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ANATOMY OF THE RETROPERITONEAL SPACE: IMPLICATIONS FOR SURGICAL ACCESS TO THE KIDNEY AND UPPER URINARY TRACT

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ABSTRACT

Background: Surgical management of upper urinary tract pathologies requires precise knowledge of retroperitoneal anatomy. This study evaluated the impact of different surgical approaches on perioperative complications and clinical outcomes.

Methods: A retrospective single-center study was conducted on 84 adult patients who underwent upper urinary tract surgery in 2023 at Hassan II University Hospital, Fez.

Results: Open surgery was the predominant approach (97.6%, n=82), favoring the lateral retroperitoneal lumbotomy route (75.6%) over the transperitoneal route (24.4%). Minimally invasive laparoscopy represented 2.4% of cases (n=2). The overall mean length of hospital stay was 5.7 days. Complications occurred exclusively within the open surgery cohort—intraoperative (5.9%) and postoperative (7.1%)—primarily during operations for oncological pathologies and complex inflammatory stone disease.

Conclusion: Mastery of retroperitoneal anatomy remains crucial for safe open surgery. Expanding the adoption of laparoscopic and minimally invasive techniques is essential to minimize perioperative morbidity while maintaining optimal oncological and functional outcomes.

Keywords: Retroperitoneal Space, Retroperitoneal Anatomy, Lumbotomy, Transperitoneal Approach, Upper Urinary Tract Surgery

1 INTRODUCTION

The retroperitoneal space (RPS) is an anatomically complex region divided into a medial compartment (containing major vascular and nervous structures) and two lateral compartments (housing the adrenal and urinary organs). In urology, the wide diversity of local pathologies—including neoplasms, urolithiasis, and congenital malformations—demands a thorough mastery of retroperitoneal surgical anatomy to plan optimal surgical access and minimize perioperative morbidity. Access to the upper urinary tract traditionally relies on either the anterior transperitoneal approach or the lateral retroperitoneal lumbotomy, both of which are increasingly supplemented by minimally invasive modalities.

This study presents the clinical experience of the Department of Urology at Hassan II University Hospital in Fez, Morocco, through a retrospective analysis of 84 patients operated on in 2023. We aimed to evaluate the impact of the selected surgical approach on clinical outcomes and perioperative complications to refine surgical safety strategies.

2 MATERIALS AND METHODS

Following institutional ethics committee approval, we retrospectively reviewed the medical records of 84 consecutive adult patients who underwent surgery for upper urinary tract conditions (kidney and/or upper tract) at the Department of Urology, Hassan II University Hospital (Fez, Morocco) between January and December 2023. Patient medical records were retrieved through the hospital information system (Hosixnet).

The collected variables included:

- **Demographics:** Age and sex.
- **Surgical Indications:** Non-functioning ("silent") kidney, urolithiasis, ureteropelvic junction obstruction (UPJO), renal tumors, upper tract urothelial carcinoma (UTUC), and simple renal cysts.
- **Operative Details:** Surgical approach (open vs. minimally invasive), patient positioning, and incision type.
- **Clinical Outcomes:** Length of hospital stay (LOS), intraoperative complications, and postoperative complications.

2.1 Preoperative Protocol and Exclusion Criteria

All patients underwent routine preoperative evaluation for comorbidities alongside contrast-enhanced computed tomography (CT) for precise anatomical mapping and surgical planning. Based on imaging findings and pathology characteristics, patients underwent open surgery (anterior transperitoneal or lateral retroperitoneal lumbotomy) or minimally invasive laparoscopy.

2.2 Exclusion Criteria

- Incomplete clinical records.
- Exclusively endoscopic or percutaneous procedures (e.g., percutaneous nephrolithotomy (PCNL), nephrostomy, renal biopsy, percutaneous drainage).
- Concomitant upper and lower urinary tract surgeries.
- Surgeries involving non-urological retroperitoneal structures.

3 RESULTS

3.1 Patient Demographics and Indications

Out of 819 patients hospitalized in the department during 2023, 84 (10.25%) met the inclusion criteria. The mean patient age was 53.7 years (range: 17–83 years), with a female predominance of 57% (n = 48; male-to-female ratio: 0.75). The disease was right-sided in 55% (n = 46), left-sided in 44% (n = 37), and bilateral in 1% (n = 1).

