# TRANSITION FROM PRONE TO SUPINE PERCUTANEOUS NEPHROLITOTOMY: EVALUATING THE LEARNING CURVE FROM THE SINGLE SURGEON EXPERIENCE

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***ABSTRACT***

***Objective:*** *This study aims to evaluate the learning curve of the urologist to perform supine PCNL and the perioperative outcome of patients based on a single surgeon's experience.* ***Material & Methods:*** *60 consecutive patients who underwent modified supine PCNL for renal stone were analyzed. A single experienced urological surgeon performed the supine PCNL. Mean operative time, drop in hemoglobin level, stone-free rate, complications, and length of hospital stay were analyzed to evaluate the learning curve of the surgeon. All parameters were compared among all six groups obtained from the 60 cases in chronological order. Besides, the outcomes of supine PCNL were also compared to prone PCNL.* ***Results:*** *Mean operative time from 60 cases of supine PCNL was 100 ± 27 minutes. The mean operative time was decreased over time, particularly after 20 cases. Significantly different mean operative times (89 ± 14 minutes vs. 126 ± 21 minutes, $p < 0.001$) in the groups of cases 21-60 compared to the group of 1–20 cases were observed. The total stone-free rate for supine PCNL from all cases was 68%. There was no difference regarding the reduction of hemoglobin level, stone-free rate, hospital stay, and complication rate. No major complication was found among study subjects. Supine PCNL showed similar outcome parameters compared to prone PCNL.* ***Conclusion:*** *The surgeon acquired the surgical competencies to perform supine PCNL after 20 cases. The supine PCNL could remove the kidney stone as effective and safe as prone PCNL.*

***Keywords:*** *Learning curve, PCNL, operative time, supine position, kidney stones.*

***ABSTRAK***

***Tujuan:*** *Studi ini bertujuan untuk menilai kurva pembelajaran seorang urolog untuk mengerjakan PCNL posisi supine dan menilai hasil keluaran perioperative pada pasien.* ***Bahan & Cara:*** *Total 60 pasien yang menjalani PCNL posisi supine untuk batu ginjal. Semua operasi PCNL posisi supine dikerjakan oleh satu orang urolog. Data mengenai rerata waktu operasi, turunnya hemoglobin, angka bebas batu, komplikasi operasi, dan lamanya masa rawat dianalisa untuk melihat kurva pembelajaran seorang urolog. Parameter ini dibandingkan secara berurutan dan sekuensial dari 60 kasus. Selain itu, dibandingkan juga hasil keluaran PCNL posisi supine dibandingkan dengan PCNL posisi prone.* ***Hasil:*** *Rerata waktu operasi untuk 60 kasus PCNL posisi supine adalah 100 ± 27 menit. Rerata waktu operasi menurun sejalan dengan waktu, utamanya setelah 20 kasus. Terdapat perbedaan yang signifikan untuk parameter waktu opersi (89 ± 14 menit vs. 126 ± 21 menit, $p < 0.001$) pada kasus ke 21-60 dibandingkan kasus ke 1-20. Angka bebas batu untuk supine PCNL adalah 68%. Tidak ada perbedaan bermakna antara penurunan level hemoglobin, angka bebas batu, lama masa rawat, dan komplikasi. Tidak ada komplikasi mayor pada studi ini. PCNL posisi supine memiliki hasil keluaran yang sama dengan PCNL posisi prone.* ***Simpulan:*** *Seorang urolog mendapatkan kompetensinya untuk melakukan PCNL supine setelah 20 kasus. Posisi PCNL supine dapat mengeluarkan batu dengan efektif dan aman seperti dengan PCNL posisi prone.*

***Kata Kunci:*** *Kurva pembelajaran, PCNL, waktu operasi, posisi supine, batu ginjal.*

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## INTRODUCTION

Percutaneous nephrolithotomy (PCNL) is a standard endoscopic procedure for the removal of the large kidney stone replacing open surgery. The first case of removing the kidney stone throughout percutaneous access ware performed by Fernstrom and Johansson in 1976.[1] Traditionally, PCNL has

been done with prone position to obtain renal access due to increased chance of vascular or colonic injury in other positions. However, there are several disadvantages of prone position PCNL including either ventilator and cardiovascular problems in patients in obesity, skeletal problem, or history of cardiovascular disease. Besides, prone PCNL requires turning the patient and there is a chance of nerve or limb injury during the turning process.[2]

