*Original Article*

# Efficacy and Safety of Percutaneous Nephrolithotomy (PCNL): A Comparative Study between General Anesthesia and Spinal Anesthesia

Md. Mostafiger Rahman[1], Md. Sazzad Hossain[2], Fatema-Tuj-Johura[3], Moriam Pervin[4]

## Abstract

***Background:*** *Percutaneous nephrolithotomy (PCNL) can be conducted under general anesthesia as well as spinal anesthesia. To compare the efficacy and safety of spinal anesthesia vs. general anesthesia in PCNL.* ***Materials and Methods****: This observational study included 160 patients who underwent PCNL for renal stone from January 2021 to July 2025; 75 received general anesthesia (GA group) and 85 spinal anesthesia (SA group). Demographic and operative variables, including age, stone size, number and location, pre- and postoperative hemoglobin and hematocrit, postoperative pain, analgesic requirement, hospital stay, complications and stone-free rate, were compared.* ***Results****: The groups were comparable in age, stone size, number and location. Peri-operative hypotension was significantly higher in the SA group than the GA group (19.27% vs. 6.6%, p=0.023), while postoperative fever was higher in the GA group (58.66% vs. 38.22%, p=0.018). Shivering was higher in the SA group (15.29% vs. 5.34%), whereas nausea and vomiting were higher in the GA group: 16.67% vs. 4.79% (p=0.031) and 13.34% vs. 3.52% (p=0.023), respectively. Mean hospital stay was similar between SA and GA groups (5.30±2.06 vs. 05.02±01.91 days, p=0.37). Hemoglobin, hematocrit and stone-free rate showed no significant difference.* ***Conclusion:*** *In PCNL, spinal anesthesia was associated with more hypotension but less postoperative fever and may be an alternative to general anesthesia with comparable efficacy and safety.*

***Keywords:*** *Percutaneous nephrolithotomy (PCNL), Spinal anesthesia (SA), General anesthesia (GA)*

*Delta Med Col J. Jan 2023;11(1):28-34*

**Author information**

1. Associate Professor, Department of Urology, Prime Medical College, Rangpur, Bangladesh
2. Associate Professor, Department of Urology, Delta Medical College, Dhaka, Bangladesh
3. Medical Officer, Department of Pharmacology, Rangpur Medical College, Rangpur, Bangladesh
4. Assistant Professor. Department of Anesthesiology, Prime medical college, Rangpur, Bangladesh

**Correspondence:** Dr. Md. Mostafiger Rahman, Associate professor, Department of Urology, Prime Medical College, Rangpur. E-mail: mostafiger.bd@gmail.com

## Introduction

Urolithiasis is one of the most common disorders among urinary diseases[1]. According to the European Association of Urology (EAU) and American Urological Association (AUA), percutaneous nephrolithotomy (PCNL) is the first line treatment modality for renal calculi sized >20 mm.[2] PCNL is also useful for treating multiple stones, staghorn stones, and stones that are resistant

to extracorporeal shockwave lithotripsy.[2,3] There are variations to PCNL, including position, imaging modality, dilation method, and anesthesia method.[4,5] GA was associated with a longer duration of surgery and postoperative length of hospital stay in most studies.[4,6,7,8] Some studies have also shown that General anesthesia (GA) costs more than spinal anesthesia (SA) and has a higher rate of complications. Complications usually occur when the patient's position is altered from supine to prone. These complications include brachial plexus injury, spinal cord injury, and lung injury.[7,8] The aim of this study was to evaluate the safety and efficacy profile, in terms of stone free rate, of GA and SA in PCNL.

