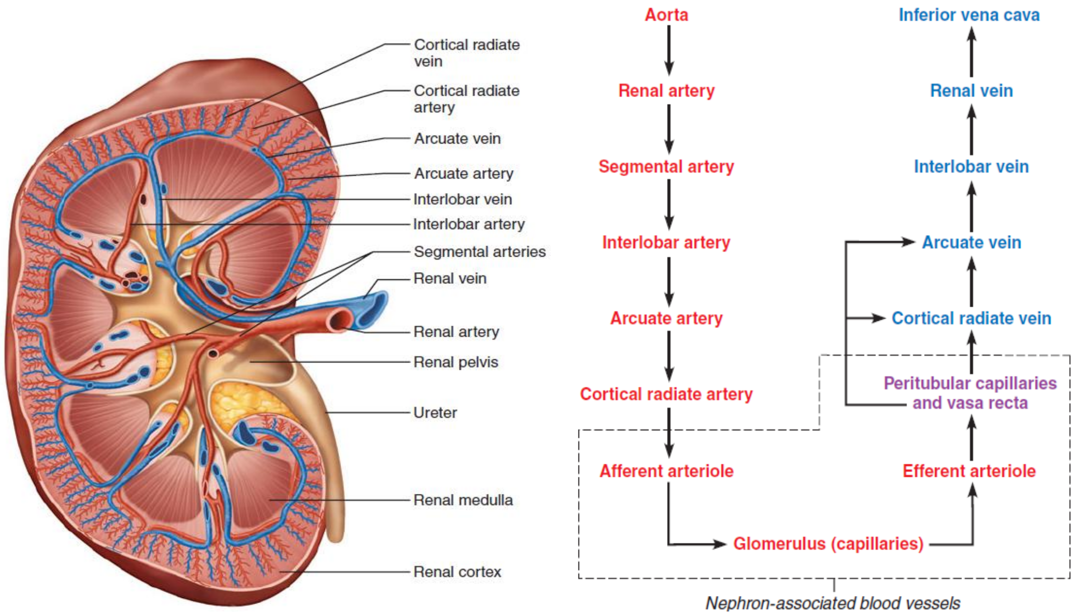

Figure 9: The Blood Supply to the Kidneys ***(Marieb et al., 2012).***

Ureter

The ureters are a pair of muscular tubes that extend inferiorly from the kidneys for about 25-30 cm (10-12 in.) before reaching the urinary bladder. The diameter of the ureter is normally 3 mm, but is slightly less at its junction with the renal pelvis, at the brim of the lesser pelvis near the medial border of psoas major, and where it runs within the wall of the urinary bladder, which is its narrowest part. These are the commonest sites for renal stone impaction. It is continuous superiorly with the funnel-shaped renal pelvis and then comprises its abdominal, pelvic and intravesical portions.