Due to the disadvantages of prone PCNL, Valdivia Uria et al. presented the supine PCNL.[1] Supine PCNL has several benefits: minimalized cardiovascular and respiratory risk compared to the prone position, increased comfortability and safety of the anesthesiologist in managing the patient, eliminated the need for position alteration, and increased time efficiency. Besides, supine PCNL may also permit ureteroscopic access simultaneously especially in the management of more complex kidney stone.[2] However, several disadvantages of supine PCNL include limited working area, longer skin to kidney distance compared to the prone position, and increase risk of visceral injury.[3]

Despite the advantages of supine PCNL, the popularity of this technique among urologists worldwide remains comparable with the prone position. The conservative viewpoint and consensus stated that the treatment of large and complex kidney stone should be done in prone position.[4] Similar with the prone PCNL, the establishment of safe renal access and the effective intrarenal procedure is a crucial point during acquiring the supine PCNL skill and thus requires minimum time and cases to achieve. This could be represented as a learning curve, a graph that shows the progress of the surgeon to master the skill overtime required for such mastery. The number of cases of the surgeon to become competent at this procedure is of the main interest. A previous study found that 60 cases were required before reaching the surgical competence for prone PCNL.[5]

## OBJECTIVE

The primary aim of this study is to evaluate the learning curve transition from prone to supine PCNL basis on the perioperative outcome of patients, performed by single surgeon. The urologist had performed more than one hundred cases of prone PCNL before adopting the practice of supine PCNL. We want to define the number of procedures required for the competence of the supine PCNL in the urologist who had acquired competence in performing prone PCNL.

## MATERIAL & METHODS

Medical record data were obtained for this cross-sectional study. The first 60 consecutive patients who underwent modified supine PCNL for renal stone at our institution from November 2017 until December 2018 were included as study subjects. The surgeon, who had experienced doing prone PCNL in more than a hundred cases, performed the supine PCNL. We compared the data of patients who undergone supine PCNL with prone PCNL that had been done previously (2015-2017). For supine PCNL, we placed the patients in the Galdako-modified Valdivia position.[6] Either in supine or prone PCNL, the targeted calyx was punctured guided fluoroscopy.

We measured mean operative time, drop in hemoglobin level, complications such as prolonged fever or transfusion rate, and stone-free rate, and length of hospital stay to evaluate the learning curve of the surgeon among every case. Stone size and location, number of punctures, calyx puncture site, and the use of JJ stent or nephrostomy tube were also recorded. The operation time was defined as the time from the beginning of the puncture until the skin was closed. Stone free rate was defined as the proportion of patients with residual stone below 5 mm on kidney, ureter, and bladder (KUB) X-ray post-operatively. For the radiolucent stones, we used ultrasonography to examine any residual stone in the kidney. We defined the tubeless as no use of any JJ stent or nephrostomy post-operatively. The use of JJ stent without nephrostomy was considered tubeless. All of the parameters were compared among the six groups obtained from the 60 cases in chronological order. In addition, we compare those parameters in supine PCNL group with the data from prone PCNL group.

The data presented as mean and standard deviation (SD). The Statistical Package for Social Science, version 21.0 for mac was used. The operation time among groups of chronological order was analyzed using analysis of variance. Other parameters were compared using chi-square, Mann-Whitney U, or t-test as appropriate. The p-value less than 0.05 was considered significant.

## RESULTS

This study evaluated 60 patients undergoing supine PCNL consecutively done by a single surgeon. As a comparator, 126 patients underwent prone PCNL. The patient characteristics were shown in table 1. There was no difference in patient characteristics in supine and prone groups. In the supine PCNL group, the majority of patients had renal pelvis stone, however, in the prone PCNL, the majority of patients had staghorn stone. The diameter of the stone was comparable in the supine and prone PCNL group. The perioperative outcome in table 1 showed that prone and supine PCNL had similar outcomes in terms of operation time, drop of the hemoglobin level, stone-free rate, hospital stay. In both groups, no major complication during surgery in the patient cohort.