## Materials and methods

This comparative study was carried out at the Department of Urology, Prime medical college Hospital, Rangpur and different specialized hospital, Rangpur, Bangladesh from January 2021 to July 2025. A total of 160 patients with ASA I-II who had large or complex renal calculi and underwent percutaneous nephrolithotomy (PCNL) were included in the study. Patients with concomitant pelviureteric junction obstruction, horseshoe kidneys, concomitant ureteric stones and patients under chronic treatment with analgesics or cortico-steroids, patient with contraindications to spinal anesthesia (coagulopathy, local infection), allergy to local anesthetic solutions or opioids, patients with significant spinal, hepatic, cardiovascular, respiratory or psychiatric disorders were excluded from the study. All patients were given written informed consent to participate in the study. All patients underwent pre-operative evaluations including detailed history, physical examination, pre-operative urine analysis, urine culture & sensitivity, serum creatinine, complete blood count and liver function tests, electrocardiography (ECG), and plain chest X-rays. To identify stone characteristics, intravenous urography and/or non-contrast computed tomography were performed. The patients were assigned to the PCNL with general anesthesia group (GA) group or the PCNL with spinal anesthesia group (Group: SA) according to the anesthesia type they received. Each specific mode of anesthesia was standardized. All patients received intravenous third-generation cephalosporin, 2 h before surgery and for the next 1 day thereafter.

### The spinal anesthesia technique:

In SA group under all aseptic and antiseptic precautions spinal anesthesia at L3- $L^4$ interspace using a 25G spinal needle with patient in sitting position was performed. It was done by injecting 3–4 ml of heavy bupivacaine 0.5% plus 25 mg fentanyl over 10-15 sec slowly after noting the clear free flow of CSF with the operating table kept flat. Patients were turned supine immediately. Head of the bed was tilted down for 5–10 min with checking the level of anesthesia. Conscious sedation during PCNL was obtained with intravenous midazolam 1–2 mg.

### The general anesthesia technique

In GA group preoxygenation with 100% oxygenation on bag and mask with attached circuit was done. Premedication of 1-2 µg/kg from fentanyl was administered. Induction of general anesthesia was induced with propofol 2–3 mg/kg and Inj. Succinylcholine I.V. 2mg/kg was given. Patients were intubated with appropriately sized endotracheal tubes by direct laryngoscopy. Anaesthesia was maintained with oxygen and nitrous oxide (50%-50%), 1-3% Isoflurane with long-acting muscle relaxant Inj. vecuronium in a dose of 0.5 mg/kg. Baseline heart rate (PR), systolic blood pressure (SBP), Diastolic blood pressure (DBP), Mean arterial pressure (MAP), $SPO^2$ were measured. In patients of the GA group neuromuscular block was antagonized with neostigmine 0.05 mg/kg and atropine 0.02 mg/kg at the end of surgery. Once all recovery criteria (head lifting, eyes opening, following verbal command) were fulfilled patients were extubated after oropharyngeal suction.

## PCNL procedure

PCNL procedure, cystoscopy was performed to place a 5 Fr ureteric catheter into the renal pelvis in modified lithotomy position. Under fluoroscopy, renal punctures were performed in all patients. All procedures were carried out in prone position. The access tract was dilated with an Amplatz dilator up to 24 Fr at which point the Amplatz sheath was placed. A nephroscope was introduced to the collecting system and the stone was fragmented with pneumatic lithotripter. The stone was removed by forceps. A 22 Fr drainage nephrostomy tubes 12 hrs after PCNL and urethral catheter were routinely left for 24 hrs after PCNL. Intra-operative parameters included recording of pulse, blood pressure, and duration of surgery was noted. Postoperative analgesia was administered in the form of Injection pethidine intramuscularly in both group of patient stat and 8 hourly. Any complications during intraoperative and postoperative period like hypotension, shivering, nausea, vomiting headache, fever, allergic reactions if present were recorded. Patients in both groups were followed up at 1 month (overall) after surgery to assess status. Stone-free status was defined as the absence of any fragment greater than 4 mm. The statistical analysis was carried out using SPSS. A p-value < 0.05 was considered significant.

