Original Article

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Urology Section

Evaluation of Highest Point of Iliac Crest as a Safety Landmark for Supine Percutaneous Nephrolithotomy: A Retrospective Observational Study

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ABSTRACT

Introduction: Colonic injury is a rare but serious complication of supine Percutaneous Nephrolithotomy (PCNL), traditionally mitigated by using the Posterior Axillary Line (PAL) as a safety landmark. However, since the PAL is an arbitrary and variable landmark, it has several limitations. There is a need for fixed and reliable safety landmark to address these limitations.

Aim: To evaluate the highest point of the iliac crest as a potentially reliable alternative safety landmark for preventing colonic injury in supine PCNL.

Materials and Methods: This retrospective observational study was conducted at Shri Mahant Indiresh Hospital, Dehradun, Uttarakhand, India in October 2024. The study included 500 patients with a suspected diagnosis of renal stone disease based on clinical symptoms or ultrasound findings, who underwent Computed Tomography (CT) imaging (CT KUB or CT urography) at the centre between January 2021 to January 2024. The highest point of the iliac crest was evaluated as a potential safety landmark. The incidence of retrorenal and lateral colon positioning and the proximity of the colon to individual renal calyces were assessed. Descriptive statistics were utilised to summarise continuous variables, such as age (mean±SD) and categorical variables, such as colon positioning (frequencies and percentages).

Results: The mean age of the patients was 44.5±12.7 years, ranging from 5 to 89 years. Of these, 313 patients (62.6%) were male and 187 patients (37.4%) were female. The colon was posterior to the line drawn at the level of the highest point of the iliac crest in 39 patients (7.8%) on left side and in 19 patients (3.8%) on right side. Retrorenal colon was observed in one patient (0.2%) on right side and in eight patients (1.6%) on left side. Lateral colon positioning was significantly higher on the left-side (178 patients; 35.6%) compared to the right side (131 patients; 26.2%). Additionally, colon proximity was most common to the lower calyx.

Conclusion: The highest point of the Iliac crest demonstrates promise as a safety landmark for preventing colonic injury in supine PCNL, offering a reliable alternative to the PAL. Larger multicentre studies are needed for further validation.

Keywords: Kidney stones, Retrorenal colon, Supine position

INTRODUCTION

PCNL is the gold standard for treating large and complex renal stones, with success rates reaching up to 90% in clearing stones larger than 2 cm [1]. Over time, the supine position for PCNL has gained increasing popularity due to its advantages, such as enhanced anaesthetic safety, improved cardiovascular stability and the ability to perform simultaneous retrograde interventions [2]. However, despite these benefits, determining a safe and effective puncture site remains one of the most critical challenges in supine PCNL. Colonic injury during PCNL, occurring in 0.2 to 0.8% of cases, is classified as a Clavien-Dindo grade IV complication [3]. If not promptly diagnosed and managed, it can result in severe consequences, including nephrocolic fistula, abscess formation, peritonitis, or sepsis [4].

Traditionally, the PAL has been used as a safety landmark to guide puncture placement and minimise the risk of colonic injury in supine PCNL [5]. However, the selection of PAL as a safety landmark is largely arbitrary and not supported by anatomical studies. Moreover, as the marking relies on soft-tissue landmarks, there is substantial variability among surgeons in interpreting and marking the line, particularly in very thin or obese individuals. Additionally, after painting and draping the patient, the markings of PAL often fade or become obscured, making it difficult to identify or remark the line in a fully draped patient [6].

To address these limitations, authors propose the highest point of the iliac crest as a novel and potentially safe alternative landmark for puncture in supine PCNL. The highest point of the iliac crest, as a fixed bony structure, provides a consistent and easily identifiable anatomical reference point. Present study retrospectively analysed CT scans of 500 patients to assess whether the bowel lies posterior to the highest point of the iliac crest, exploring its potential as a safety landmark. Additionally, the anatomical relationship of the colon to the kidney and the incidence and distribution of retrorenal and lateral colon was also studied. By providing objective data and scientific validation, this study aimed to address the limitations of the PAL and improve the safety and reproducibility of supine PCNL.