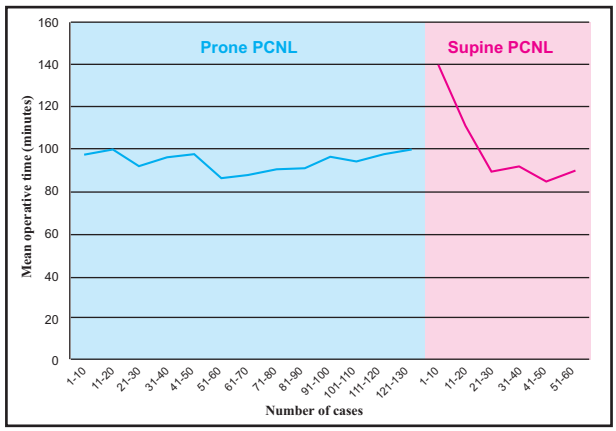


**Figure 1.** Comparison of mean operation time between supine and prone PCNL based on number of cases.

The mean operation time of supine PCNL group was 100 ± 27 minutes. In figure 1. decreased mean operative time, particularly after 20 cases in supine PCNL group, was seen. There was statistically difference of the operative time in the group 1-10 cases (140 ± 15 minutes) compared to group 11-20 cases (112 ± 16 minutes), with $p < 0.001$. Besides, there was significant difference in the group 11-20 cases compared to 21-30 cases (112

**Table 1.** Patient characteristics of the supine and prone PCNL.

| Variables | | Value | | P - value |
|---|---|---|---|---|
| | | Supine (n = 60) | Prone (n =126) | |
| Sex | Male, n(%) | 32 (53.3) | 68 (53.9) | 0.935+ |
| | Female, n(%) | 28 (46.6) | 58 (46.1) | |
| Age, year | Mean ± SD | 50 ± 9.6 | 51.2 ± 11.5 | |
| | Median (range) | 52 (27 - 69) | 52 (21 - 83) | 0.546* |
| Side | Right, n(%) | 28 (46.6) | 64 (50.7) | 0.631+ |
| | Left, n(%) | 32 (53.4) | 62 (49.3) | |
| Stone location | Staghorn, n(%) | 23 (38.3) | 63 (50) | |
| | Renal pelvis n(%) | 33 (55) | 53 (42) | 0.810 + |
| | Individual calyx,n(%) | 4 (6.7) | 10 (8) | |
| Stone diameter | Mean ± SD | 28 ± 8.9 | 31 ± 12.3 | 0.232* |
| (mm) | Median (range) | 28 (10 - 58) | 30 (12 – 75) | |
| Stone | Single, n(%) | 21 (35) | 62 (49.2) | 0.068+ |
| | Multiple, n(%) | 39 (65) | 64 (50.8) | |
| Operation time | Mean ± SD | 100.1 ± 27.3 | 100.2 ± 34.8 | 0.776* |
| (min) | Median (range) | 100 (50 – 160) | 90 (30 – 210) | |
| Post operative tube | Totally tubeless, n(%) | 10 (16.7) | 23 (18.2) | |
| | Tubeless, n(%) | 42 (70) | 92 (73.0) | 0.621+ |
| | Nephrostomy, n(%) | 8 (13.3) | 11 (8.8) | |
| Drop in | Mean ± SD | 0.9 ± 0.88 | 1.09 ± 0.86 | |
| hemoglobin level(g/dl) | Median | 0.6 (0.2 – 4.2) | 0.9 (0.2 – 4.1) | 0.072* |
| Stone free | N(%) | 41 (68.3) | 93 (73.8) | 0.437+ |
| Hospital stay (day) | Mean ± SD | 2.8 ± 0.88 | 2.7 ± 1.3 | 0.369* |
| | Median | 3 (2 - 5) | 2 (2 - 7) | |