Surgical indications were distributed as follows:

- Non-functioning/silent kidney: 30% (n = 25)
- Urolithiasis: 24% (n = 20)
- Ureteropelvic junction obstruction (UPJO): 20% (n = 17)
- Renal tumors: 17% (n = 14)
- Simple renal cysts: 3.5% (n = 3)
- Upper tract urothelial carcinoma (UTUC): 3.5% (n = 3)

- Renal hydatid disease: 2% (n = 2)

3.2 Surgical Approaches (Table 1)

Open surgery represented the primary management strategy (97.6%, n = 82), whereas laparoscopy accounted for 2.4% (n = 2); no direct retroperitoneoscopic (lumboscopic) procedures were performed.

The lateral retroperitoneal approach via lumbotomy (performed in lateral decubitus with a 12th rib incision) was the preferred open route, accounting for 76.8% of open surgeries (n = 63). It was used mainly for silent kidneys (n = 22), stone disease (n = 19), all UPJO cases (n = 17), and UTUC (n = 2).

Table 1: Surgical Indications by Approach

Surgical Indications	Open Surgery: Transperitoneal Approach	Open Surgery: Retroperitoneal Approach	Minimally Invasive Surgery: Laparoscopy
Renal tumor	14 (16.7%)	---	---
UTUC (Upper tract urothelial carcinoma)	1 (1.2%)	2 (2.4%)	---
Silent kidney	3 (3.6%)	22 (26.1%)	---
Renal lithiasis	1 (1.2%)	19 (22.6%)	---
Renal cyst	---	1 (1.2%)	2 (2.4%)
Renal hydatide cyst	---	2 (2.4%)	---
UPJO (Ureteropelvic junction obstruction)	---	17 (20.2%)	---

The anterior transperitoneal approach accounted for 23.1% of open procedures (n = 19). Performed in the supine position via subcostal incisions, it was primarily reserved for oncology (14 cases of renal tumors, 1 complex UTUC), as well as 3 cases of silent kidneys and 1 case of complex stone disease. Minimally invasive laparoscopy (in modified lateral decubitus) was used exclusively for simple renal cysts (n = 2).

3.3 Length of Stay and Complications

The overall mean length of hospital stay (LOS) was 5.7 days (range: 1–57 days). By approach, the mean LOS was:

- **Laparoscopy:** 1.5 days
- **Open transperitoneal surgery:** 5.35 days
- **Open retroperitoneal surgery:** 5.89 days

Intraoperative Complications (5.9%, n = 5): 80% (n = 4) occurred during transperitoneal procedures. These consisted of hemorrhagic events (n = 3), including one subcapsular splenic hematoma rupture requiring emergency splenectomy, and visceral injuries (n = 2: 1 splenic capsular tear and 1 ipsilateral adrenal injury).

Postoperative Complications (7.1%, n = 6): 100% (n = 6) occurred following a retroperitoneal approach. These included infectious complications (n = 3: 2 surgical site infections and 1 infected retroperitoneal hematoma), vascular/hematologic events (n = 2: retroperitoneal compartment hematomas requiring transfusions), and neurological sequelae (n = 1: femoral nerve monoparesis following total nephroureterectomy).

Morbidity by Pathology: Complication rates varied significantly across underlying pathologies: open renal lithiasis surgery yielded the highest morbidity (25% combined intra- and postoperative complications), followed by radical nephrectomy for renal cancer (21% intraoperative events), non-functioning kidneys (n = 2), and radical nephroureterectomy (n = 1). No complications occurred during open pyeloplasty for UPJO, renal cyst marsupialization, or renal hydatid cyst excision.

4 DISCUSSION

The retroperitoneal space **(Figure 1)** is an intricate anatomical region containing adipose tissue, vascular structures, and nerve plexuses, located posterior to the peritoneal cavity and anterior to the posterior abdominal wall [1]. Its anatomical boundaries comprise superiorly the diaphragm, inferiorly the pelvic extraperitoneal space (communicating directly with the true pelvis), anteriorly the posterior parietal peritoneum, posteriorly the lumbar spine and axial musculature (psoas major, quadratus lumborum, and iliacus), and laterally the lateroconal fascia.