MATERIALS AND METHODS

This retrospective observational study was conducted in the Department of Urology at Shri Mahant Indiresh Hospital, Dehradun, Uttarakhand, India in October 2024, following formal approval from the Institutional Ethics Committee (IEC) (SGRR/IEC/06/24).

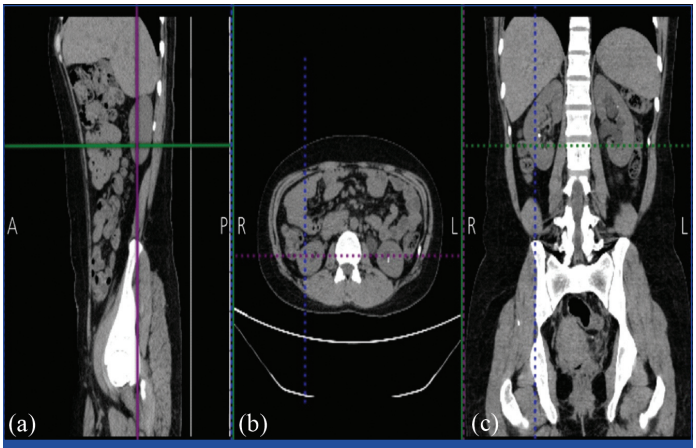
Inclusion criteria: The study included 500 patients with a suspected diagnosis of renal stone disease based on clinical symptoms or ultrasound findings, who underwent CT imaging (CT KUB or CT urography) at the centre between January 2021 and January 2024. Data analysis was conducted in October 2024.

Exclusion criteria: Patients with a history of prior abdominal surgeries, renal anomalies such as horseshoe kidney, or incomplete imaging data were excluded from the study.

Data collection: CT KUB or urography scans from 500 patients were retrieved from the hospital's Picture Archiving and Communication System (PACS). Demographic data, including age and sex, were collected. Additional data from the CT scans included:

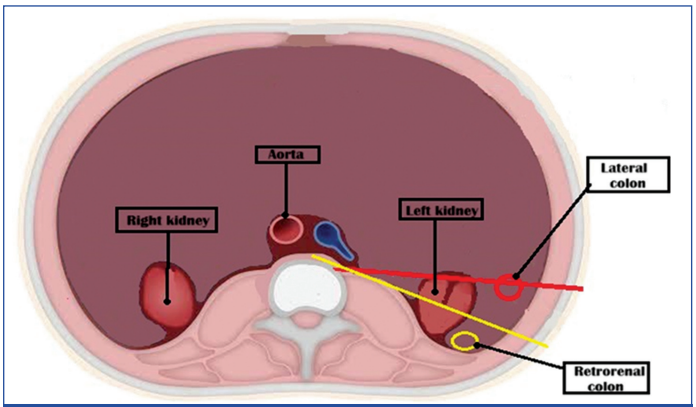
- Stone location (right or left kidney),
- The position of the colon relative to each kidney,
- The alignment of the colon with respect to a straight cranio-caudal line drawn at the level of the highest point of the iliac crest.

CT scan assessment: In the sagittal view, a vertical line was drawn at the level of the highest point of the iliac crest. In multiplanar images, axial scans were checked simultaneously to determine whether any bowel loops were located posterior to this line at the level of each calyx of the kidney [Table/Fig-1].



