Original Research Article

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Comparison of anatomical changes in computed tomography (CT) scan in supine position and prone position with respect to percutaneous nephrolithotomy (PCNL).

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ABSTRACT

Objective: To compare the anatomical organ positional changes, renal access tract length and maximum renal access angle in relation to the kidney in supine and prone positions through CT scan images.
Methods: CT Urography was performed in 52 patients with various urological complaints in supine and delayed images in prone position. A comparison in both supine and prone position was done to analyse the organ interposition, pleural interposition, mean access tract length, maximum renal access angle for PCNL.
Results: The difference in the organ interposition was not statistically significant whereas Pleural interposition was more common in the prone position compared to supine position on both the right (9 vs 2, p = 0.03) and left (3 vs 0, p = 0.24). Mean access tract length was shorter in prone position on both the right (69.93mm vs 61.74mm, p <0.001) and left (69.78mm vs 63.57mm, p <0.001) sides. Maximum renal access angle was greater in the supine position on both the right (73.570 vs 69.030, p = 0.4) and left (73.780 vs 64.700, p = 0.025) sides with statistical significance on the left side.
Conclusion: PCNL in prone position has an advantage of having shorter access tract length compared to supine position. PCNL in supine position has an advantage of having a wider access angle compared to prone position. Upper calyx puncture for PCNL in prone position has a high chance of pleural interposition.

Keywords:
organ interposition, pleural interposition, maximum renal access angle, renal access tract length, ct scan prone vs supine, pcnl.

INTRODUCTION

Percutaneous nephrolithotomy (PCNL) is a commonly performed endourological procedure and a gold standard for renal stones >2cm. Organ interposition, renal access tract length and renal access angle are important parameters for planning the procedure of percutaneous nephrolithotomy (PCNL).
We have come a long way since 1941 when Rupel and Brown performed the first nephroscopy. A rigid cystoscope was passed into the kidney following open surgery [1]. In 1978, it was Arthur Smith, along with Kurt Amplatz who took PCNL to the heights that it stands today [2,3,4]. The prone position was presumed to be the standard of PCNL and the safest approach in preventing colonic perforation. Valdivia-Uria was the first person who showed that supine PCNL could be done with equal complication rates and success rates and has the advantage in terms of patient positioning and management during anaesthesia [5,6]. A lot of new enthusiasm is being generated among the urologists all over the world to convert to supine PCNL from the prone PCNL. There are two groups claiming the superiority of supine over prone PCNL or prone over supine PCNL [9].
Traditionally computed tomography (CT) scan is done in supine position and the PCNL is being done in prone position. Although there are substantial number of publications available to take care of this discussion [10,11,12], there is a very scanty literature available on the actual anatomical variations of surrounding structures like colon, liver, and the spleen in relation to the kidney in both prone and supine positions. Our present study aims to compare the anatomical organ positional changes in relation to the kidney in supine

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and prone positions through CT scan images and to study the differences in the renal access tract length and maximum renal access angle in supine and prone positions through CT scan images and its likely implications [1,4,8,10,11,12] on performing PCNL.

MATERIALS & METHODS

The patients enrolled in this study were informed about the study and a verbal and a signed informed consent was taken to participate in this study. Approval of the ethical committee of institute xxxx was taken (REF: BVDUMC/IEC/15). 52 patients who underwent CT urography as a part of their evaluation for various urological complaints were included in this study. These patients were imaged in both supine and prone positions. The non-contrast and nephrogenic images were obtained in supine position and the delayed excretory images were obtained in prone position. None of the patients were exposed to increased radiation.

Inclusion criteria
Patients above 18 years of age with creatinine values within the reference range (adult male: 0.73 -1.18 mg/dl, adult female: 0.55 – 1.02 mg/dl) were included in this study for CT scan to be done in plain and contrast phases.

Exclusion criteria
Patients below 18 years of age, patients with anatomical and renal anomalies, patients with high creatinine values (beyond the reference range), and patients with a history of renal surgeries were excluded from this study. Organ interposition, renal access tract length and maximum renal access angle were calculated using supine and prone CT scan images. Organ interposition was seen as presence of any organ (liver, spleen, or colon) along the line from the posterior most calyx to the posterior axillary line in the upper, middle, and lower poles of both the right and the left kidney. If there was presence of organ interposition along the above-mentioned path, it was noted as "yes" and if there was no organ interposition, it was noted as "no" (figure 1-4).

Figure 1. Shows presence of organ (liver) interposition in supine position.

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Figure 2. Shows no organ interposition in supine position.

Figure 3. Shows presence of organ (liver) interposition in prone position.