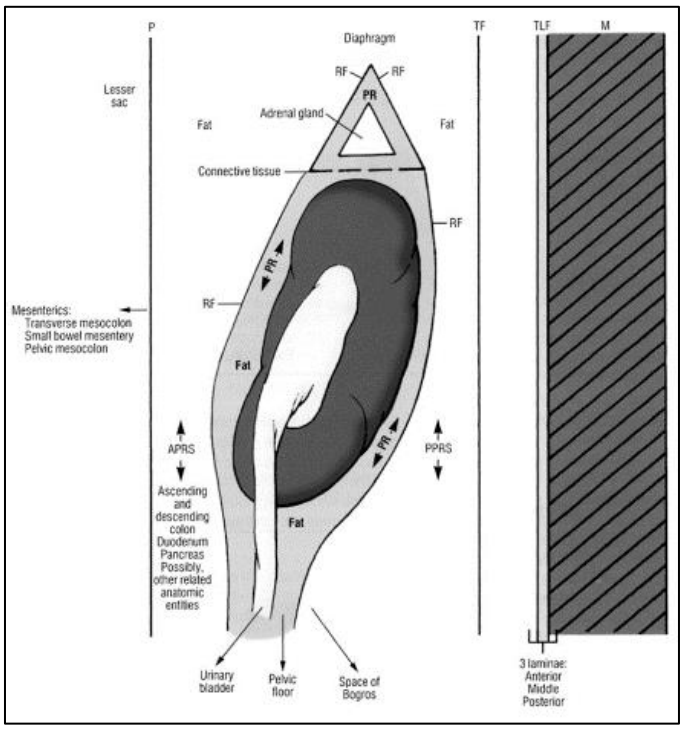

Figure 1: Retroperitoneal spaces (highly diagrammatic). PR, perirenal space; RF, renal fascia (Gerota's); P, peritoneum; APRS, anterior pararenal space; PPRS, posterior pararenal space; TLF, thoracolumbar fascia; TF, transversalis fascia; M, muscles. [1]

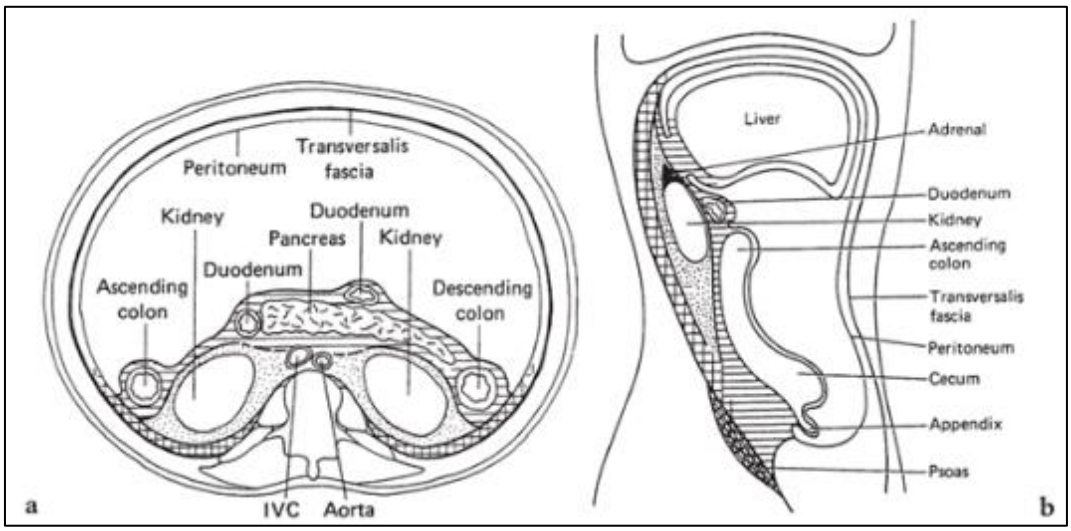

Figure 2A: Axial diagram at level of kidneys. B, Sagittal diagram in plane of right kidney. Three major retroperitoneal compartments are shown: anterior pararenal space (striped), perirenal space (stippled), posterior pararenal space (cross-hatched) [1]

