SUPERIOR INFERIOR CALYCES AXIS IN SAGITTAL VERSUS CORONAL PROJECTION OF NON CONTRAST ABDOMINAL MULTISLICE COMPUTED TOMOGRAPHY: AN ANATOMICAL STUDY IN SUPINE PCNL

[1]Muhammad Sidharta Krisna, [1]Indrawarman, [2]Zulfikar Ali.

[1] Division of Urology/Department of Surgery, Faculty of Medicine/Gadjah Mada University, Sardjito General Hospital, Yogyakarta.
[2] Division of Urology/Department of Surgery, Kardinah General Hospital, Tegal.

ABSTRACT

Objective: *Getting the right access to the kidney calyces that has been determined is the most important part of PCNL. Less optimal access can cause an increase in operating time and a decrease in stone free rate. The use of inferior calyx as access decreases the risk of complications, but there are difficulties in reaching the superior calyx, which affects the stone free rate. The angle and depth of the puncture on PCNL can be determined by coronal and sagittal cuts in the non contrast MSCT scan of the abdomen.* ***Material & Methods:*** *This is an analytical study with a prospective cross-sectional method. An analysis was done to 198 samples of patients in Kardinah Tegal Hospital. Samples were taken with 16 slices non-contrast abdominal MSCT using Philips MSCT MX16 (120 kVp; 2x0.75 mm slice thickness). Samples were collected with consecutive sampling method, excluding patients who had a history of other illnesses or surgical history that resulted in anatomical changes in kidney position, age<18 year old, BMI>30 (obesity), grade 4 hydronephrosis (calyces had disappeared). Reconstruction of 3D non contrast abdominal MSCT was performed by measuring the angle of the coronal cut which was simulated as a puncture in the supination position and sagittal cut which was simulated as puncture in pronation position. An imaginary line was drawn from the imaginary point between the iliac crest and 12th rib as high as 3th to 4th lumbar to the inferior renal calyx. Axis was drawn from the inferior renal calyx towards the superior renal calyx.* ***Results:*** *There is significant difference (P=0.000) in the angle of the imaginary line drawn from the inferior calyx to the superior calyx between the right supination position compared to the right pronation position. The angle in the supination position is more gentle 142.8 (±9.7)/(118-165) degrees compared to 96.5 (±13.2)/(11-138) degrees. On the left side, the angle formed from inferior calyx to the superior calyx in the supination position is more gentle 143.4 (±9.6)/(119-162) degrees) compared with 97.3 (±11.2)/(76-132) degrees formed in pronation position, with a value of P=0.000.* ***Conclusion:*** *PCNL puncture with an inferior calyx approach to reach the superior calix on abdominal MSCT without contrast will be easier to do in the supine position. This is because the angle from the inferior calyx to the superior calyx is more gentle in the supine position so that maneuvers are easier to do.*

Keywords: *Axis, calyx, MSCT, coronal, sagittal.*

ABSTRAK

Tujuan: *Mendapatkan akses yang tepat untuk kaliks ginjal yang telah ditentukan adalah bagian yang paling penting dari PCNL. Akses yang kurang optimal dapat menyebabkan peningkatan waktu operasi dan penurunan stone free rate. Penggunaan kaliks inferior sebagai akses menurunkan resiko komplikasi tetapi terdapat keterbatasan menjangkau kaliks superior sehingga mempengaruhi stone free rate. Sudut dan kedalaman pungsi pada PCNL dapat ditentukan melalui potongan koronal dan sagital pada foto MSCT scan abdomen tanpa kontras.* ***Bahan & Cara:*** *Penelitian ini merupakan studi analitik dengan metode prospektif potong lintang. Dilakukan analisis terhadap 198 sampel pasien di RSUD Kardinah Tegal dengan yang dilakukan MSCT abdomen tanpa kontras 16 potongan dengan menggunakan MSCT Philips MX16 (120 kVp; ketebalan potongan 2x0.75 mm). Sampel diambil dengan teknik consecutive sampling dengan mengeksklusi pasien yang mempunyai riwayat penyakit lain ataupun riwayat operasi yang mengakibatkan perubahan anatomi posisi ginjal, usia<18 tahun dan BMI>30 (obesitas), hidronefrosis grade 4 (kaliks sudah menghilang). Rekonstruksi terhadap data MSCT abdomen 3D tanpa kontras dilakukan dengan cara mengukur sudut pada potongan koronal yang disimulasikan sebagai pungsi pada posisi supinasi dan potongan sagital yang disimulasikan sebagai pungsi pada posisi pronasi. Garis imajiner ditarik dari titik imajiner diantara Crista Iliaca dan costa XII setinggi lumbal 3-4 ke arah kaliks inferior ginjal. Dari kaliks inferior ginjal ditarik aksis ke arah kaliks superior ginjal.* ***Hasil:*** *Besar sudut garis imajiner yang dibentuk dari kaliks inferior ke kaliks superior antara posisi supinasi kanan dibanding posisi pronasi kanan juga mengalami perbedaan yang signifikan (P=0.000). Dimana sudut pada posisi supinasi lebih landai 142.8 (±9.7)/(118-165) derajat dibanding 96.5 (±13.2)/(11-138) derajat). Begitu juga pada sisi sebelah kiri, sudut dari kaliks inferior ke kaliks superior pada posisi supinasi lebih landai 143.4 (±9.6)/(119-162) derajat) dibanding dengan posisi pronasi 97.3 (±11.2)/(76-132) derajat)*