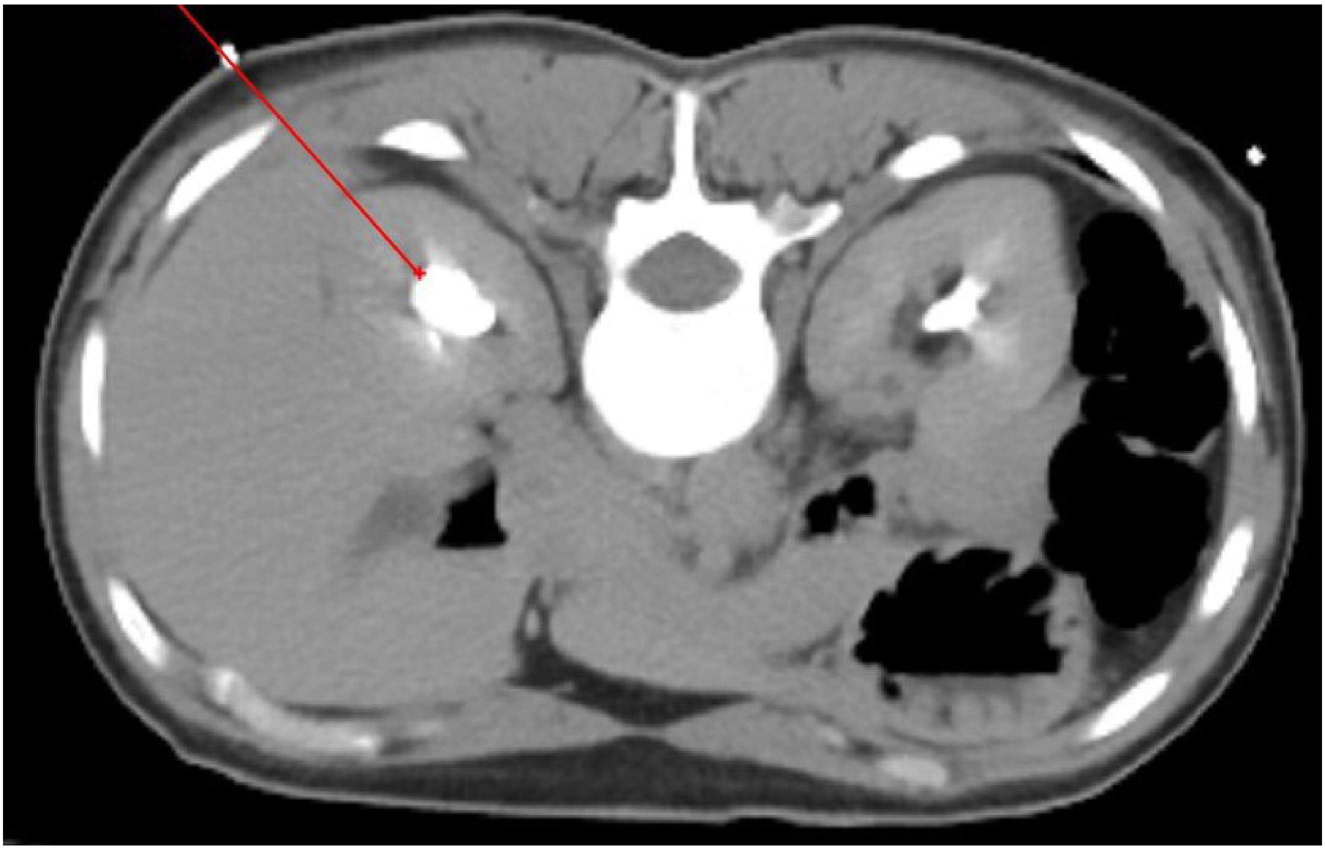

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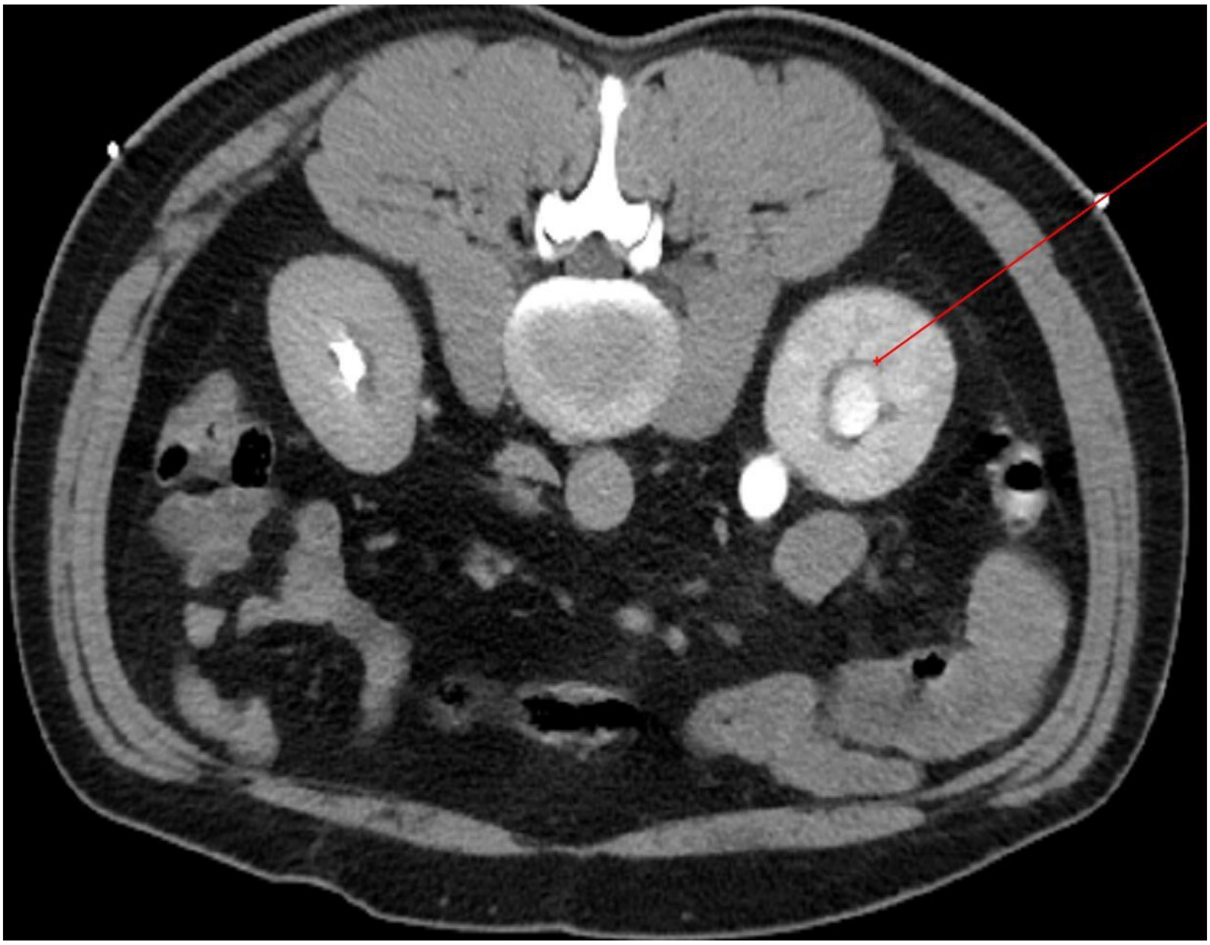
Figure 4. Shows no organ interposition in prone position.