Figure 3 : Anatomical dissection of the kidneys, major retroperitoneal blood vessels (aorta and inferior vena cava), and perirenal fat (Department of Anatomy, Faculty of Medicine and Pharmacy of Fez)

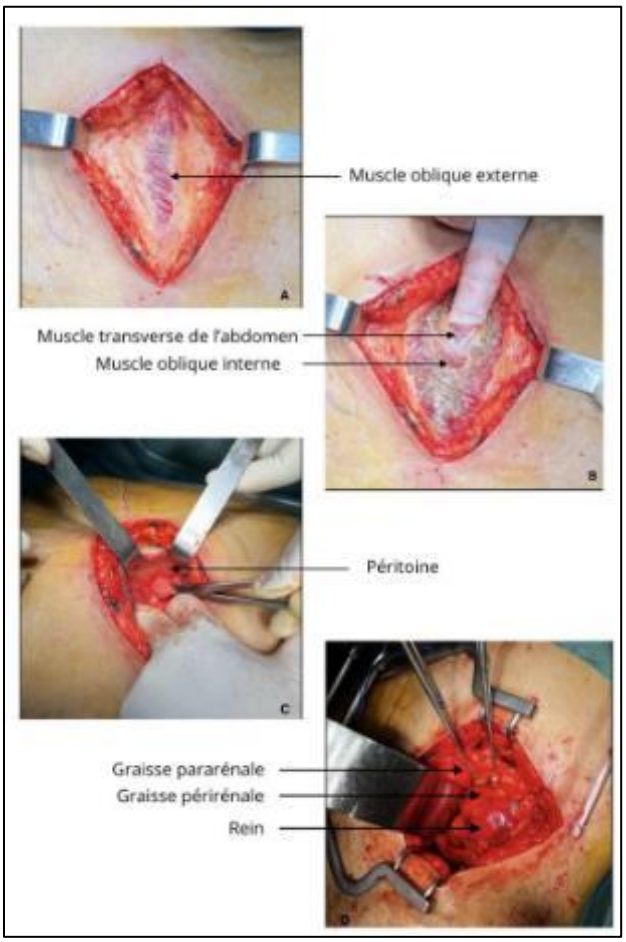

Figure 4: Surgical View of a Lumbotomy: Layer-by-Layer Dissection, A: External oblique muscle, B: Internal oblique and transverse muscles, C: Retraction of the peritoneum after its release from the muscular attachments, D: Opening of the renal fossa (operating room, department of urology)

In the sagittal plane along the transverse processes, the retroperitoneum is subdivided into two primary topographic zones **(Figure 2)**:

- **Medial Retroperitoneal Region:** Positioned anterior to the vertebral column, housing the abdominal aorta, inferior vena cava, retroperitoneal lymph nodes, and autonomic nervous plexuses.
- **Lateral Retroperitoneal Region:** Paired spaces containing the primary urological target organs (kidneys, adrenal glands, and ureters) **(Figure 3)**. This space is further divided into three distinct compartments by the anterior (Gerota's) and posterior (Zuckerkandl's) renal fascial layers:
    - *Perirenal Space:* Encloses the kidney, adrenal gland, renal pedicle, and perirenal fat.
    - *Anterior Pararenal Space:* Located anterior to Gerota's fascia, containing secondary retroperitoneal organs (duodenopancreatic complex, ascending and descending colon).
    - *Posterior Pararenal Space:* Situated posterior to Zuckerkandl's fascia, composed predominantly of retroperitoneal fat.

Surgical exposure of these retroperitoneal compartments relies on three primary approaches [2]:

- **Open Transperitoneal Access:** Performed via subcostal, midline, or chevron incisions. It remains the classical choice for high-complexity oncological resections due to immediate, direct access to the renal vascular pedicle. However, it exposes patients to intraperitoneal complications, such as paralytic ileus and adhesive bowel obstruction.
- **Open Extra-peritoneal Access (Lumbotomy) (Figure 4):** Performed via subcostal or trans-rib (11th or 12th rib) incisions [3,4]. It is highly effective for benign conditions (complex stones, UPJO, or non-functioning kidneys) because it completely avoids the peritoneal cavity, eliminating intestinal morbidity. The main drawbacks include post-lumbotomy pain, flank wall weakness/atony, intercostal neuralgia, or pleural injury.
- **Minimally Invasive Approaches (Laparoscopy / Robotics):** Encompassing transperitoneal laparoscopy, retroperitoneoscopy (lumboscopy), and robotic-assisted techniques [5,6]. These approaches offer documented advantages, including minimal blood loss, lower analgesic consumption, and significantly shorter hospital stays (averaging 1.5 days).