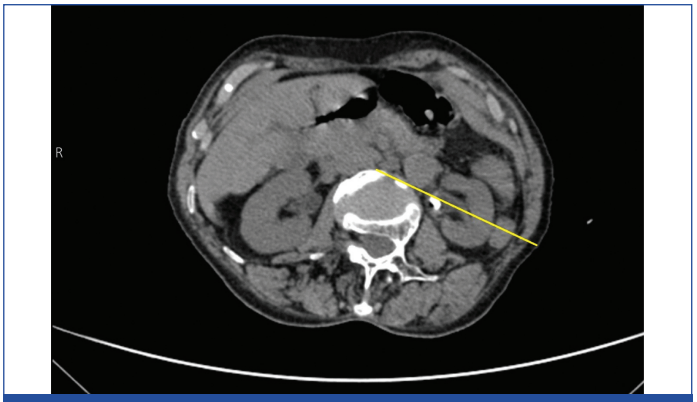
[Table/Fig-1]: a) Note straight craniocaudal line drawn at the level of highest point of iliac crest on right-side (purple solid line); b) Corresponding axial image shows part of ascending colon crossing this line on right-side (purple dotted line); c) Corresponding coronal image shows inferior calyx level (green dotted line).

Graphical representations of the definitions of retrorenal and lateral colon are shown in [Table/Fig-2]. Retrorenal colon positioning was determined by drawing a line from the anterolateral edge of the vertebral body through the middle of the renal hilum and extending it to the abdominal wall surface on the axial scan [Table/Fig-3] [7]. Any part of the colon located posterior to this line was classified as retrorenal.

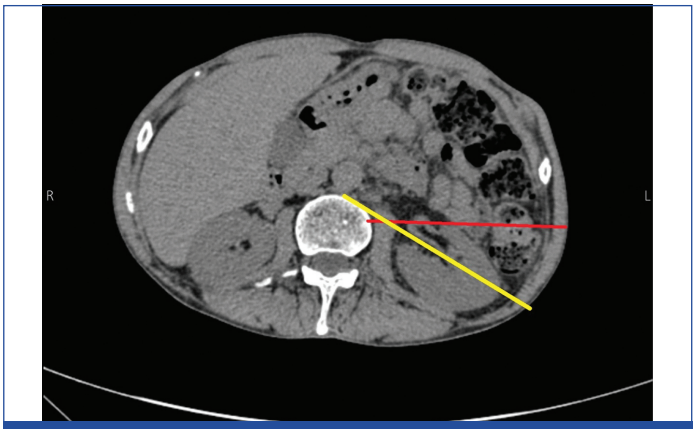


[Table/Fig-2]: Graphical representation of retrorenal and lateral colon. Note yellow line drawn from the anterolateral edge of the vertebral body through the middle of the renal hilum and extending to the abdominal wall surface. Any part of colon lying posterior to this line is termed as retrorenal colon. Note red line drawn through anterior border of kidney. Any part of colon lying between red line and yellow line is termed as lateral colon.

Each scan was further assessed for lateral colon positioning, defined as any part of the colon lying posterior to a horizontal straight line drawn through the anterior border of the kidney on the axial scan (not lying retrorenal) [Table/Fig-4] [8]. Among patients with lateral colon, a horizontal line was drawn at the level of the superior, middle and lower calyces of each kidney using both axial and coronal images to assess which calyx (part of the calyx or the entire calyx) was laterally covered by the colon.



[Table/Fig-3]: Axial images of CT scan showing part of descending colon lying retrorenal on left-side.



[Table/Fig-4]: Axial image of CT scan showing lateral colon on left-side.

STATISTICAL ANALYSIS

The statistical analysis was conducted using the Statistical Package for the Social Sciences (SPSS), version 28.0 (IBM Corp., Armonk, NY, USA). Descriptive statistics were utilised to summarise continuous variables, such as age (mean±SD) and categorical variables, such as colon positioning (frequencies and percentages).

RESULTS

The study analysed data from 500 patients who underwent CT imaging for renal stone disease. The mean age of the patients was 44.5±12.7 years, ranging from 5 to 89 years. Of these, 313 patients (62.6%) were male and 187 patients (37.4%) were female. Regarding stone location, 175 patients (35.0%) had stones exclusively in the right kidney, 203 patients (40.6%) had stones exclusively in the left kidney and 122 patients (24.4%) had stones in both kidneys.