We have done multiple pilot studies to mark the posterior axillary line to visualize that mark on the CT scan image. We first used a metallic wire, but it led to artefacts. We then used a 9 fr infant feeding tube and it was not clearly visible. We then used a 6 fr ureteric catheter to mark the posterior axillary line by affixing with a tape over the posterior axillary line in standing position. It showed no artefacts and it was clearly visible on CT scan images.

The renal access tract length was calculated from the posterior axillary line on the surface of the skin to the posterior most calyx in the middle and lower poles, and the posterior most aspect of the lateral calyx in the upper pole (figure 5,6). This technique was used to measure the access tract lengths of upper, middle, and lower pole. Maximum renal access angle was measured or defined as angle between the lateral margin of paraspinous muscle to the posterior most border of either the liver, spleen, or colon (figure 7,8).

We have also seen for the proportion of pleural interposition along the path from the posterior axillary line to upper calyx in both supine and prone positions on the right and left sides. If there was presence of pleural interposition along the above-mentioned path, it was noted as "yes" and if there was no pleural interposition, it was noted as "no" (figure 9,10).

Proportion of organ interposition, mean access tract lengths and maximum renal access angle were calculated and tabulated using the same calyx in supine and prone images for upper, middle, and lower poles for right and left kidneys and statistical significance was calculated. Statistical analysis was performed using Microsoft excel. To compare the measurements, student's t-test was used.

Figure 5. Shows access tract length in Supine Position.

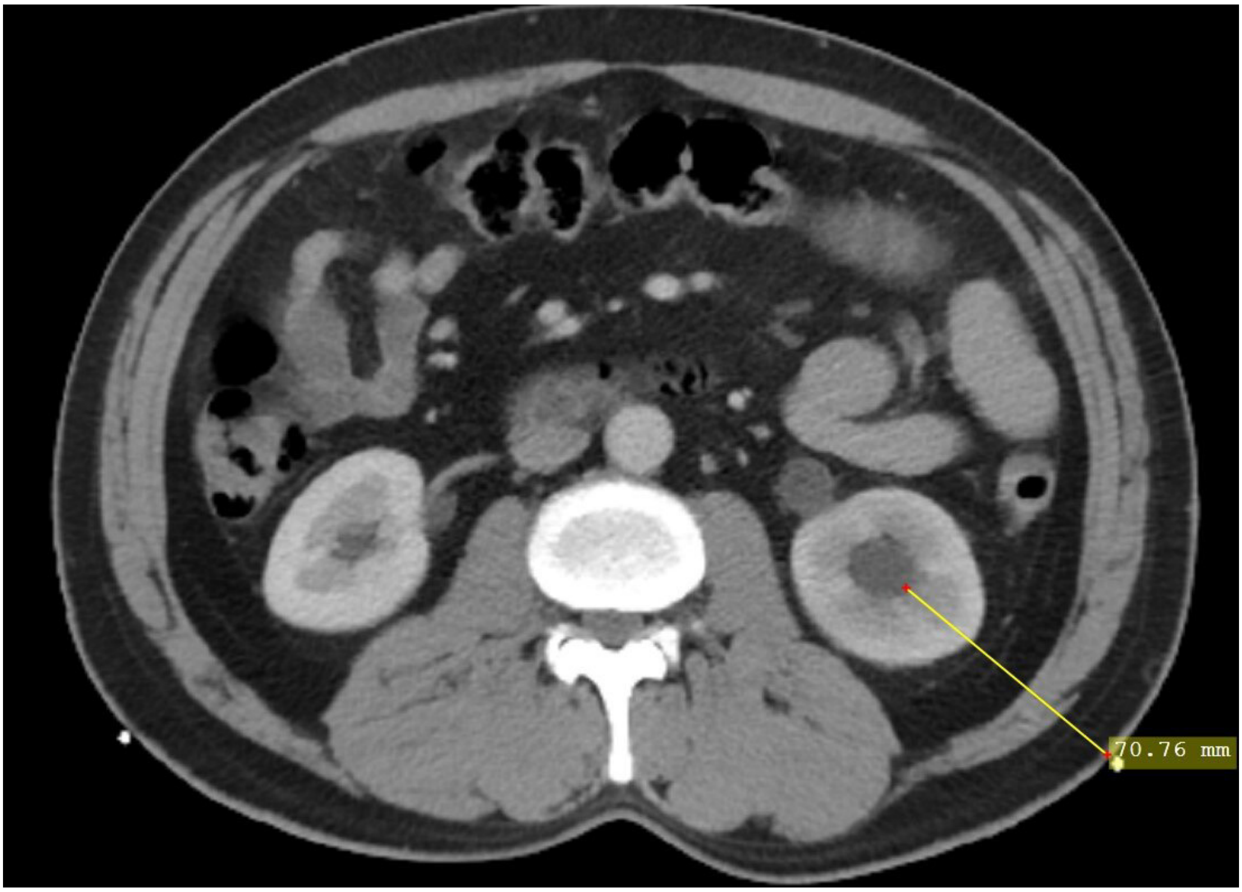


Figure 6. Shows access tract length in prone position.