+chi-square; * Mann-Whitney test

**Table 2.** The perioperative outcome of the supine PCNL.

| | Case 1-10 | Case 11-20 | Case 21-30 | Case 31-40 | Case 41-50 | Case 51-60 |
|---|---|---|---|---|---|---|
| Operation time (min) | 140 ± 15.7 | 112 ± 16.8 | 89 ± 15.9 | 92.5 ± 6.3 | 84 ± 23 | 90 ± 8.6 |
| Drop-in hemoglobin level (g/dl) | 1.1 ± 1.26 | 1.3 ± 1.26 | 0.7 ± 0.54 | 0.9 ± 0.67 | 0.7 ± 0.52 | 0.9 ± 0.9 |
| Stone free, n(%) | 8(80) | 4(40) | 8(80) | 9(90) | 6(60) | 6(60) |
| Hospital stay, mean (d) | 2.6 ± 0.97 | 2.8 ± 0.92 | 2.5 ± 0.53 | 3.2 ± 0.79 | 3.0 ± 0.85 | 2.8 ± 0.9 |
| Complications | | | | | | |
| Post operative transfusion, n(%) | 1(10) | 0(0) | 0(0) | 1(10) | 0(0) | 0(0) |
| Fever > $38^0$C, n(%) | 0(0) | 2(20) | 0(0) | 2(20) | 1(2) | 1(10) |

± 16 minutes vs. 89 ± 16 minutes, p = 0.04). We found no significant difference of the operative time in the group cases 21-30 (89 ± 16 minutes), 31-40 (92.5 ± 6.3), 41-50 (82 ± 22 minutes), and 51-60 (90 ± 8.6 minutes). If the groups of cases 21-60 were combined and compared to the group of 1 – 20 cases, there were significantly different mean operative times (89 ± 14 minutes vs 126 ± 21 minutes, p < 0.001). Mean operative time in the prone group was relatively stable with mean operative time was 100 ± 34.8 minutes. The prone groups showed plateau graph. The graph of the supine PCNL was crossed the prone PCNL after 20 cases and after that, the supine PCNL group showed plateau operative times.

Table 2 shows the perioperative outcome of the supine PCNL base on the number of case groups. The drop in hemoglobin level shows slightly decreased after the surgeon gained the experience level, especially after 20 cases. However, the drop of the hemoglobin was not statistically significant in the cases 1-20 vs. above 20 cases (p = 0.095). There was no difference in the hospital stay between the cases (p = 0.187). From all cases, the stone-free rate was 68%. Stone free rate also comparable between the groups (p = 0.254). No major complications such as colonic injury, conversion to open surgery in this cohort. Two cases were required post-operative transfusion. Almost ten percent had fever postoperatively.

## DISCUSSION

Firstly recognized in 1976 by Fernstrom and Johansson, percutaneous nephrolithotomy (PCNL) has been accepted as one of the therapy modalities for renal stones. Based on the urolithiasis guideline released by the European Association of Urology, PCNL is more favorable for kidney stone size > 20 mm or smaller stone with complex anatomical consideration such as lower pole renal stones.[7] The advantage of PCNL compared to other treatments such as extracorporeal shockwave lithotripsy or ureteroscopy is that PCNL can remove the large stone in a single setting procedure. However, compared to other therapies previously mentioned is that PCNL is probably the most invasive. Because of that, the learning curve to perform effectively and safely PCNL has to establish.

Traditionally, PCNL was done in prone position. Worldwide, only 20% of PCNL is performed in supine position.[4] Despite several advantages of supine position, many experienced surgeons who have experienced in prone PCNL not very enthusiastic to do the supine position because the change might impact the surgical outcome during the process of the learning curve. Supine PCNL had several advantages such as it allows the single position to do the entire operation, ventilation and monitoring of the patients is easier for the anesthesiologist in supine position, combination surgery with PCNL and flexible ureteroscopy for treatment of complex stone, and the operation can be done in sitting position.[8]

However, there are several technical limitations of supine PCNL compared to prone PCNL. In the supine position, the pressure filling of the collecting system decreases so that the collecting system tends to collapse during the procedure.[9] It is

make nephroscopy procedure and maneuver more difficult. Compared to prone position, the distance between the 12th rib and superior edge of the iliac crest is lesser in supine position, thus there is reduce of nephroscope maneuver during the procedure.[10] In addition, a kidney in supine position is more floating in the retroperitoneum compared to prone position and make dilatation more difficult.[11] Because of the several technical limitations in supine PCNL, the surgeons who want to change the practice from prone to supine PCNL must have a transition of the learning curve that allows the procedure more safely.