For renal cell carcinoma, partial nephrectomy via minimally invasive routes is the gold standard for T1a masses to maximize parenchymal preservation and reduce cardiovascular mortality [7]. In our cohort, extended radical nephrectomy was performed in 93% of renal tumor cases, reflecting late-stage clinical presentations at diagnosis. Similarly, for high-risk UTUC, radical nephroureterectomy with a bladder cuff excision remains standard, whereas segmental ureterectomy is restricted to low-risk or solitary kidney cases [8,9].

For benign pathologies, simple nephrectomy for non-functioning kidneys frequently required a subcapsular approach due to dense perirenal inflammatory adhesions secondary to chronic pyelonephritis [10]. Although international guidelines strongly recommend minimally invasive endourology (e.g., PCNL, flexible URS) or laparoscopic surgery for complex urolithiasis [11], conventional open lumbotomy remains widely used locally to prevent peritoneal contamination and manage severe chronic inflammatory tissue alterations **(Table2)**

Evaluating surgical complications highlights the safety profile of these procedures alongside the inherent morbidity of open access in complex inflammatory environments:

- **Oncological Cases:** The 21% complication rate in our radical nephrectomy series (primarily intraoperative bleeding and inadvertent adrenal trauma) aligns with published literature for open radical nephrectomy in locally advanced stages [19].
- **Inflammatory and Lithiasic Conditions:** Non-functioning kidneys demonstrated a 12% complication rate, whereas open surgery for renal lithiasis carried the highest morbidity (25%), predominantly driven by surgical site infections and retroperitoneal hematomas requiring transfusions [20].
- **Reconstructive and Cystic Disease:** Open pyeloplasty for UPJO and laparoscopic cyst decortication yielded zero perioperative complications in our series, however, these findings do not establish superiority over published series, particularly given the small laparoscopic subgroup (n = 2).

Table 2: Results of Laparoscopic Treatment for Kidney Cysts

Series	Number of Patients	Surgical Approach	Complications	Type	Follow-up (months)
Rubenstein et al. [12]	8	Retroperitoneal (1) Transperitoneal (7)	1	Ileus Lumbar paresthesia	10
Brown et al. [13]	15	Transperitoneal	1	Incisional hernia	12
Denis et al. [14]	8	Retroperitoneal (1) Transperitoneal (7)	1	Hemorrhage (conversion), then urinary fistula	8
Roberts et al. [15]	32	Retroperitoneal (12) Transperitoneal (20)	4 (13%)	Ureteral stricture	18.1
Yoder et al. [16]	18	Transperitoneal	1	Pyelonephritis	52
Gupta et al. [17]	24	Retroperitoneal	0	None	34
Atug et al. [18]	45	Transperitoneal	1	Hemorrhage (conversion)	58
Our study	2	Transperitoneal	0	None	12

5 CONCLUSION

A comprehensive mastery of retroperitoneal anatomy is the cornerstone of upper tract urological surgery, directly influencing surgical approach selection, safety, and therapeutic success. Our findings highlight the complementary roles of transperitoneal access—essential for early vascular control in complex oncological cases—and retroperitoneal lumbotomy, valued for avoiding peritoneal contamination in benign inflammatory states. Expanding the adoption of minimally invasive laparoscopic and robotic platforms remains key to reducing surgical morbidity and length of stay while maintaining oncological and functional outcomes.

STATEMENTS ON COMPLIANCE WITH ETHICAL STANDARDS

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Disclosure of conflict of interest

The authors declare no competing interests

Statement of informed consent

Written informed consent was obtained from the patient's legal guardian for the publication of this case report and any accompanying images.

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