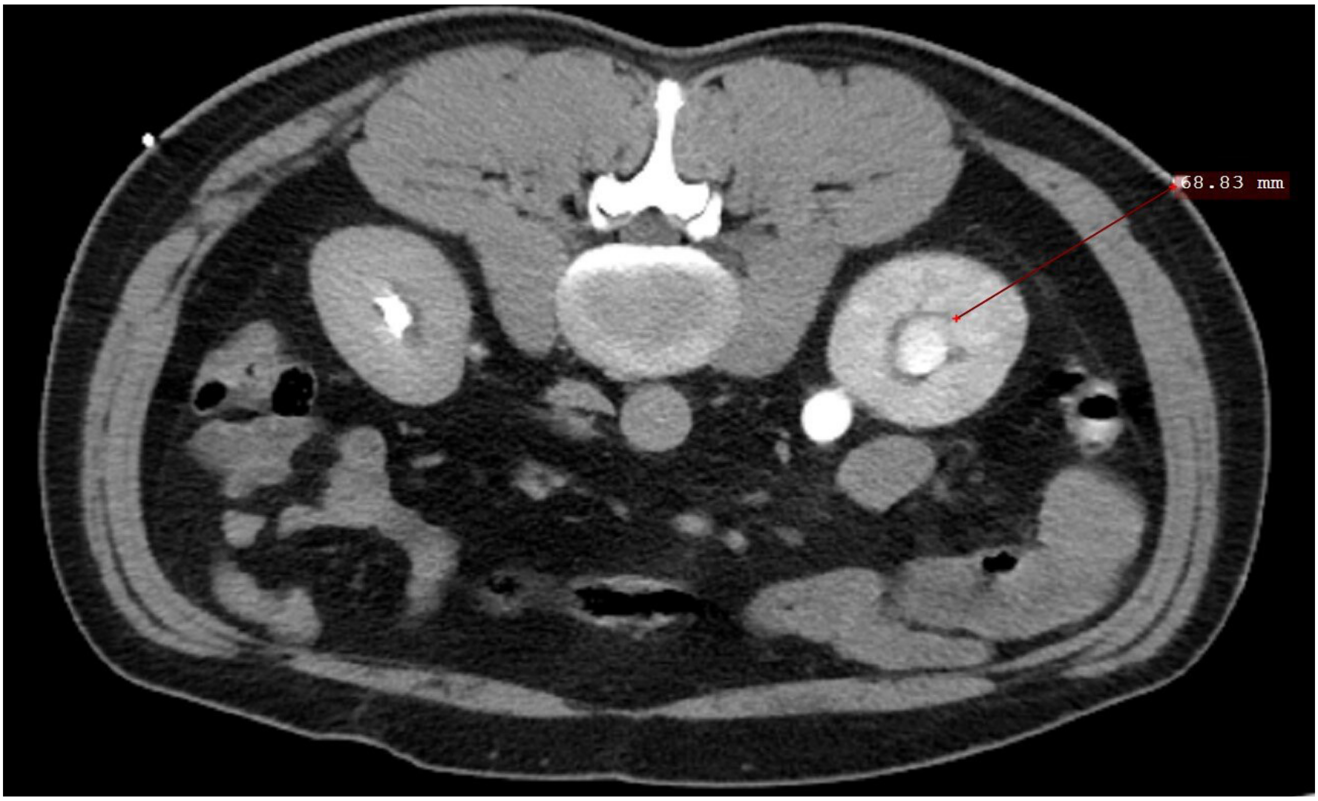


Figure 7. Shows maximum renal access angle in supine position.