The previous study by Tanriverdi et al. that evaluated the learning curve of prone PCNL suggested that competence to perform prone PCNL was established after 60 cases. They assessed the learning curve of a single surgeon experience who never done the PCNL before. The learning curve was based on mean operative time and fluoroscopy time. After 60 cases of PCNL, the plateau of mean operative time and fluoroscopic time during the PCNL was achieved.[5] Besides, a study by Allen et al. suggested the same result. In the single surgeon experience, the plateau of mean operative time was reached after 60 cases, but the surgeon required 115 cases to achieve the shorter fluoroscopic time.[12]

Jang et al. studied the experience of a single surgeon to perform 53 cases of flank PCNL. They found that surgical competence was achieved after completing 36 cases of flank PCNL. However, they did not mention the previous experience of the surgeon whether the surgeon had experience for PCNL in another position.[13] In our study, the surgeon who performed the supine PCNL had experienced do the prone PCNL that almost one hundred cases before perform the supine PCNL. This study suggested that in the surgeon who had the experience to perform prone PCNL, the competence of supine PCNL could be achieved after 20 cases of surgery in the parameters of operation time. In this study, the mean operation time was 100 ± 25 minutes. There was a statistical difference of the operative time in the group 1-20 cases (126 ± 21 minutes) compared to group 21-53 cases (87 ± 16 minutes), with $p < 0.01$

Our study found that there was no difference in the parameters of perioperative outcome such as hospital stay, drop of hemoglobin, complication rate, and stone-free rate between the supine PCNL groups. The only statistical difference was found in operation time parameters. The reducing operation time after several cases of supine PCNL might be influenced by increased familiarity of the position, especially interpretation of the three-dimensional anatomy on a two-dimensional fluoroscopic picture of the calyx during the obtaining renal access. The most consuming part of the PCNL is obtaining renal access and dilation of the tract. This study was in line with the study by Jang et al.

There was no significant difference of hospital stay, drop of hemoglobin, complication rate, and stone-free rate between the consecutive groups of flank PCNL. The only parameters that decrease after the surgeon achieved more cases were the operative times.[13] Study by Sofer et al. found that there was a significant decrease in operation time after performing more cases of PCNL.[8] Previous studies stated that the stone clearance and complications were not the best tools to assess the surgeon competency during PCNL. The novice surgeon could gain a high stone-free rate in their initial cases and the stone-free rate is very variable depending on the stone burden and stone location. In addition, the complication of the surgery also cannot be used to assess the learning curve because major complications occur so rarely so that many cases were needed to make a conclusion.[5]

In this study, approximately 87% of the supine PCNL patients had tubeless or totally tubeless for post-operative drainage. No difference was found for the proportion of tubeless between the groups of the supine PCNL patients. This study was different from the previous study that showed the more the learning curve gained, the proportion of patients with tubeless or totally tubeless was increased.[8] They suggested that the use of tubeless or totally tubeless was associated with shorter length of stay.[14] Since our cohort showed no difference in the proportion of patients that had tubeless or totally tubeless for post-operative drainage, we found no difference in length of stay between the group of patients.

The analysis performed in this study showed that there is no significant difference between the clinical outcome and position of the PCNL procedure. Operation time, drop in hemoglobin, stone-free rate, hospital stay, and complications were not significantly different between supine and prone PCNL ($p > 0.05$). Stone free rate in prone group and supine group showed the approximately same value of 71%. Our study was as same as the randomized study by Al-Dessoukey et al that showed no difference of stone-free rate in the supine or prone PCNL groups.[15] In addition, other randomized clinical trial showed no difference in mean hospital

stay, mean blood loss, and complication between supine and prone PCNL.[16]

This study has several limitations. This study was an observational study that included a small population of patients, especially in the supine PCNL groups. With the small number of patients in supine PCNL, the operation time has reached its plateau. It might be caused by the experience of the surgeon performing the previous PCNL in the prone position so that to get the plateau of the competency just needs a small number of patients. In addition, due to this paper was the basis on single surgeon experience, the generalizability of the learning curve that found in this paper had to confirm in another center with various experience of the surgeon.