dengan nilai P=0.000. ***Simpulan:*** *Pungsi PCNL dengan pendekatan kaliks inferior untuk menjangkau kaliks superior secara anatomi pada telaah MSCT abdomen scan tanpa kontras akan lebih mudah dilakukan pada posisi supinasi. Hal ini karena sudut dari kaliks inferior menuju kaliks superior lebih landai pada posisi supinasi sehingga manuver lebih mudah dilakukan.*

Kata Kunci: *Aksis, kaliks, MSCT, koronal, sagital.*

Correspondence: Muhammad Sidharta Krisna; c/o: Department of Urology, Faculty of Medicine/Gadjah Mada University, Sardjito General Hospital, Yogyakarta, Indonesia. Phone: +62274587333; Fax: +62274543980. Email: muhammadsidhartakrisna13@gmail.com.

INTRODUCTION

Percutaneous nephrolithotomy (PCNL) was first performed in 1976.[1] This technique was then widely accepted by urologists because of safety, good efficacy as an upper urinary tract stone modality.[2] PCNL has several advantages over open surgery. PCNL is also a good therapeutic modality for kidney stones more than 20mm.[1]

PCNL is recommended for the treatment of radiopaque kidney stones or cystine stones with a diameter of more than 20 mm.[3] PCNL is the choice for large proximal ureteral stones.[4] The average stone free rate is reported to be 86%.[5] The dilated proximal ureter causes the stone can be reached with rigid nephroscopes or instruments that have a large caliber that is flexible so it can break down and remove large pieces of rock efficiently.[6]

Percutaneous puncture is the most important part of percutaneous kidney surgery.[7] The ideal percutaneous access is a short, straight, with the puncture track directly to the desired calyx.[8] Shorter track access makes easier to reach the calyx, increases stone free rate and reduces the risk of bleeding.[9] In addition, the more sloping angle maneuver reduces the likelihood of visceral organ injury.[10] It is important to choose the correct calyx as an entrance route in order to allow maximum stone evacuation.[11] The use of inferior calyx as access decreases the risk of complications but there are limitations in reaching the superior calyx which affects the stone free rate.[12]

Getting proper access to the targeted kidney calyx is the most important part of PCNL.[13] Less optimal access can cause an increase in operating time and a decrease in stone free rate.[14] Percutaneous tracks for PCNL must be decided after careful assessment of preoperative radiographs. Knowledge of intra-kidney anatomy is very important for PCNL planning.[14]

Initially, the patient is positioned in the prone position during PCNL.[15] This position has several advantages including easy access to reach the brodel avascular plane, risk of bleeding and lower rate of abdominal organ trauma, and the wider field of operation for renal instrumentation.[16] In the consensus of endourologist, experience in the superior calyx approach through inferior calyx at the PCNL pronation position is still limited.[12] In 1980-1990, Valdivia et al. introduced PCNL with supination position, with several advantages including ease in positioning the patient, anesthesia and airway control, and the position of the operator sitting during the operation. Unfortunately, this position was not familiar enough to urologists.[17-19]