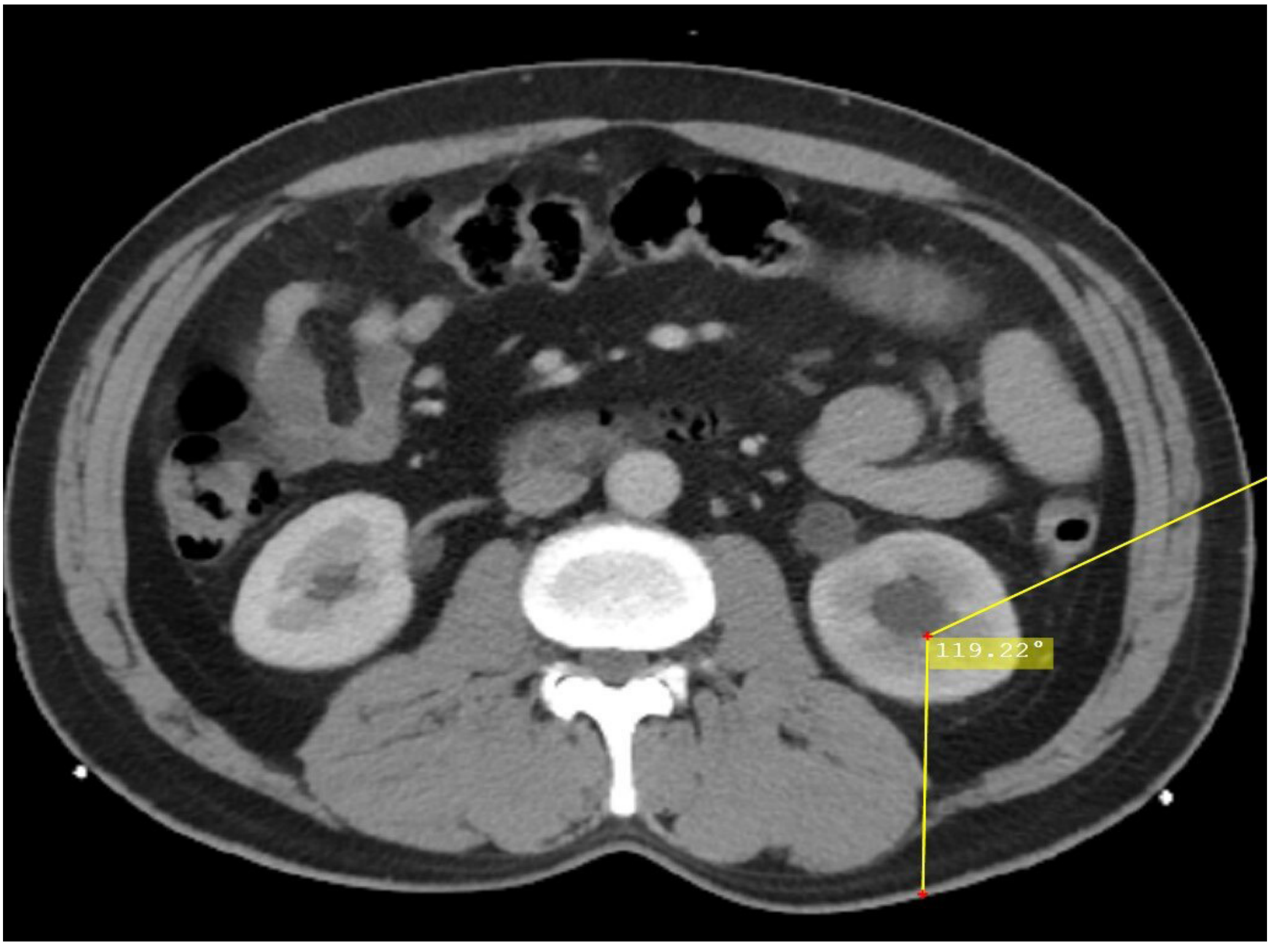


Figure 8. Shows maximum renal access angle in prone position.

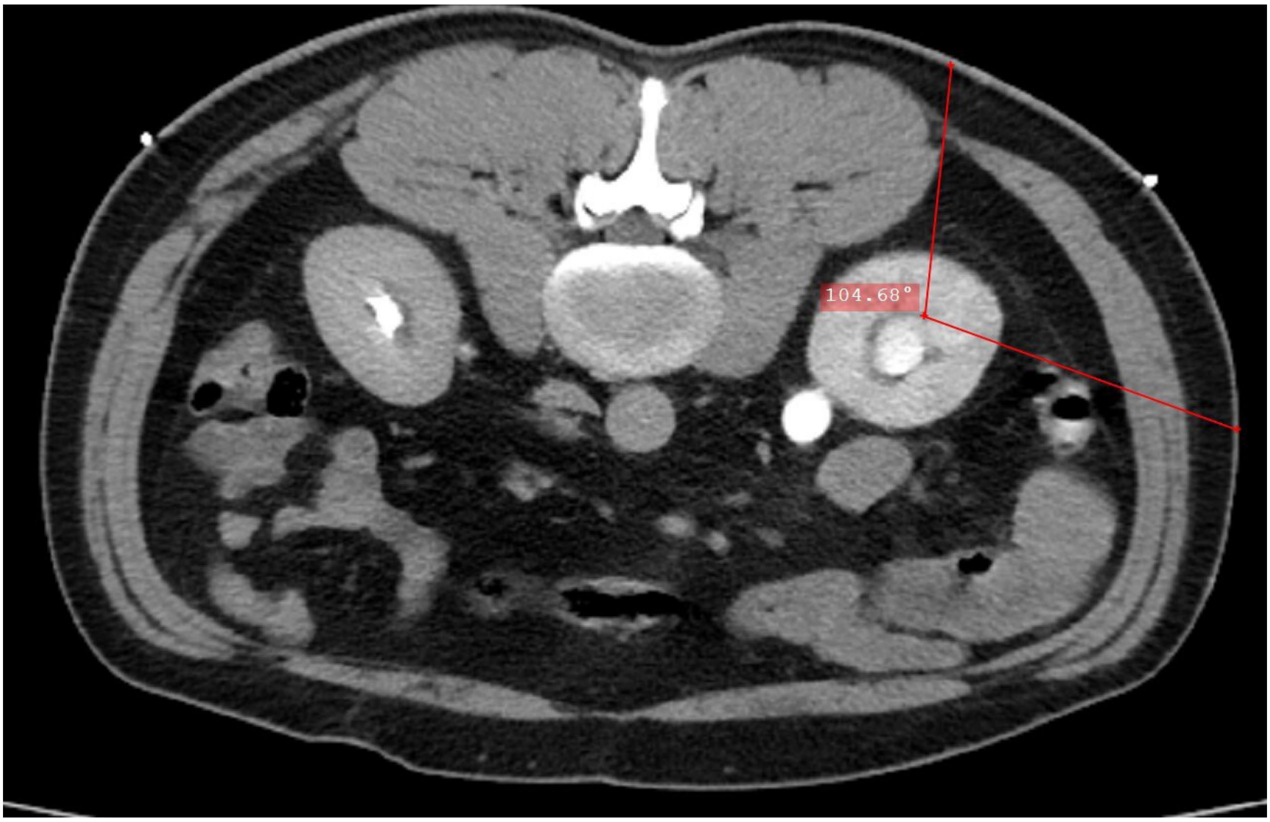


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Figure 9. Shows presence of pleural interposition in prone position.

