

Valsalva Maneuvre assisted Upper Pole Access is Safe and Effective for Pediatric Percutaneous Nephrolithotomy

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ABSTRACT

OBJECTIVE: To evaluate the association between access techniques and pulmonary outcomes in pediatric PCNL.

METHODOLOGY: A retrospective review (2022-2024) at the Multan Institute of Kidney Diseases categorized patients by pulmonary complications. Access type and Valsalva use were recorded and analyzed descriptively.

RESULTS: Among 244 pediatric patients who underwent tubeless PCNL, 13 (5.3%) developed pulmonary complications. The complication group had more males (77%) and a lower mean age (9.87 ± 4.14 years) and BMI (15.71 ± 2.60) than the non-complication group (11.54 ± 3.84 years, BMI 16.15 ± 3.24). Complications were more frequent with supracostal access: 8 cases (61.8%) without Valsalva and 4 (30.6%) with Valsalva. Subcostal access with Valsalva led to 1 case (7.6%), while none occurred without Valsalva. In the non-complication group, supracostal access with and without Valsalva accounted for 13.8% and 33.3%, and subcostal access with and without Valsalva for 30.3% and 22.6%, respectively. Postoperative fever occurred in 62% of cases with complications versus 21.2% without. The mean haemoglobin drop was 0.91 ± 0.80 g/dL in the complication group versus 0.76 ± 0.33 g/dL. Hospital stay averaged 3.92 ± 1.27 days in the complication group compared to 2.01 ± 0.09 days without complications.

CONCLUSION: Descriptive findings suggest Valsalva-assisted supracostal access appears safe in pediatric PCNL, but larger prospective studies are needed to confirm these findings.

KEYWORDS: Percutaneous Nephrolithotomy, Valsalva Manoeuvre, Supracostal, Subcostal, Renal stones

INTRODUCTION

Percutaneous nephrolithotomies (PCNL) has emerged as a recognized method for the management of pediatric nephrolithiasis¹. Indications include substantial or complex stone burdens, obstructed kidneys, dense stones (e.g., cystine), and residual stones after unsuccessful SWL². Concerns with PCNL in pediatric patients encompass the utilization of big devices relative to diminutive kidney size, the potential for significant complications, and the long-term consequences of renal punctures³. These issues have progressively diminished with the development of tools like miniature nephroscopes and intracorporeal lithotripsy devices, which enable the use of mini-percutaneous procedures⁴.

Furthermore, advancements in anesthetic methodologies and surgical proficiency in conducting PCNL in pediatric patients by trained anesthesiologists and endourologists have enhanced the safety and effectiveness of the treatment. Consequently, PCNL is currently the preferred therapy at several sites globally for pediatric renal calculi that are inappropriate for SWL⁴⁻¹⁰. Although several studies on pediatric PCNL have been published, no documented cases of pulmonary complications have been reported, particularly with supracostal or subcostal access strategies, with or without the Valsalva manoeuvre. Considering the limited literature on children, we conduct a descriptive analysis of outcomes without drawing inferential judgments. Our objective is to elucidate trends that might guide future research and therapeutic decision-making in pediatric stone care.

METHODOLOGY

Study Design and Setting

This retrospective record review was conducted in March 2025. We analyzed pediatric percutaneous nephrolithotomy (PCNL) procedures performed between 1 January 2022 and 31 December 2024 at the Multan Institute of Kidney Diseases (MIKD), a high-volume tertiary care center in Multan, Pakistan, where approximately 131 PCNL procedures are conducted annually. Indus Hospital & Health Network Institutional Review Board granted the exemption letter for ethical approval (IHHN_IRB_2025_03_012) before the study began.

Data Collection

The surgical team systematically documented operative and recovery data for all pediatric patients (aged <18 years) who received PCNL during the study period in a dedicated database. Cases managed by procedures other than PCNL were excluded from the study. Descriptive statistics were employed to summarize patient demographics, access methods, and surgical results. Categorical variables are expressed as frequencies and percentages (n%). Continuous variables are represented as mean $\pm$ standard deviation (SD). The data were originally generated in Microsoft Excel, verified for accuracy, and subsequently transferred to SPSS (IBM Corp., Armonk, NY, USA) for descriptive statistical analysis.