There have been a lot of studies conducted in order to determine of puncture distance in various PCNL position.[2] The aim of these studies are to increase the accuracy of percutaneous puncture in various PCNL position in order to increase the success rate of PCNL.[5] The measurement of the distance between calyx to the skin on CT scan is more accurate and can assess the percutaneous entry angle. Whereas the measurement of the distance between calyx to the skin using ultrasound cannot be used to determine the percutaneous puncture entry angle.[12] The angle between calyces seen from reconstruction of CT scan is a predictor for determining calyx access.[14]

Skin distance to SPC is shorter in pronation position when compared to supination position. This difference in this distance will be increased in obese and morbid obese patients. Pronation position increases the mobility of the nephroscope and increases the stone free rate.[10,16]

Based on a number of previous studies, there are differences in the anatomy, the inferior calyx angle to the superior calyx and the depth of puncture between the pronation and supination positions of PCNL.[16] A deeper study is needed to obtain information regarding this matter. It is hoped that this

information can determine the easiest access between PCNL supination and pronation positions. The angle and depth of PCNL can be determined through coronal and sagittal view on a CT scan.[19]

The hypothesis is that there is a significant difference in the inferior calyx angle to the superior calyx where the supine position will result in a more sloping angle and there are significant differences in track length where the supine position will have shorter track length.[18]

OBJECTIVE

Getting the right access to the kidney calyces that has been determined is the most important part of PCNL. Less optimal access can cause an increase in operating time and a decrease in stone free rate. The use of inferior calyx as access decreases the risk of complications, but there are difficulties in reaching the superior calyx, which affects the stone free rate. The angle and depth of the puncture on PCNL can be determined by coronal and sagittal cuts in the non contrast MSCT scan of the abdomen.

MATERIAL & METHODS

This is an analytical study with a cross sectional prospective method. Study was performed on 198 patients in Kardinah Tegal Hospital with 16-piece non-contrast abdominal MSCT using Philips MX16 MSCT (120 kVp; 2x0.75 mm thickness). The sample was taken with consecutive sampling technique, with exclusion of patients who had other diseases, history of operation that cause change in kidney position, age<18 years, BMI>30(obesity), grade 4 hydronephrosis (calyx has disappeared). Reconstruction of 3D non-contrast abdominal MSCT was carried out by measuring the angle in the coronal view which simulated as puncture in supine position and the sagittal view which simulated as puncture in the pronation position. An imaginary line is drawn from imaginary point between Iliac crest and 12th rib as high as 3rd to 4th lumbar towards the inferior calyx of the kidney. From the inferior calyx of the kidney the axis is pulled towards the superior calyx of the kidney. Measurements of skin thickness, muscle thickness and visceral fat thickness in sagittal and coronal view were also conducted. The puncture angle determined by drawing an imaginary line from the skin to the inferior calyx of the kidney towards the imaginary axis of the body.

RESULTS

This study conducted in urology polyclinic in patients underwent non-contrast CT urology since October 2016-February 2017. There were 198 patients met the inclusion criteria with 137 male (69.2%) and 61 women (30.8%). The average subject age is 58.5 (15)/(20-85) year old, with the average Body Mass Index 22.3 (2)/(19-24) kg/m2. Half of the sample experienced grade 1-3 hydronephrosis either in ipsilateral or bilateral kidneys and the other half did not experience hydronephrosis.

Table 1. Baseline Characteristics of Patients Underwent Uro CT in Kardinah District Hospital Tegal.

Variable	N(%)
Sex	
- Male	69.2% (137)
- Female	30.8% (61)
Hydronephrosis	
- Yes	50% (99)
- No	50% (99)
Age (year old)	58.5 (±15)/(20-79)
BMI (kg/m^2)	22.3 (±2)/(19-24)

Average skin thickness in the supination position on the right side is 19.6 (±10.36)/(1-64) mm and 18.2 (±10.4)/(2-77) mm on the left side. These results showed no significant difference (p=0.065 and p=0.024) when compared to skin thickness at the pronation position with an average of 17.7 (±10.8)/(2-86) mm for the right and 17.7 (±10.8)/(2-86) mm for the left. In muscle thickness calculation, there is significant difference with P=0,000 between measurements of muscle thickness in the right supination position (20.1 (±6.24)/(8-36)) mm compared with right sagittal position (58.7 (±13.2)/(5-104)) mm and also between measurements of muscle thickness in the left supination position (22.5 (±7.4)/(3-46)) mm compared with left sagittal position(60.9 (±14.1)/(6-100)) mm.