## Results

## Patients' characteristics

In the present study, 160 patients were enrolled (43 males and 32 females in the GA group vs. 57 males and 24 females in the SA group) and male predominance was observed (p= 0.078). Mean ages in these groups were 52.8±16.2 years and 50.8±11.8 years, respectively (p=0.3712). In both groups, most patients were classified as ASA Grade II, followed by Grade I. No considerable variance was observed among the groups in terms of patients age, gender and ASA grades.

**Table 1. Comparison of patients' characteristics in between general & spinal anesthesia.**

| Variable | GA group (n=75) | SA group (n=85) | P Value |
|---|---|---|---|
| Age (Mean± SD) | 52.8±16.2 | 50.8±11.9 | 0.371 |
| Gender | | | 0.078 |
| Male (n %) | 43(57.33) | 57(67.05) | 0.078 |
| Female (n %) | 32(42.67) | 24(32.95) | 0.078 |
| ASA grade | | | 0.159 |
| ASA I | 34(45.33) | 48( 56.48) | 0.159 |
| ASA II | 41(54.67) | 37(43.52) | 0.159 |

## Stones characteristics

Mean stone sizes in GA group & SA Group was 3.24 ± 1.4 mm and 4 ± 36.1 mm, respectively; p=0.2135.

**Table 2. Comparison of stone characteristics in two groups before operation**

| Variable | GA group (n=75) | SA group (n=85) | P Value |
|---|---|---|---|
| Stone size (Mean ± SD, cm | 3.24 ± 1.4 | 3.48 ± 1.02 | 0.213 |
| Stone Laterality | | | 0.846 |
| Right | 28(37.34) | 33(38.83) | |
| Left | 47(62.66) | 52(61.17) | |
| Stone number | | | 0.692 |
| Single | 61(81.34) | 67(78.84) | 0.692 |
| Multiple | 14(18.66) | 18(26.86) | 0.692 |
| Stone location | | | 0.204 |
| Pelvic+ Staghorn | 43(57.34) | 57(67.05) | 0.204 |
| Others | 32(42.66) | 28(32.95) | 0.204 |

## Preoperative and postoperative 24 hours hemoglobin and hematocrit levels

Preoperative and postoperative hemoglobin and hematocrit were no different between the two groups respectively in the regional and general anesthesia groups.

**Table 3. Comparison of mean preoperative and postoperative 24 hours hemoglobin and hematocrit levels in both Groups**

| Variable | GA group (n=75) | SA group (n=85) | P Value |
|---|---|---|---|
| Pre-op Hb (g/dL) | 13.38 ± 2.23 | 13.15 ± 1.93 | 0.098 |
| Post op Hb 24 hours (mg/dL) | 11.63 ± 2.07 | 11.39 ± 1.37 | 0.383 |
| Pre-op Hct (%) | 39.86 ± 5.56 | 40.64 ± 5.54 | 0.376 |
| Post op Hct 24 hours (%) | 33.54 ± 5.32 | 34.26 ± 5.91 | 0.428 |

## Operative time

No significant differences were found in between mean surgical times 82.25±18.90 minutes in GA group and 79.23±24.56 minutes in SA group.

**Table 4. Comparison of stone characteristics in between general & spinal anesthesia.**

| Variable Mean ± SD (, min) | GA group (n=75) | SA group (n=85) | P Value |
|---|---|---|---|
| Operative time | 82.25 ± 18.90 | 79.23 ± 24.56 | 0.3895 |

## Analgesic requirement

Post-operative requirement of analgesia in GA and SA group was no significant difference (p=0.068).

**Table 5. Comparison of analgesic requirements in between general & spinal anesthesia**

| Analgesic requirement | GA group (n=75) | SA group (n=85) | P Value |
|---|---|---|---|
| Pethidine | | | |
| ≤ 75 mg | 70 (93.34) | 84(98.81) | 0.068 |
| >75 mg | 05(06.66) | 01(01.19) | |
| Paracetamol | | | |
| ≤ 1000 mg | 67(89.34) | 74(87.06) | 0.657 |
| >1000 mg | 08(10.66) | 11(14.86) | |

## Hospital stay

Length of hospital stay was no different between the two groups.