Surgical Technique

Experienced urologists skilled in both regular and mini-PCNL procedures conducted each treatment. Every surgery was performed in a sterile operating room setting while under general anesthesia. The lithotomy position was used for the cystoscopy after following routine preparation and aseptic draping. To determine the position of the stone and the pelvicalyceal anatomy, a retrograde pyelogram (RPG) was conducted after insertion of a ureteric catheter. Later, a minimally invasive PCNL procedure was started, and the patient was moved to the prone position. Using a suitable calyx and fluoroscopic guidance, an 18-gauge needle was used to gain access to the collecting system. After inserting a 0.032-inch guidewire into the renal pelvis, the needle was removed. After performing facial dilatation, a

single-step metallic dilator was used to dilate the tract. An appropriately sized metallic Amplatz sheath was introduced, and a stiff nephroscope was put through it. A pneumatic lithotripter was used to break up the stones, and the pieces were then removed. The ureteric and Foley catheters were removed the next morning after stone removal was confirmed by a plain X-ray KUB. Stable patients were discharged from the hospital per hospital policy. We obtained clinical and demographic information of patients from the electronic medical record (EMR) system. In accordance with the research protocol, the Valsalva manoeuvre's use during renal access was recorded as either Yes or No. Based on the surgeon's judgment and predetermined grouping criteria, the subcostal or supracostal puncture location and the Valsalva manoeuvre were chosen intraoperatively.

RESULTS

Thirteen (5.3%) of the 244 individuals enrolled in the study experienced pulmonary problems, whereas 231 (94.7%) did not. The complication group included three women (23%) and ten men (77%), whereas the non-complication group included 78 women (33.7%) and 153 men (66.3%). This indicates that a comparatively greater percentage of men than women had pulmonary problems, suggesting that gender may be a contributing factor but not a determining factor (**Table I**).

Patients with pulmonary problems were 9.87 ± 4.14 years old on average, whereas those without issues were 11.54 ± 3.84 years old. Likewise, the complication group's mean BMI was 15.71 ± 2.60 , whereas the non-complication group's was 16.15 ± 3.24 . Although the differences are minimal, these results imply that younger patients and those with a lower BMI may be more susceptible to pulmonary problems (**Table I**).

Pulmonary problems were noted in 13 individuals (5.3%) out of 244 participants. Four patients (30.8%) underwent PCNL using the supracostal approach with the Valsalva manoeuvre, while eight patients (61.5%) received PCNL using the supracostal technique alone. After subcostal access with Valsalva, 1 patient (7.7%) had problems. Interestingly, patients who underwent subcostal PCNL without Valsalva did not experience problems. In the non-complication group, thirty-two patients (13.8%) underwent PCNL with supracostal access with Valsalva, 77 patients (33.3%) underwent supracostal access without Valsalva, 70 patients (30.3%) underwent subcostal access with Valsalva, and 52 patients (22.5%) underwent subcostal access without Valsalva. Based on this descriptive comparison, the subcostal approach without Valsalva appears safest, with no recorded complications. In contrast, the supracostal approach, especially when not combined with the Valsalva manoeuvre, has a comparatively higher frequency of complications (**Table I**).

In terms of laterality, 4 patients (30.7%) had left-sided surgeries, whereas 9 of the 13 patients (69.3%) with pulmonary problems had right-sided procedures. In the non-complication group, right-sided access was performed on 127 patients (55%), while left-sided access was performed on 104 patients (45%). These findings suggest that right-sided treatments have a somewhat increased risk of complications (**Table I**).

Table I: Demographic data of patients with and without pulmonary complications (244 patients)

Patient's Profile	Pulmonary Complications (n = 13)	No Pulmonary Complications (n = 231)
Male, n (%)	10(77%)	153 (66.3%)
Female, n (%)	3(23%)	78 (33.7%)
Age (years), mean $\pm$ SD	9.87 $\pm$ 4.14	11.54 $\pm$ 3.84
BMI mean $\pm$ SD	15.71 $\pm$ 2.60	16.15 $\pm$ 3.24
Access Technique		
Supracostal + Valsalva YES	4 (30.8%)	32 (13.8%)
Supracostal + Valsalva NO	8 (61.5%)	77 (33.3%)
Subcostal + Valsalva YES	1 (7.7%)	70 (30.3%)
Subcostal + Valsalva NO	0 (0%)	52 (22.6%)
Laterality		
Right n (%)	9 (69.3%)	127 (55%)
Left n (%)	4 (30.7%)	104 (45%)
Operative Outcome		
Postoperative fever, n (%)	8 (62.0%)	49 (21.2%)
Blood transfusion, n (%)	0 (0%)	2 (0.8%)
Hematuria	1 (7.6%)	16 (7.0%)
Leakage	1 (7.6%)	11 (4.8%)
Nephrostomy	1 (7.6%)	10 (4.4%)
Tubeless PCNL, n (%)	0 (0.0%)	0 (0.0%)
Drop In Hb g/dL (mean $\pm$ SD)	0.91 $\pm$ 0.80	0.76 $\pm$ 0.33
Hospital stay days (mean $\pm$ SD)	3.92 $\pm$ 1.27	2.01 $\pm$ 0.09