Visceral fat thickness also has a significant difference (P=0.000) between fat thickness in the right supination position compared to visceral fat in the right pronated position and between fat thickness at the left supination position compared with visceral fat in the left pronated position ((50.3 (±18.4)/(5-103) mm compared to 10 (±7.9)/(2-77) mm and 47.9 (±15.8)/(7-90) mm compared to 9.8 (±6.06)/(3-57) mm)).

Table 2. Comparison Between Supination and Pronation Procedure in Non-Contrast Abdominal MSCT.

	Variable	Supination	Pronation	P value
1	Skin thickness right side (mm)	19.6 (±10.36)/(1-64)	17.7 (±10.8)/(2-86)	0.065
2	Muscle thickness right side (mm)	20.1 (±6.24)/(8-36)	58.7 (±13.2)/(5-104)	0.000
3	Fat thickness right side (mm)	50.3 (±18.4)/(5-103)	10 (±7.9)/(2-77)	0.000
4	Right superior inferior axis (degree)	142.8 (±9.7)/(118-165)	96.5 (±13.2)/(11-138)	0.000
5	Skin thickness left side (mm)	18.2 (±10.4)/(2-77)	16 (±9.1)/(2-66)	0.024
6	Muscle thickness left side (mm)	22.5 (±7.4)/(3-46)	60.9 (±14.1)/(6-100)	0.000
7	Fat thickness left side (mm)	47.9 (±15.8)/(7-90)	9.8 (±6.06)/(3-57)	0.000
8	Left superior inferior axis (degree)	143.4 (±9.6)/(119-162)	97.3 (±11.2)/(76-132)	0.000
9	Right puncture side angle (degree)	46 (±7.1)/(25-73)	47.1 (±8.03)/(25-73)	0.023
10	Left puncture side angle (degree)	44.39 (±7.2)/(25-66)	44.6 (±6.7)/(25-69)	0.001

Table 3. Comparison with Other Study.

	Kardinah District Hospital 2017		Sofer M. et al. 2016
	Right	Left	
Muscle thickness in supination vs pronation	0.000	0.000	<0.0005
Skin thickness in supination vs pronation	0.065	0.024	0.6
Inferior –superior xis in supination vs pronation	0.000	0.000	<0.05

The imaginary line angle formed from the inferior calix to the superior calix between the right supination position compared to the right pronation position also experienced a significant difference (P=0.000). The angle of the supination position is more sloping (142.8 (±9.7)/(118-165) degrees compared to 96.5 (±13.2)/(11-138) degrees. Likewise on the left side, the angle from the inferior calyx to the superior calyx in supination position is more sloping (143.4 (±9.6)/(119-162) degrees) compared to the pronation position (97.3 (±11.2)/(76-132) degrees) with a value of P=0,000.

The puncture side angle formed on the imaginary line towards the inferior calyx of the kidney to the body axis at the supination position compared to the pronation position has a significant difference with the p value=0.023 on the right and P=0.001 on the left.

DISCUSSION

This study shows no significant difference in skin thickness between puncture performed in the supination and pronation positions, similar with finding previous studies mentioning skin thickness ratio did not have a significant difference with P=0.6.[11] This is probably due to the BMI difference from the sample that produces difference in subcutaneous fat thickness in each sample. Muscle thickness that must be penetrated by the puncture needle at the supination position is significantly thinner than the thickness of the muscle in the pronation position both on the right side and on the left side. This is in accordance with Sofer M. et al. in 2016, where the average muscle thickness at the supination position was thinner than the pronation position (29.9 (13-64.2) mm compared to 19.1 (8.7-30) mm with p value<0.0005. Thinner muscle thickness on the puncture side in supination position minimize the difficulty in performing puncture.

The same study mentioning the inferior to superior calyx axis in supination position was significantly superior compared to the pronation position that make easier to do maneuver to evacuate the stone in the superior calyx with the inferior caliber approach in order to increase the stone free rate in PCNL procedure. The average of the inferior to superior calyx angles at the supination position is 141 (90-170) degrees compared to 84 (65-110) degrees in the pronation position with a value of P<0.05.