Right kidney findings [Table/Fig-5]: In the right kidney, the colon was found behind the highest point of the iliac crest in 19 (3.8%) patients. When analysing the proximity of the lateral colon to specific calyces, the lower calyx was most frequently associated with colon proximity, observed in 132 (26.4%) patients.

Findings	Right kidney	Left kidney
Number (n)	500	500
Colon behind the highest point of iliac crest	19 (3.8%)	39 (7.8%)
Retrorenal colon	1 (0.2%)	8 (1.6%)
Lateral colon	131 (26.2%)	178 (35.6%)
Upper calyx covered	3 (0.6%)	20 (4%)
Middle calyx covered	34 (6.8%)	98 (19.6%)
Lower calyx covered	132 (26.4%)	167 (33.4%)

[Table/Fig-5]: Results of colon-kidney relationship determined from CT scans.

Left kidney findings [Table/Fig-5]: The colon was found behind the highest point of the iliac crest in 39 (7.8%) patients on the left-side. When analysing the proximity of the lateral colon to specific calyces, the lower calyx was again the most frequently associated, with 167 (33.4%) cases showing colon proximity.

DISCUSSION

Various studies have been conducted to assess the relationship between the colon and the kidney during PCNL. However, this was the first study to explore the use of the highest point of the iliac crest as an alternative safety landmark for supine PCNL, offering a novel approach to minimise colonic injury during renal access. Additionally, present study was unique as it provided a more detailed anatomical description, including not only retrorenal and lateral colon positioning but also whether the colon covers each individual calyx (upper, middle, or lower).

Colonic injury, although rare, is a significant complication of PCNL that can result in serious morbidity, including infections, fistula formation, or even life-threatening peritonitis and sepsis if undetected [4]. Concerns about the potential for higher colonic injury rates with supine PCNL have been alleviated by studies showing no significant difference in complication rates compared to prone PCNL [9,10]. Swami YK and Rana YPS reported colonic perforation in 0.3% of 1,270 PCNL procedures, while Asl Zare M et al., documented a rate of 0.2% in 5260 procedures, both demonstrating the safety of PCNL when performed with proper preoperative imaging and technique [11,12].

Traditionally, the risk of bowel injury during PCNL has been linked to the presence of a retrorenal colon, especially in prone procedures. Given the lower incidence of retrorenal colon in the supine position, it has been assumed that the risk of bowel injury in supine PCNL is theoretically less [13]. However, in the supine position, punctures are typically performed laterally, which may place the colon at risk, even if it is not in a retrorenal position. If the colon is located lateral to the kidney, the trajectory of the puncture needle may pass through or near the colon, increasing the risk of injury.

The PAL is widely used by urologists as a safety landmark for supine PCNL. However, based on our experience, marking this line can be cumbersome and unreliable, particularly in patients who are extremely thin or obese. Ideally, the PAL is marked with the patient in a standing position if PCNL is being performed in a semisupine position [14]. However, this marking often fades after skin preparation and becomes challenging to remark intraoperatively, especially on a draped patient when a second puncture is required [6].

In contrast, marking a line at the level of the highest point of the iliac crest is simpler and more practical. The iliac crest is anatomically closer to the puncture site compared to the axilla, making it more logical to use as a surface landmark for PCNL. Additionally, traditional anatomy teachings state that bony landmarks are more consistent and reliable than soft-tissue landmarks [15]. Moreover, the highest point of the iliac crest is an easily identifiable and highly consistent anatomical landmark, a fact well-established in anaesthesiology for determining the level of lumbar punctures during spinal anaesthesia. These advantages make the highest point of the iliac crest a potential alternative to the PAL as a safety landmark in supine PCNL.