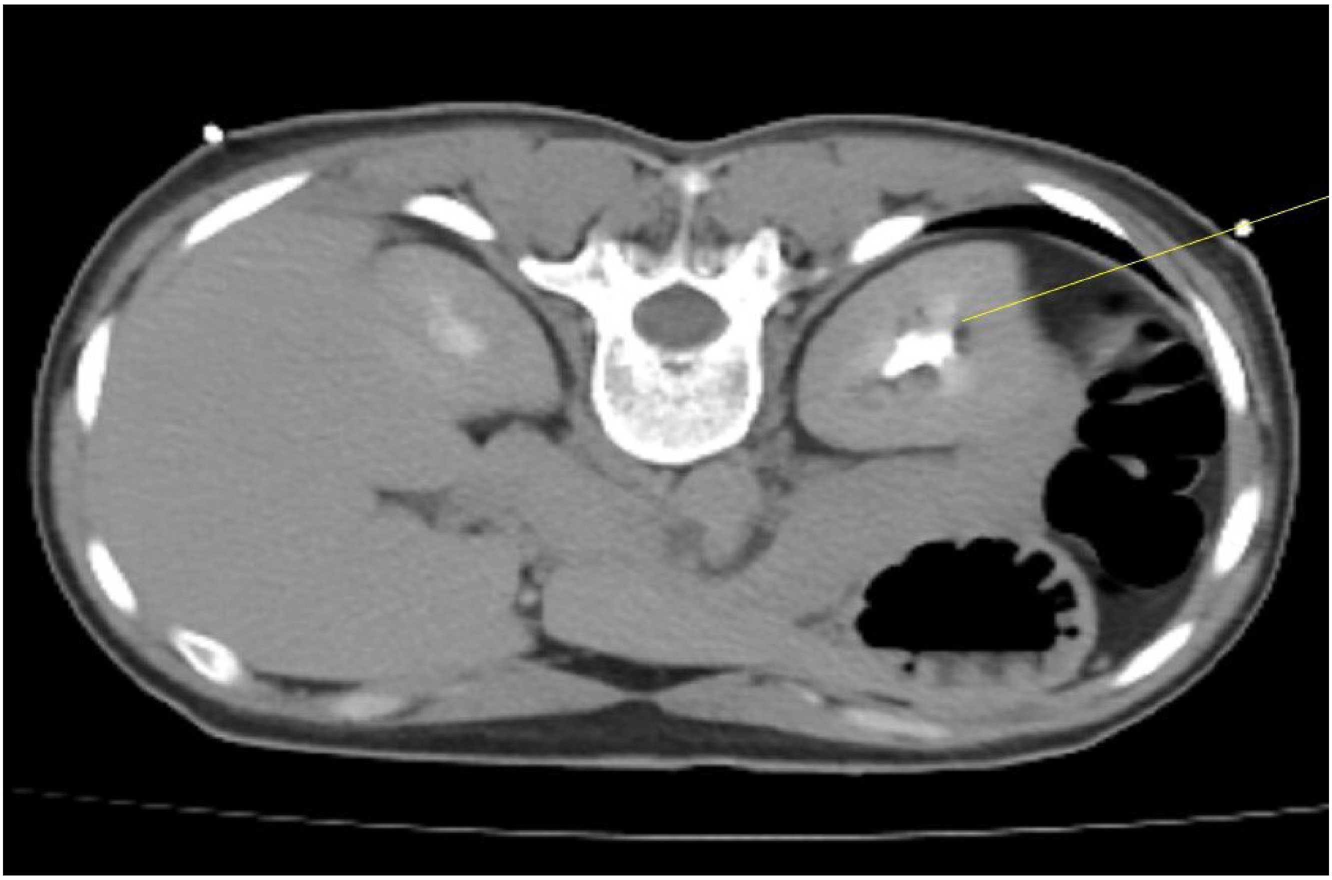
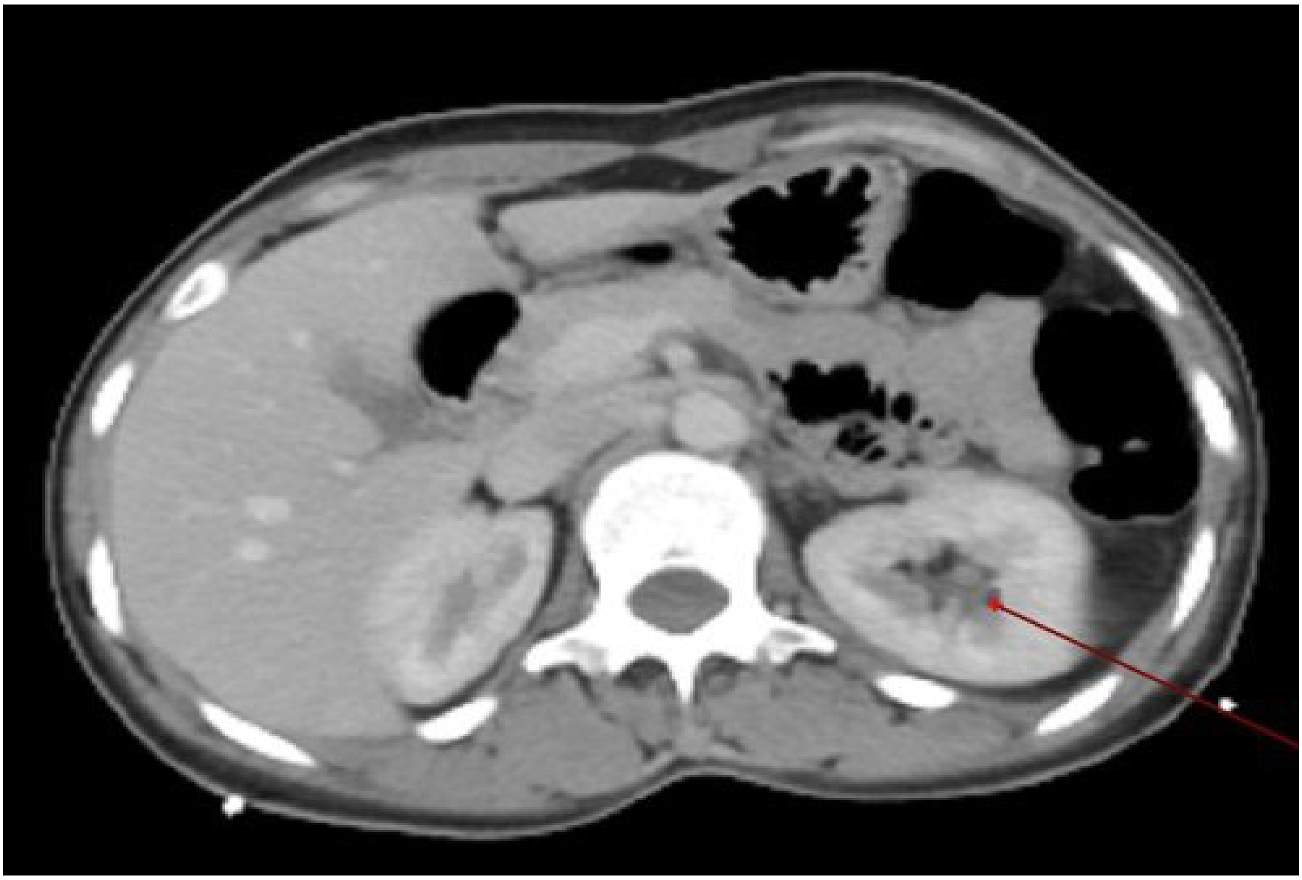


