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IATROGENIC RENAL INJURY DURING PCNL

Ahmed Kamal Khazaal[1]*, Yousif Salim Khalaf[2], Hayder I. Jawad[3] and Ehab Jasim Mohammad[4]

[1]MBChB, FIBMS, Al-Karama Teaching Hospital, Iraq.
[2]MBChB, FIBMS (Urology), Fellow in Renal Transplantation Surgery, Ibn Sina University of Medical and Pharmaceutical Sciences, Iraq.
[3]MBChB, FICMS (Urology), FRCS (Glasgow), Head of Al-Yarmouk Urology Training Center, Iraq.
[4]MBChB, FICMS, FEBU, FABMS, FRCS (Glasgow), FACS Consultant Urologist (Endourology Subspecialty), Department of Surgery, College of Medicine, Ibn Sina University of Medical and Pharmaceutical Sciences, Baghdad, Iraq.

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***Corresponding Author: Ahmed Kamal Khazaal**
MBChB, FIBMS, Al-Karama Teaching Hospital, Iraq.

ABSTRACT

Background: PCNL is a popular minimally invasive treatment for eliminating big renal calculi. Iatrogenic injuries during PCNL can include bleeding, renal vein injury, and organ damage, but the surgery is normally safe. Improving surgical safety and results requires identifying these injuries' occurrence and kinds. This study will investigate intraoperative and postoperative iatrogenic injuries during PCNL in a multicenter Endourology setting in Iraq to improve surgical accuracy and patient safety. **Methods**: A retrospective multicenter study was conducted from February 2020 to February 2024, evaluating 6,278 patients who underwent PCNL. Among them, 35 cases of iatrogenic injuries were identified. Patients were monitored intraoperatively for access-related injuries, vascular injuries, ureteric and colonic injuries, tract dilation complications, and torque-related trauma. Postoperatively, patients were assessed for urinoma, pleural effusion, continuous urinary leakage, and bleeding. **Results**: Of the 6,278 PCNL procedures, iatrogenic injuries occurred in 35 cases (0.6%). The most common complication was tract dilatation injury (28.6%), followed by access-related injuries (20%) and bleeding (14.3%). Less frequent injuries included torque-related trauma (8.6%), continuous urinary leakage (11.4%), and urinoma (5.7%). Rare complications, such as renal vein injury, ureteric injury, colonic injury, and pleural effusion, accounted for 2.9% each. **Conclusion**: PCNL remains a safe and effective procedure with a low incidence of iatrogenic injuries. The majority of complications are preventable through precise surgical techniques, careful patient selection, and adherence to anatomical landmarks. Continuous refinement of surgical approaches can further minimize complications and improve patient outcomes.

KEYWORDS: Iatrogenic, Renal Injury, PCNL.

INTRODUCTION

Percutaneous nephrolithotomy (PCNL) is a minimally invasive procedure used to remove renal stones through a small percutaneous tract, typically about 1 cm in diameter. It is the preferred treatment for kidney stones larger than 2 cm, particularly those located near the renal pelvis.[1] PCNL offers superior stone clearance rates, with success rates reaching up to 95% in appropriately selected patients.[2] According to the American Urological Association (AUA) guidelines, PCNL remains the gold-standard treatment for managing staghorn calculi due to its high efficacy in achieving complete stone clearance compared to other modalities.[3] The technique was first introduced in 1976 by Fernström and Johansson.[4] Anatomically, the left kidney is slightly larger than the right, with an average length of 11.21 cm compared to 10.97 cm for the right kidney.[5] Within the kidney, the upper pole is generally broader, more medial, and positioned posteriorly relative to the lower pole.[6] When accessing the kidney for PCNL, caution is necessary to avoid injury to adjacent structures, including the liver, spleen, diaphragm, pleura/lung, and colon.[7] The adult kidney contains approximately 8–9 calyces, which may be oriented anteriorly or posteriorly. Posterior calyces are typically preferred for PCNL access due to their proximity to the skin and their facilitation of improved intrarenal navigation.[8] The renal arterial system comprises a larger anterior division and a smaller posterior division, both of which further divide into segmental and lobar arteries.[9] The safest site for

calyceal puncture is at the center of the calyx to minimize the risk of vascular injury. Puncturing the renal infundibulum or pelvis may lead to significant bleeding due to damage to major arterial branches.[10] The optimal access route follows Brodel's line, an avascular plane between the anterior and posterior arterial branches, reducing the risk of hemorrhagic complications.[11] The anatomical arrangement of renal calyces follows two primary patterns: Brödel-type and Hodson-type. The Brödel configuration features a longer posterior calyx with a 20-degree angle relative to the frontal plane, while the shorter anterior calyx is oriented at 70 degrees. This configuration is observed in approximately 69% of right kidneys. In contrast, Hodson-type kidneys have posterior calyces at a 70-degree angle and larger anterior calyces at a 20-degree angle, a pattern found in about 79% of left kidneys.[12] Knowledge of these anatomical variations is crucial for optimizing access and minimizing complications during PCNL. This study is to evaluate, in a multicenter Endourology environment in Iraq, the occurrence and treatment of iatrogenic injuries during PCNL. Its main goal is to find intraoperative and postoperative problems thereby enhancing surgical results and patient safety.

Method

This multicenter study was conducted in Endourology centers across Iraq over a four-year period, from February 2020 to February 2024. A total of 6,278 patients who underwent percutaneous nephrolithotomy (PCNL) were evaluated, among whom 35 patients experienced iatrogenic injuries during the procedure.