## CONCLUSION

This present study reported the learning curve and perioperative outcome of supine PCNL performed by a single surgeon. The surgeon acquired the surgical competencies to perform supine PCNL after 20 cases, in the parameters of surgical time. Renal stones were removed effectively and safely in the supine position that showed no difference of perioperative outcome between supine and prone PCNL.

## REFERENCES


1. Valdivia Uria JG, Valle Gerhold J, Lopez Lopez JA, et al. Technique and complications of percutaneous nephroscopy: experience with 557 patients in the supine position. J Urol. 1998; 160: 1975-8.
2. Basiri A, Mohammadi Sichani M. Supine percutaneous nephrolithotomy, is it really effective? A systematic review of literature. Urol J. 2009; 6: 73-7.
3. Valdivia JG, Scarpa RM, Duvdevani M, et al. Supine versus prone position during percutaneous nephrolithotomy: a report from the clinical research office of the endourological society percutaneous nephrolithotomy global study. J Endourol. 2011; 25: 1619-25.
4. Ghani KR, Andonian S, Bultitude M, et al. Percutaneous Nephrolithotomy: Update, Trends, and Future Directions. Eur Urol. 2016; 70: 382-96.
5. Tanriverdi O, Boylu U, Kendirci M, Kadihasanoglu M, Horasanli K, Miroglu C. The learning curve in the training of percutaneous nephrolithotomy. Eur Urol. 2007; 52: 206-11.
6. Ibarluzea G, Scoffone CM, Cracco CM, et al. Supine Valdivia and modified lithotomy position for simultaneous anterograde and retrograde endourological access. BJU Int. 2007; 100: 233-6.
7. Türk C, Pet?ík A, Sarica K, et al. EAU guidelines on interventional treatment for urolithiasis. European urology. 2016; 69: 475-82.
8. Sofer M, Tavdi E, Levi O, et al. Implementation of supine percutaneous nephrolithotomy: a novel position for an old operation. Cent European J Urol. 2017; 70: 60-5.
9. Nour HH, Kamal AM, Ghobashi SE, et al. Percutaneous nephrolithotomy in the supine position: Safety and outcomes in a single-centre experience. Arab J Urol. 2013; 11: 62-7.
10. Duty B, Okhunov Z, Smith A, Okeke Z. The debate over percutaneous nephrolithotomy positioning: a comprehensive review. J Urol. 2011; 186: 20-5.
11. De Sio M, Autorino R, Quarto G, et al. Modified supine versus prone position in percutaneous nephrolithotomy for renal stones treatable with a single percutaneous access: a prospective randomized trial. Eur Urol. 2008; 54: 196-202.
12. Allen D, O'Brien T, Tiptaft R, Glass J. Defining the learning curve for percutaneous nephrolithotomy. J Endourol. 2005; 19: 279-82.
13. Jang WS, Choi KH, Yang SC, Han WK. The Learning Curve for Flank Percutaneous Nephrolithotomy for Kidney Calculi: A Single Surgeon's Experience. Korean J Urol. 2011; 52: 284-8.
14. Sofer M, Beri A, Friedman A, et al. Extending the application of tubeless percutaneous nephrolithotomy. Urology. 2007; 70: 412-6.
15. Al-Dessoukey AA, Moussa AS, Abdelbary AM, et al. Percutaneous nephrolithotomy in the oblique supine lithotomy position and prone position: a comparative study. J Endourol. 2014; 28: 1058-63.
16. Wang Y, Wang Y, Yao Y, et al. Prone versus modified supine position in percutaneous nephrolithotomy: a prospective randomized study. Int J Med Sci. 2013; 10: 1518-23.