Figure 10. Shows no pleural interposition in supine position.



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RESULTS

52 patients were included in this study. There were 23 males and 29 females ranging in age from 22 years to 70 years (mean: 44.17).

Organ interposition

The results are summarized in table 1. The proportion of organ interposition for the upper, middle, and lower pole of the kidneys were compared in supine and prone positions on both the right and the left side. The difference in the organ interposition between the supine and the prone positions was not statistically significant.

Table 1

ORGAN INTERPOSITION (n = 52)				
RIGHT KIDNEY		**YES**	**NO**	**p-value**
UPPER POLE	Supine	33	19	0.42
	Prone	29	23	
MID POLE	Supine	6	46	0.51
	Prone	4	48	
LOWER POLE	Supine	1	51	0.99
	Prone	2	50	
LEFT KIDNEY		**YES**	**NO**	**p-value**
UPPER POLE	Supine	32	20	0.12
	Prone	24	28	
MIDDLE POLE	Supine	3	49	0.49
	Prone	6	46	
LOWER POLE	Supine	2	50	0.27
	Prone	6	46	

Pleural interposition

The results of pleural interposition are summarized in table 2. On the right side, 2 patients had pleural interposition in supine position, while 9 patients had pleural interposition in prone position (p = 0.03). On the left side, no patient had pleural interposition in supine position, while 3 patients had pleural interposition on prone position (p = 0.24). These differences were statistically significant on right side but not on the left side.

Table 2

PLEURAL INTERPOSITION (n=52)				
	YES	**NO**	**p-value**	
RIGHT SIDE	Supine	2	50	0.03
	Prone	9	43	
LEFT SIDE	Supine	0	52	0.24
	Prone	3	49	

Renal access tract length

The results are summarized in table 3. The mean right sided supine tract length was 69.93 mm vs 61.74 mm in the prone position (p = <0.001). The mean left sided supine tract length was 69.78 mm vs 63.51 mm in prone position (p = <0.001). The access tract length was less in the prone position compared to supine position on both the right and left sides. The differences between supine and the prone positions were statistically significant.

Table 3

ACCESS TRACT LENGTH VALUES (n=52)			
RIGHT KIDNEY		**Mean**	**p-value**
UPPER POLE	Supine	66.17	0.015
	Prone	61.77	
MID POLE	Supine	67.78	0.008
	Prone	60.95	
LOWER POLE	Supine	76.27	<0.001
	Prone	64.68	
LEFT KIDNEY		**Mean**	**p-value**
UPPER POLE	Supine	66.18	0.03
	Prone	61.77	
MIDDLE POLE	Supine	67.28	0.02
	Prone	61.23	
LOWER POLE	Supine	75.88	0.008
	Prone	67.71	
ACCESS TRACT LENGTH OVERALL VALUES			
		Mean	**p-value**
RIGHT KIDNEY	Supine	69.93	<0.001
	Prone	61.74	
LEFT KIDNEY	Supine	69.78	<0.001
	Prone	63.57	

Maximum renal access angle

The results are summarized in table 4. The mean right sided supine access angle was 73.570 vs 69.030 in the prone position (p = 0.4). The mean left sided supine access angle was 73.780 vs 64.700 in the prone position (p-value = 0.025). The maximum renal access angle was greater in the supine position compared to the prone positions and the differences between the supine and the prone positions were statistically significant on the left side but not on the right side. Despite the differences between supine and prone positions were not statistically significant for the right side, the differences were statistically significant for the right lower pole.

Table 4

ACCESS ANGLE VALUES (n=52)			
RIGHT KIDNEY		**Mean**	**p-value**
UPPER POLE	Supine	30.43	0.81
	Prone	32.13	
MID POLE	Supine	82.30	0.87
	Prone	81.07	
LOWER POLE	Supine	107.98	0.02
	Prone	93.88	
LEFT KIDNEY		**Mean**	**p-value**
UPPER POLE	Supine	30.43	0.61
	Prone	32.12	
MIDDLE POLE	Supine	90.32	0.04
	Prone	76.29	
LOWER POLE	Supine	96.85	0.01
	Prone	80.15	
ACCESS ANGLE OVERALL VALUES			
		Mean	p-value
RIGHT KIDNEY	Supine	73.57	0.4
	Prone	69.03	
LEFT KIDNEY	Supine	73.78	0.025
	Prone	64.70	

DISCUSSION

Percutaneous entry into the kidney was initially started with the prone position and now it is also being done in supine position. The reason for preferring the prone position over supine position was regarding the presumed decreased risk of visceral injury in prone position.

The measurements were calculated using axial images as like all the prior studies done to evaluate anatomical changes between patient's position were done using axial images [7,8,9].