In present study, the colon was located posterior to the highest point of the iliac crest in 7.8% of patients on the left-side and 3.8% of patients on the right side. Thus, in more than 94% of patients undergoing supine PCNL (right and left-sides combined), the colon will not cross the line drawn at the level of the highest point of the iliac crest. However, preoperative CT scans should be reviewed carefully to assess the relationship between the colon and the desired target calyx. The authors in their another study which was prospective and included 82 patients, used the highest point of iliac crest as a safety landmark and did not report any bowel complications [6].

The incidence of retrorenal colon was lower in the supine position (1.9%) compared to the prone position (10%), as reported by Hopper KD et al., [16]. In present study, retrorenal colon positioning was observed in 0.2% and 1.6% of cases on the right and left-sides, respectively, in the supine position.

Lateral colon positioning, a common anatomical variation, poses additional risks during supine PCNL. Hur KJ et al., reported posterolateral and retrorenal colon positioning in 15.7% of supine PCNL cases, compared to 24.5% in prone cases, though their analysis excluded anterolateral colon [8]. Present study demonstrated lateral colon positioning (both anterolateral and posterolateral) in 26.2% of right kidneys and 35.6% of left kidneys, emphasising the higher risk associated with the left kidney. This high incidence of lateral colon underscores the critical importance of reviewing preoperative CT scans to ensure that there is no bowel lying within the desired puncture trajectory while performing fluoroscopy-guided puncture in supine PCNL. In spite of the high incidence of lateral colon, the majority of the patients had two out of three calyces not covered by colon and these calyces could be targeted to ensure safe punctures. However, in rare cases when it is not possible to clear the stone through the safe calyx, as determined by CT images, alternative strategies such as ultrasound-guided puncture, prone PCNL, or Retrograde Intrarenal Surgery (RIRS) should be considered.

Akbulut F et al., in their study including 22 cases of PCNL-related colonic perforation, reported 77.3% of perforations on the left-side [17]. Similarly, Atar M et al., in their study including 1,000 CT scans, concluded that the risk of colonic injury was more likely while puncturing the lower calyx of the left kidney, findings consistent with our study [18]. These results reinforce the need for heightened vigilance when operating on the left kidney, where the risk of colonic injury is inherently higher.

The findings from present study have important implications for surgical planning during supine PCNL:

1. **Preoperative imaging:** Routine CT imaging is essential to identify retrorenal and lateral colon and the images should be properly reviewed preoperatively to ensure that no bowel lies within the desired puncture trajectory.
2. **Safety landmarks:** The highest point of the iliac crest could serve as a safety landmark and prevent bowel injury in more than 94% of cases; however, one should not rely on safety landmarks alone and should combine the use of safety landmarks with CT scan images to ensure adequate safety.
3. **Individualised planning:** The variability in colon positioning necessitates a tailored surgical strategy for each patient, prioritising safety and minimising complications.

Limitation(s)

This study had several limitations. Its retrospective design and single-centre setting may limit the generalisability of the findings. The study primarily focused on anatomical observations without directly assessing clinical outcomes, such as rates of colonic injury or complications. Prospective, multicentre studies are needed to validate the highest point of the iliac crest as a reliable safety landmark in supine PCNL.

Future advancements, such as the real-time integration of imaging with Artificial Intelligence (AI) algorithms, hold the potential to enhance intraoperative decision-making, improve the accuracy of identifying high-risk zones and further refine surgical techniques to ensure optimal patient safety.

CONCLUSION(S)

Present study reinforces the importance of understanding anatomical variations in colon positioning based on CT scan images to optimise patient outcomes in supine PCNL. The highest point of the iliac crest, in conjunction with CT scan images, has the potential to be

used as a reliable safety landmark to prevent colonic injury during supine PCNL. However, large-scale multicentre studies are needed to validate its utility and broader clinical application.