Regarding surgical outcomes, 49 patients (21.2%) in the non-complication group developed post-operative fever, compared with 8 patients (62.0%) in the complication group. Compared to two patients (0.8%) without difficulties, none of the patients (0%) with complications needed blood transfusions. In 16 patients (7.0%) without difficulties and 1 patient (7.6%) with complications, hematuria was seen. Among patients with complications, one patient (7.6%) had both leakage and nephrostomy, whereas the non-complication group had 10 patients (4.4%) and 11 patients (4.8%), respectively. Regardless of group, every patient had tubeless PCNL. Although surgical outcomes were similar, the significantly higher prevalence of postoperative fever in the problem group may indicate a systemic reaction associated with pulmonary risk (**Table I**).

In the group that experienced complications, the average haemoglobin decline was 0.91 $\pm$ 0.80 g/dL, while in the group that did not, it was 0.76 $\pm$ 0.33 g/dL. Additionally, the average length of hospital stay for patients with pulmonary issues was 3.92 $\pm$ 1.27 days, compared with 2.01 $\pm$ 0.09 days for the group without difficulties. These variations demonstrate that pulmonary problems are linked to greater resource use and longer recovery times (**Table I**).

DISCUSSION

The purpose of this study was to evaluate the relationship between the emergence of pulmonary problems and various access procedures used during PCNL, including the function of the Valsalva manoeuvre. Thirteen of the 244 patients experienced pulmonary problems. Intercostal drainage was used to treat the 5.3% overall incidence of pulmonary problems. Although pediatric-specific data are currently lacking, these results agree with earlier adult trials. Analysis showed that the supracostal access was linked to most of these issues, particularly when the Valsalva technique was not used. Additionally, the complication group's very small patient population reduced the power of the formal statistical tests and may have produced false results. As a result, the results prioritize patterns above statistical inference and are presented in an easy-to-understand, clinically interpretable manner (**Table I**).

The most frequent complications after PCNL, according to the CROES worldwide research, are bleeding and infection. The most frequent neighboring organ harm after this operation is pleural damage. Significant pleural effusion on the chest film, accompanied by oxygen desaturation, dyspnea, and chest discomfort, is classified as a pleural complication. The location of renal access affects the likelihood of pleural complications. Higher access location increases the likelihood of harm. In supracostal access, the incidence is greater (3–15% above the 12th rib and 10–100% above the 11th rib). In subcostal access, the incidence is less than 5%¹¹. Oxygen desaturation is a clinical indicator of severe pleural damage. Physical examination revealed reduced breath sounds and difficulty breathing. When patients recover from a prone posture and return to a supine position, they may start breathing on their own, and pleural damage is typically observed. During surgery under general anaesthesia, some individuals exhibit symptoms of elevated peak inspiratory pressure. Damage can occur during renal access and tract dilatation: the nephroscope step and stone breakdown cause fluid to build up in the pleura. Pneumothorax, hemothorax, hydrothorax, or a mix of these conditions may be the issue¹²⁻¹⁸.

Pleural complications have been demonstrated to be an issue in supracostal access. In 332 patients, Sharma et al. documented the variables that predicted pleural complications after percutaneous nephrolithotomy. Ten individuals had a 3% pleural complication rate. The incidence for subcostal and supracostal access was 2% and 4.2%, respectively. The following characteristics are predictive of pleural complications: low BMI, mean age <27 years, and supracostal access¹⁵. Longer distances between the diaphragm and upper pole, as well as posterolateral perirenal fat at the level of the renal hilum, are two ways that obesity can prevent pleural complications^{14,19,20}.

Pleural complications are more likely to affect younger people. This can be explained by younger patients' lower BMI and tendency toward aggressive therapy^{15,22}. Sharma noted that patients under the age of 27 were more likely to experience pleural problems¹⁴. According to Palnizkya, the mean age of patients with pleural complications was 43±22 years, whereas the mean age of patients without complications was 55±15 years²¹. Pleural complications, which were 1.8% in patients over 70 and 1.4% in patients between the ages of 18 and 70, did not differ by age group in the CROES research²².

Our findings indicate that younger patients and individuals with a slightly lower BMI may have an increased risk of pulmonary complications. The observed differences are modest and suggest that Valsalva-assisted access provides some protective benefits by displacing the diaphragm inferiorly, hence reducing the risk of pleural transgression.

The association between access laterality and pleural injury is still debated. Certain studies indicate elevated complication rates on the left side attributed to the kidney's superior anatomical position, whereas others propose a heightened risk on the right side. Percutaneous

nephrolithotomy (PCNL) on the left kidney has been associated with a higher incidence of pleural complications. Because of the liver, the right kidney is positioned lower than that of the left kidney.