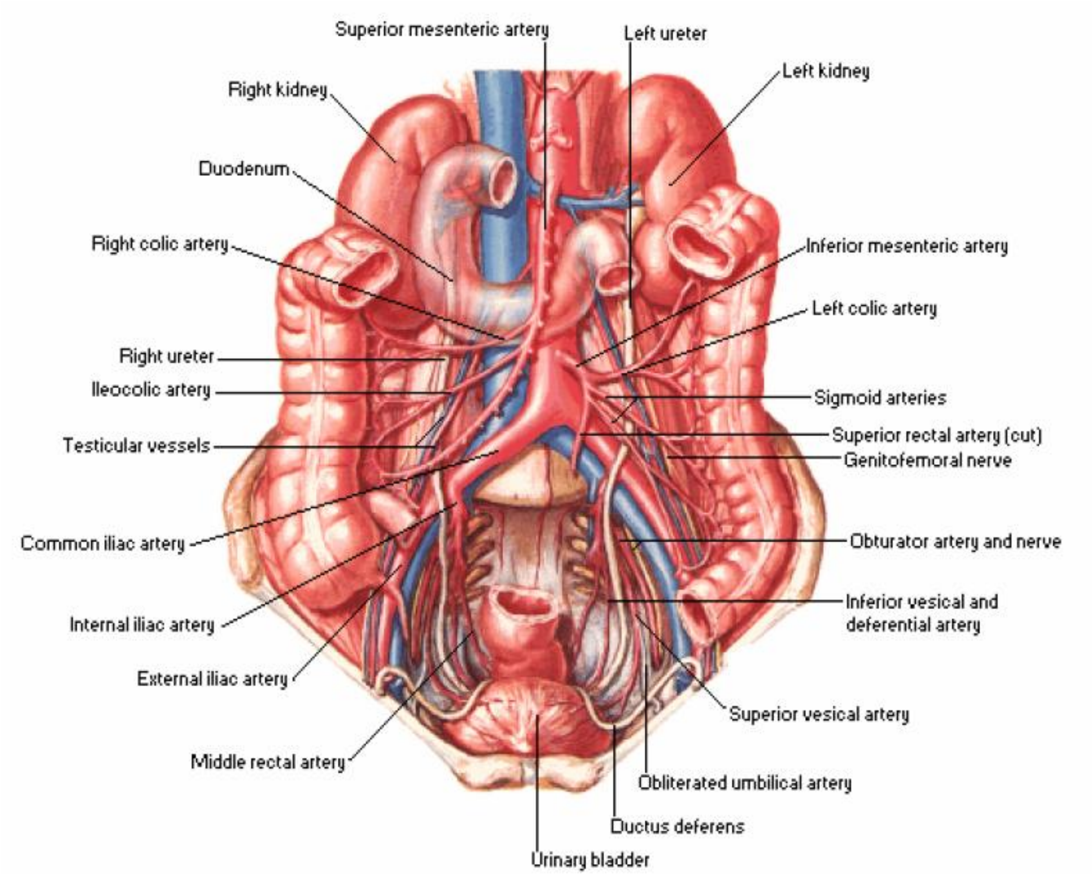

Figure 10: Relations of the Ureter in males ***(Netter, 2011).***

The **abdominal ureter** lies on the medial edge of psoas major (which separates it from the tips of the lumbar transverse processes (L2–L5). During surgery on intraperitoneal structures, the ureter can be tented up as the peritoneum is drawn anteriorly, resulting in inadvertent ureteric injury. It then crosses into the pelvis at the bifurcation of the common iliac artery in front of the sacroiliac joint. Anteriorly, the right ureter is covered at its origin by the second part of the duodenum and then lies lateral to the inferior vena cava and behind the posterior peritoneum. It is crossed by the gonadal (testicular or ovarian), right colic, and ileocolic vessels. The left ureter is crossed by the gonadal (testicular or ovarian) and left colic vessels and then passes above the pelvic brim, behind the mesosigmoid and sigmoid colon to cross the common iliac artery immediately above its bifurcation. The inferior mesenteric vein has a long retroperitoneal course lying close to the medial aspect of the left ureter (Figure 10) ***(Marieb et al., 2012)***

The ***pelvic ureter*** runs on the lateral wall of the pelvis in front of the internal iliac artery and the beginning of its anterior trunk to just in front of the ischial spine; it then turns forwards and medially above levator ani to enter the bladder. Posterior to which are the internal iliac vein, lumbosacral nerve and sacroiliac joint.

Laterally it lies on the fascia of obturator internus. It progressively crosses to become medial to the umbilical, inferior vesical, and middle rectal arteries. *In the male,* the pelvic ureter hooks under the vas deferens, then passes in front of and slightly above the upper pole of the seminal vesicle to traverse the bladder wall obliquely before opening at the ipsilateral trigonal angle **(Figure 10)**.

In females, the pelvic part at first has the same relations as in males, but anterior to the internal iliac artery it is immediately behind the ovary, forming the posterior boundary of the ovarian fossa. In the anteromedial part of its course to the bladder it is related to the uterine artery, uterine cervix and vaginal fornices. It is in extraperitoneal connective tissue in the inferomedial part of the broad ligament of the uterus where it may be damaged during hysterectomy.

In the broad ligament, the uterine artery is anterosuperior to the ureter for 2.5 cm and then crosses to its medial side to ascend alongside the uterus. The ureter turns forwards slightly above the lateral vaginal fornix and is generally 2 cm lateral to the supravaginal part of the uterine cervix in this location. It then inclines medially to reach the bladder, with a variable relation to the anterior aspect of the vagina. As the uterus is commonly deviated to one side, one ureter, usually the left, may be more extensively apposed to the vagina, and may cross the midline **(Figure 11).**