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REFERENCES

[1] Turk C, Petrik A, Sarica K, Seitz C, Skolarikos A, Straub M, et al. EAU guidelines on interventional treatment for urolithiasis. Eur Urol. 2016;69:475-82.
[2] Li J, Gao L, Li Q, Zhang Y, Jiang Q. Supine versus prone position for percutaneous nephrolithotripsy: A meta-analysis of randomized controlled trials. Int J Surg. 2019;66:62-71.
[3] Michel MS, Trojan L, Rassweiler JJ. Complications in percutaneous nephrolithotomy. Eur Urol. 2007;51(4):899-906.
[4] Gerspach JM, Bellman GC, Stoller ML, Fugelso P. Conservative management of colon injury following percutaneous renal surgery. Urology. 1997;49:831-36. Doi: 10.1016/s0090-4295(97)00237-9.
[5] Valdivia Uría JG, Valle Gerhold J, López López JA, Villarroya Rodriguez S, Ambroj Navarro C, Ramirez Fabián M, et al. Technique and complications of percutaneous nephroscopy: Experience with 557 patients in the supine position. J Urol. 1998;160(6 Pt 1):1975-78.
[6] Dixit VK, Vijjan VK, Aggarwal A. A prospective study of supine percutaneous nephrolithotomy with a modified technique: A safe and desirable tool in the armamentarium of urologists. J Clin Diagn Res. 2022;16(3):PC16-PC19.
[7] Prassopoulos P, Gourtsoyiannis N, Cavouras D, Pantelidis N. A study of the variation of colonic positioning in the pararenal space as shown by computed tomography. Eur J Radiol. 1990;10:44-47.
[8] Hur KJ, Moon HW, Kang SM, Kim KS, Choi YS, Cho H. Incidence of posterolateral and retrorenal colon in supine and prone position in percutaneous nephrolithotomy. Urolithiasis. 2021;49(6):585-90.
[9] Wu P, Wang L, Wang K. Supine versus prone position in percutaneous nephrolithotomy for kidney calculi: A meta-analysis. Int Urol Nephrol. 2011;43:67-77.
[10] Liu L, Zheng S, Xu Y, Wei Q. Systematic review and meta-analysis of percutaneous nephrolithotomy for patients in the supine versus prone position. J Endourol. 2010;24:1941-46.
[11] Swami YK, Rana YPS. Colonic perforation during percutaneous nephrolithotomy: Can we predict it? Int Surg J. 2022;9(2):368-71.
[12] Asl Zare M, Darabi MR, Shakiba B, Gholami-Mahtaj L. Colonic perforation during percutaneous nephrolithotomy: An 18-year experience. Can Urol Assoc J. 2014;8(5-6):E323-26.
[13] Emiliani E, Quiroz YY, Llorens E, Quintian C, Motta G, Villada D, et al. Retrorenal colon in pediatric patients with urolithiasis: Is the supine position for PCNL advantageous? J Pediatr Urol. 2022;18(6):741.e1-741.e6.
[14] Gamal W, Moursy E, Hussein M, Mmdouh A, Hammady A, Aldahshoury M. Supine pediatric percutaneous nephrolithotomy (PCNL). J Pediatr Urol. 2015;11(2):78.e1-e5.
[15] Davies J, Fattah A. Anatomic landmarks for localization of the branches of the facial nerve. OA Anatomy. 2013;1(1):01-08.
[16] Hopper KD, Sherman JL, Luethke JM, Ghaed N. The retrorenal colon in the supine and prone patient. Radiology. 1987;162(2):443-46.
[17] Akbulut F, Tok A, Penbegul N, Daggulli M, Eryildirim B, Adanur S, et al. Colon perforation related to percutaneous nephrolithotomy: From diagnosis to treatment. Urolithiasis. 2015;43(6):521-26.
[18] Atar M, Hatipoglu NK, Soylemez H, Penbegul N, Bozkurt Y, Gumus H, et al. Relationship between colon and kidney: A critical point for percutaneous procedures. Scandinavian J Urol. 2012;47(2):122-25.

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