All patients were closely monitored intraoperatively for potential injuries related to different stages of PCNL, including

- Access-related injuries: Complications arising from the use of access needles and Alken needles.
- Vascular injuries: Bleeding and renal vein injury.
- Ureteric and colonic injuries: Damage sustained during access or instrument manipulation.
- Dilatation-related injuries: Trauma occurring during tract dilation.
- Torque-induced injuries: Complications resulting from excessive instrument torque.

Postoperative follow-up included monitoring for the development of:

- Urinoma
- Pleural effusion
- Continuous urinary leakage
- Postoperative bleeding

Patients were observed for early detection and management of complications, ensuring optimal outcomes. Data collection was standardized across centers to maintain consistency and accuracy in reporting intraoperative and postoperative complications.

RESULTS

The data from Table 1 highlights that out of 6,278 PCNL procedures performed over four years, only 35 cases (1%) resulted in iatrogenic injuries. This indicates that PCNL is a highly safe procedure with a very low complication rate (99% of cases were free from iatrogenic injuries), reflecting good surgical precision and patient safety**.**

Table 1: Iatrogenic injuries during PCNL.

Category	Number of Patients	Percentage
Total Patients	6278	99%
Iatrogenic Injury	35	1%

Table 2 categorizes the types of iatrogenic injuries observed during PCNL. The most common injury was related to tract dilatation (10 cases, 28.6%), followed by access-related injuries (7 cases, 20%) and bleeding (5 cases, 14.3%). Less frequent complications included continuous leak (4 cases), torque-related injury (3 cases), and urinoma (2 cases). Renal vein injury, ureteric injury, colonic injury, and pleural effusion were the least common, each occurring in only 1 case (2.9%). This distribution underscores the importance of careful dilation techniques and precise access to minimize complications.

Table 2: Categorizes the types of iatrogenic injuries observed during PCNL.

Injury Type	Number of Cases	Percentage
Access needles, Alken needle	7	20.0%
Bleeding	5	14.3%
Renal vein injury	1	2.9%
Ureteric injuries	1	2.9%
Urinoma	2	5.7%
Colonic injury	1	2.9%
Continuous leak	4	11.4%
Pleural effusion	1	2.9%
Dilatation	10	28.6%

Torque	3	8.6%

DISCUSSION

Percutaneous nephrolithotomy (PCNL) is associated with various complications, primarily hemorrhagic, infectious, thoracic, and organ injuries. Preoperative, intraoperative, and postoperative hemorrhagic complications occur in about one-third of PCNL cases.[13] The need for blood transfusion ranges between 0-20%, with an overall rate of 7%.[14] Risk factors include multiple punctures, large bore access sheaths, staghorn calculi, and prolonged surgery.[13] Hemorrhage may result from venous or arterial injury, arteriovenous fistula, or pseudoaneurysm.[13] Tamponade by the access sheath can often control bleeding, but severe cases may require aborting the procedure, nephrostomy tube placement, or selective embolization.[15] Delayed hemorrhage, occurring in 1.2% of cases, is often due to pseudoaneurysm or arteriovenous fistula.[16] Life-threatening hemorrhage from major renal vessel injury may necessitate nephrectomy.[17]

Post-PCNL fever occurs in 2.8-32.1% of cases, and urosepsis, though rare, is a severe complication.[14] Risk factors include preoperative bacteriuria, renal abnormalities, prolonged operative time, and high irrigation pressure.[18] Preoperative urine culture and antibiotic prophylaxis reduce infection risks.[19] A meta-analysis found prophylactic antibiotics significantly decrease postoperative urinary infection rates.[20] Cases with purulent urine should be postponed and treated with antibiotics before PCNL.[15] Pneumothorax, hydrothorax, hemothorax, and urinothorax are rare (<2%) and result from pleural puncture [21]. Supracostal punctures (above the 12th rib) are associated with higher risk.[20] Small pneumothoraxes typically resolve without intervention, while significant hydrothorax or urinothorax requires drainage.[17] Persistent nephrocutaneous fistula occurs in 1.5-4.6% of cases, with risk factors including large nephrostomy tubes and prolonged catheterization.[22] Injuries to the pelvicalyceal system may cause urine extravasation or urinoma (5.2% incidence), usually managed conservatively with nephrostomy or ureteral stents.[14] Colonic perforation occurs in 0.5% of cases, more commonly in left-sided PCNL, elderly patients, or those with horseshoe kidneys.[23] Splenic and hepatic injuries are rare, with splenic injuries occurring in supracostal approaches.[24] Computed tomography (CT) is essential for diagnosing complications such as hemorrhage, urinoma, and organ injuries.[25] Preventative strategies include proper patient selection, preoperative imaging, careful dilation techniques, and controlled irrigation pressure. In cases of severe complications, conservative or interventional management, such as embolization or surgical repair, is required.[17]

CONCLUSION

Iatrogenic renal injuries may occur during any stage of PCNL interventions. The risk of significant complication or mortality is low, and percutaneous nephrolithotomy is a well-tolerated procedure. Minor complications, such as transient fever or nephrostomy tube leakage, frequently resolve spontaneously. It is probable that the complication rates will continue to decrease as a result of the continued refinement of the technique, increased utilisation of the procedure, and advancements in PNL technology.

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