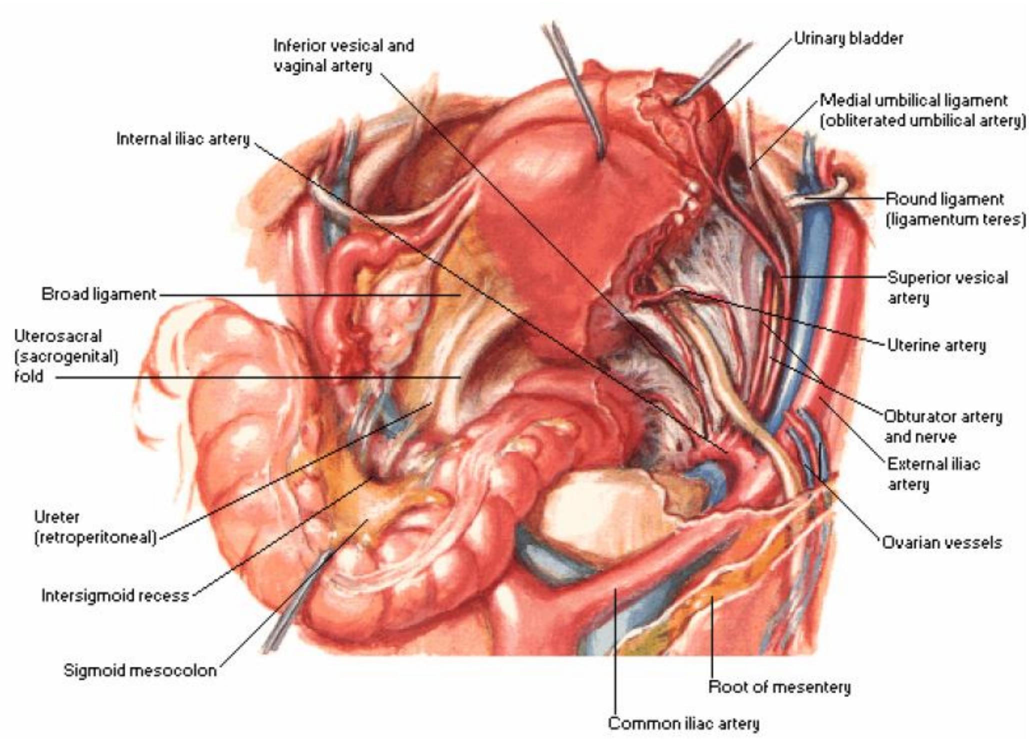

Figure 11: Relations of the pelvic Ureter in females ***(Netter, 2011).***

Superior view

The ***intravesical ureter*** passes obliquely through the wall of the bladder for 0.75 in (2 cm); the vesical muscle and obliquity of this course produce respectively a sphincteric and valve-like arrangement at the termination of this duct ***(Healy & Borley, 2008).***

Blood supply:

The ureter is supplied by branches from the renal, gonadal, common iliac, internal iliac, vesical and uterine arteries, and the abdominal aorta.

The abdominal ureter is supplied from vessels originating medial to the ureter, while the pelvic ureter is supplied by vessels lateral to the ureter. There is a good longitudinal anastomosis between these branches on the wall of the ureter, which means that the ureter can be safely transected at any level intraoperatively without compromising its viability. The branches from the inferior vesical artery are constant in their occurrence and supply the lower part of the ureter as well as a large part of the trigone of the bladder (Figure 12). The branch from the renal artery is also constant and is preserved whenever possible in renal transplantation to ensure good vascularity of the ureter ***(Healy & Borley, 2008).***

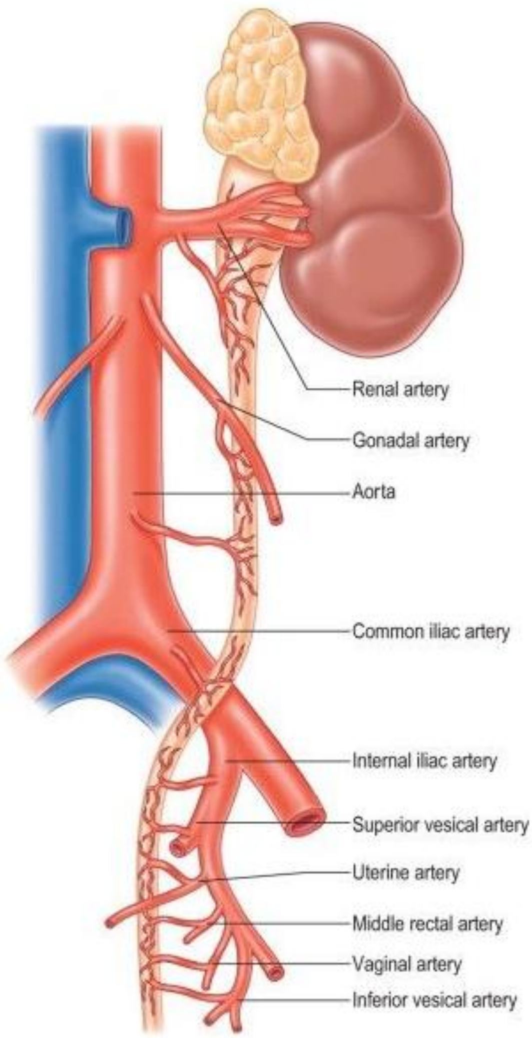

Figure 12: Blood supply of the ureter *(Walsh et al., 2008)*