CONCLUSION

PCNL puncture with an inferior calyx approach to reach the superior calyx anatomically in patients who have performed non-contrast

abdominal MSCT will be easier to do in the supine position. This is because the angle from the inferior calyx to the superior calyx is more sloping at the pronation position so that the maneuver is easier to do. In addition, thinner muscle thickness facilitates easier puncture.

REFERENCES

1. Bozkurt, Ibrahim Halil, et al. 2015. Minimally invasive surgical treatmen for large impacted upper ureteral stone : Ureteroscopic lithoripsy or percutaneous nephrolitotomy. Can Urol Assac. 2015; 9: 3-4.
2. Chien GW, Bellman GC. Blind percutaneous renal access. J Endourol. 2002; 16(2): 93-6.
3. Davis WB, Trerotola SO, Johnson MS, et al. Percutaneous imaging-guided access for the treatment of calculi in continent urinary reservoirs. Cardiovasc Intervent Radiol. 2002; 25: 119–122
4. Harbans Singh. PCNL Pungsi Technique. JIMSA July-September 2011; 24(3).
5. Falahatkar S, Farzan A, Allahkhah A. Is complete supinasi percutaneous nephrolithotripsy feasible in all patients? Urol Res. 2011; 39: 99-104.
6. Marchini G., BertoF., Vicentini F., et al. Preoperative Planning with Noncontrast Computed Tomography in the Pronasi and Supinasi Position for Percutaneous Nephrolithotomy: A Practical Overview. Journal of Endourology. 2014; 20(20): 1-7
7. Hassan, Amira R. et al. Different Regional Anestesia Techniques for supinasi Percutaneous Nephrolitotomy. Med.J.Kairo. 2010; 663-66.
8. Miano R, Scoffone C, De Nunzio C, et al. Position: Pronasi or supinasi is the issue of percutaneous nephrolithotomy. J Endourol. 2010; 24: 931–938.
9. Duty B., Waingankar N., Okhunov Z., et.al. Anatomical Variation Between the Pronasi,Supinasi, and Supinasi Oblique Positions on Computed Tomography: Implications for Percutaneous Nephrolithotomy Access. J UROLOGY. 2012; 79: 67–71.
10. Brian Duty et al. Anatomical Variation Between the Pronasi, Supinasi, and Supinasi Oblique Positions on Computed Tomography: Implications for Percutaneous Nephrolithotomy Access. Urology. 2012; 79(1).
11. Sofer M., Giusti G., Proietti S., et al. Upper Calyx Approachability through a Lower Calyx Access:Comparison between Pronasi and Supinasi Percutaneous Nephrolithotomies, and Assessment of Anatomical Factors that May Influence It Using 3-Dimensional Computerized Tomography Reconstructions. The Journal of Urology. 2016; 195 :1-6.
12. Chen Jen Shan, Eduardo Mazzucchi, Fabio Payão, Andrea Cavalanti Gomes, Ronaldo Hueb Baroni, Fabio Cesar Torricelli, Fabio Carvalho Vicentini, Miguel Srougi. The skin-to-calyx distance measured by renal ct scan and Ultrasound. Int Braz J Urol. 2014; 40: 212-9.
13. Yazici C., Kayhan A., Dogan C. Supinasi or Pronasi Percutaneous Nephrolithotomy: Do Anatomical Changes Make it Worse?. Journal of Endourology. 2014; 28(1): 10-16.
14. Miller NL, Matlaga BR, Lingeman JE. Techniques for fluoroscopic percutaneousrenal access. J Urol. 2007; 178(1): 15-23.
15. Wolf S. Percutaneous Approach to the Upper Urinary Tract Collecting System, Campbell- Walsh Urology. 2012; 47.
16. Mourad Abouelleil et al. . In Obese Patients, the Distance Between Skin and Renal Collecting System Changes with the Position of the Patient from Supinasi to Pronasi. Journal of Endourology. 2015; 29(10).
17. Cormio L, Annese P, Corvasce T, et al. Percutaneous nephrostomy, in supinasi position. Urology 2007; 69: 377–380.
18. Liu L, Zheng S, Xu Y, Wei Q. Systematic review and meta-analysis of percutaneous nephrolithotomy for patients in the supinasi versus pronasi position. J Endourol. 2010; 24: 1941.
19. Valdivia-Uria JG. Complete supinasi percutaneous nephrolithotripsy comparison with the pronasi standard technique: the time for change from pronasi to supinasi position has come. UroToday Int J. 2009; 2.