The access tract length is important for many reasons. The access sheath within the lumbar fascia and parietal muscles acts as a fulcrum [9]. As a result, the farther this is from the skin towards the collecting system, the lesser is the manoeuvrability of the sheath within the collecting system leading to lesser stone free rates. This leads to more torque being applied and high chances of bleeding. As the access tract length increases, longer access sheaths are required.

In our current study, the mean access tract length was significantly shorter in prone position compared to supine on both the right and left sides. The right side was shorter by 8.19 mm (p <0.001) and the left side was shorter by 6.21 mm (p <0.001). Our findings were similar and supported by the study published by Duty et al [9].

The access angle represents the area for all the potential points of entry for access tracts. Therefore, a wider access angle gives a larger safety margin for entry into the collecting system, thereby facilitating higher stone free rates. In our study, it was found that the mean access angle in the supine position on the right side is 73.570 vs 69.030 in the prone position (p = 0.4). The mean left sided access angle in the supine position was 73.780 vs 64.700 in the prone position (p = 0.025). The differences between the supine and the prone positions were statistical significance on the left side but not on the right side. Our findings were contrary to the study published by Duty et al [9], which described a wider access angle in the prone position.

Our study has a few limitations

1. The study was conducted only through CT scan images without any clinical correlations. We thought that correlating with clinical findings during PCNL procedure will have surgeon's bias as well as case bias.
2. We have used a fixed mark of entry into the collecting system (which is the posterior axillary line) to compare the organ interposition in prone position as compared to supine. As a result, our studies showed a higher organ interposition. Whereas in clinical scenario, the surgeon will change the entry point into the calyx as per the convenient entry into the desired calyx.
3. Due to increased risk of radiation, we have taken plain and nephrogenic phases of CT scan in supine position, and excretory phase in prone position. Had the plain nephrogenic and excretory phase been done in both the prone position and supine position individually, the amount of radiation would have increased. But this did not change the outcome of our study."

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CONCLUSION

Puncture for PCNL attempted in prone position could have an advantage of having a shorter access tract length compared to supine position, thereby giving more manoeuvrability for the access sheath within the collecting system. Puncture for PCNL attempted in supine position (especially for middle and lower calyx) could have an advantage of having a wider access angle compared to prone position, thereby giving wider access to puncture a targeted calyx. Upper calyceal puncture for PCNL attempted in prone position has a high chance of pleural interposition compared to supine position, with the right sided upper calyceal puncture having a higher chance of pleural interposition (statistically significant). Organ interposition, though not statistically significant, puncture of upper calyx has a higher chance of organ interposition in supine position compared to prone position. Therefore, if an upper calyceal puncture is attempted in prone position, it could have a less likelihood of having an organ interposition, but could have a high likelihood of pleural interposition compared to supine position. But this study is based on the interpretation of findings of the CT scan images and need clinical correlation.

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DECLARATIONS

Ethics Committee Approval
Ethical approval for this study was obtained from INSTITUTIONAL REVIEW BOARD (BVDUMC/IEC/15)

Consent for publication
Written informed consent was obtained from all subjects before the study.

Availability of data and material
The datasets used and/or analysed during the current study are available from the corresponding author on request.

Competing interests
The author(s) declare(s) that they have no competing interests.

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Conflicting interests
The Authors declare that there is no conflict of interest.

REFERENCES

1. Rupel E, Brown R. Nephroscopy with removal of stone following nephrostomy for obstructive calculus anuria. J Urol 1941;46:177-82.

2. Smith AD, Lange PH, Miller RP, Reinke DB. Introduction of the Gibbons ureteral stent facilitated by antecedent percutaneous nephrostomy. J Urol 1978;120:543-544.
3. Smith AD. A personal perspective on the origins of endourology and the endourological society. J Endourol 2002;16:705-8.

4. Castaneda-Zuniga WR, Clayman R, Smith A, Rusnak B, Herrera M, Amplatz K. Nephrostolithotomy: Percutaneous techniques for urinary calculus removal. J Urol 2002;167:849-853.

5. Valdivia-Uria JG, Lanchares E, Villarroya S, Taberner J, Abril G, Aranda JM. Nefrolitectomia percutanea: Tecnica simplificada (nota previa). [Percutaneous nephrolithotomy: simplified technique (preliminary report)] Arch Esp Urol 1987;40:177-180.

6. Valdivia Uria JG, Valle Gerhold J, López López JA, et al. Technique and complications of percutaneous nephroscopy: experience with 557 patients in the supine position. J Urol. 1998;160:1975-1978.

7. Ray AA, Chung DG, Honey RJ. Percutaneous nephrolithotomy in the prone and prone-flexed

positions: anatomic considerations. J Endourol. 2009;23:1607-1614.

8. Tuttle DN, Yeh BM, Meng MV, et al. Risk of injury to adjacent organs with lower-pole fluoroscopically guided percutaneous nephrostomy: evaluation with prone, supine, and multiplanar reformatted CT. J Vasc Interv Radiol. 2005;16:1489-1492.

9. Brian Duty, Arthur Smith, et al. Anatomical Variation Between the Prone, Supine, and Supine Oblique Positions on Computed Tomography: Implications for Percutaneous Nephrolithotomy Access. Urology. 2012 Jan;79(1):67-71.

10. Mulay A, Mane D, Mhaske S, Shah AS, Krishnappa D, Sabale V. Supine versus prone percutaneous nephrolithotomy for renal calculi: Our experience. Curr Urol 2022;16 (1):25-29.

11. Hopper KD, Sherman JL, Luethke JM, Ghaed N. The retrorenal colon in the supine and prone patient. Radiology. 1987 Feb;162(2):443-6

12. Kannan D, Quadri M, Sekaran P G, et al. (July 16, 2023) Supine Versus Prone Percutaneous Nephrolithotomy (PCNL): A Single Surgeon's Experience. Cureus 15(7): e41944.