However, pleural complications were more common in right-sided PCNL, according to previous research^{14,20,23}. The incidence of pleural damage was 1.8% for left-sided PCNL and 4% for right-sided PCNL. An anatomical link between the kidney, pleura, and lung during PCNL was documented by Hopper et al. In normal anatomy, only the 12th rib crosses the right kidney, whereas the 11th and 12th ribs cross the left kidney. Although both right and left-sided access complications occurred in our series, the majority of pulmonary complications (69.3%) happened after right-sided PCNL, which is in line with anatomical findings that suggest the right kidney's proximity to the diaphragm may make it more likely to cause pleural damage, especially when upper pole access is necessary. The pleura was passed via the supracostal access on the right in 29% of cases and the left in 14% of cases during forced complete expiration. The greater incidence of pleural complications in right-sided PCNL may be explained by this observation²³.

For post-PCNL pleural evaluation, radiological instruments like chest X-rays remain the gold standard. Chest X-rays are less sensitive than CT scans and intraoperative fluoroscopy; nevertheless, some investigations have found substantial false-negative rates²⁰. We identified all pleural problems in our group by imaging and clinical signs, such as reduced breath sounds and oxygen desaturation, after surgery.

Only 5% of patients with substantial pulmonary complications required intercostal drainage, while 15.3% of patients experienced pleural complications on the 12th access to the supracostal ribs²⁴. Because hospital stays were longer for those with pleural damage, the condition appears to prolong hospital stay. The average length of hospital stay was 3.92 days, compared with 2.01 days in the non-complication group. Previous research showed similar patterns, indicating that pleural injuries, despite being frequently manageable, affect the healing process after surgery^{21,25}. Crucially, the tubeless PCNL method was utilized for every surgery in our study. The retrospective nature of the present study and unequal group sizes are two major drawbacks that limit firm conclusions and affect applying broad observations.

Because the alternative technique significantly increases chest injuries, we used the Valsalva manoeuvre strategy²². Due to their smaller thoracic cavities, pediatric patients have a narrower intercostal gap and a pleura that is comparatively closer to the renal organs. Furthermore, the pleural cavity is more vulnerable to surgical injury during upper-pole access in PCNL because the diaphragm is more flexible and the ribs are more compliant^{26,27}. These anatomical factors increase the risk of pleural breach during the supracostal route, which may lead to pneumothorax or hydrothorax. The Valsalva technique, under anesthesia, is purposefully used to reduce this danger. By lowering the kidney and diaphragm, the puncture site is lowered from a supracostal to a subcostal position. This change reduces the risk of pulmonary complications by allowing surgeons to access the upper pole without passing through the intercostal space. Because this method has less room for procedural mistakes, it is especially useful in kids, when maintaining thoracic integrity is crucial.

To the best of our knowledge, this is the first study to compare supracostal and subcostal methods for upper-pole access in pediatric patients using the Valsalva manoeuvre for PCNL. Although more extensive prospective research is needed to confirm these outcomes, our results suggest that the Valsalva manoeuvre is a useful, physiologically sound addition to pediatric PCNL, especially when upper pole access is required. As a result, this descriptive study offers important new information in a field that has received little attention, laying the groundwork for future research employing hypothesis-driven designs and inferential statistics.

CONCLUSION

This study suggests that the Valsalva technique may be safe and practical during upper pole access in pediatric percutaneous nephrolithotomy. An organized summary of pediatric patients receiving PCNL is given by this descriptive analysis, which pays special emphasis to access methods and related postoperative pulmonary problems. Access procedures and pulmonary problems in pediatric PCNL have received limited attention in the literature. It is advised that a prospective, randomized study be conducted in the future to confirm the role of the Valsalva maneuver and provide uniform guidelines for its use in pediatric PCNL.

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Data Sharing Statement: The corresponding author can provide the data proving the findings of this study on request. Privacy or ethical restrictions bound us from sharing the data publicly.

AUTHOR CONTRIBUTION

Salman A: Literature search, Study design, concept, data collection, analysis, interpretation, drafting and revision, final approval, agree to be accountable

Ahmad I: Study design, concept, data collection, analysis, interpretation, drafting, revision, final approval, agree to be accountable

Zaidi AI: Substantial contributions to the conception, draft revision, final approval, and agreement to be accountable

Afzal MM: Substantial contributions to the conception, draft revision, final approval, agree to be accountable

Masood MN: Substantial contributions to the conception, draft revision, final approval, agree to be accountable

Bilal MA: Substantial contributions to the conception, draft revision, final approval, agree to be accountable

Masood B: Substantial contributions to the conception, draft revision, final approval, agree to be accountable

Saeed HMK: Literature search, Study design, data collection, analysis, interpretation, extensive drafting and final approval, agree to be accountable

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