**Table 6. Comparison of hospital stay in two groups**

| Variable Mean ± SD (,day ) | GA group (n=75) | SA group (n=85) | P Value |
|---|---|---|---|
| Hospital stay | 05.30 ± 02.06 | 05.02± 01.91 | 0.373 |

## Complications

Peri-operative hypotension more in SA group (19.27%) than GA group (6.6%) with a significant difference (p= 0.023).The postoperative fever rate was significantly higher in the general anesthesia group (58.66% vs. 38.22%, respectively, p=0.018). Postoperative shivering was higher in SA group than GA group (15.29% vs. 5.34%) while Nausea & vomiting was higher in GA group than SA group 16.67% vs 4.79 % (p=0.031) & 13.34% vs. 3.52% p=0.023 respectively. There are no difference between the blood transfused per patient in between two groups (02.6% vs. 4.71 %, respectively; p=0.498)

**Table 7. Complications of PCNL according to the modified clavien grading system**

| Variable | GA group (n=75) | SA group (n=85) | P Value |
|---|---|---|---|
| Grade I | | | |
| Peri-operative Hypotension | 05(06.66) | 16(19.27) | 0.023 |
| Postoperative shivering | 04 (05.34) | 13(15.29) | 0.041 |
| Nausea | 11(16.67) | 04(04.79) | 0.031 |
| Vomiting | 10 (13.34) | 03(03.52) | 0.023 |
| Post-operative Fever | 44(58.66) | 33(38.82) | 0.018 |
| Grade II | | | |
| Hemorrhage need blood transfusion | 02(02.66) | 04(04.71) | 0.498 |

## Operative outcomes

Intergroup differences between initial stone-free rates 85.33% (GA group) and 90.58 %( SA group) respectively; p=0.2206) and overall stone-free rates (90.66% and 97.67%, respectively; p=0.322) were no significantly different.

**Table 8. Comparison of operative outcomes in between general & spinal anesthesia.**

| Outcomes, n (%) | GA group (n=75) | SA group (n=85) | P Value |
|---|---|---|---|
| Initial stone free | 64(85.33) | 77(90.58) | 0.220 |
| Overall stone-free rates | 71(94.66) | 83(97.67) | 0.322 |
| Clinical insignificant residual fragment(CIRF) | 07(09.34) | 06(07.06) | 0.558 |
| Retained stone | 04(05.33) | 02(02.35) | 0.305 |

## Discussion

PCNL remains the first-line treatment of choice for managing renal stone disease, although minimally invasive modalities, such as retrograde intrarenal surgery (RIRS), have been introduced.[9] This procedure is traditionally performed after administering general anesthesia (GA).[10] In PCNL, GA may result in fluid absorption and electrolyte imbalance, therefore performing GA in patients with comorbidities could be challenging. General anesthesia is more likely to cause severe morbidities, such as drug-induced anaphylaxis, complications associated with endotracheal tube insertion, and cardiovascular, pulmonary, and neurologic complications, than regional anesthesia.[11] There are several studies in which spinal anesthesia (SA) was performed for PCNL candidates who were critically-ill and morbidly obese to avoid cardiorespiratory compromise during the procedure.[8,12] Using SA in PNCL surgery is acceptable and more secure. By faster discharge and reduced recovery time, the patients' quality of life can be improved using SA, which can be a good choice for urologist.[13] Several comparative studies on anesthesia methods in PCNL have demonstrated various benefits for PCNL under regional anesthesia compared with general anesthesia. Kuzgunbay et al.,[14] compared the safety as well as the effectiveness of PCNL among thirty-seven subjects who went through the procedure under combined spinal epidural anesthesia and forty-five subjects under general anesthesia. Parameters such as stone surface area, age, change in hemoglobin, operative time, hospital stay, and stone-free rates showed no significant variations between the two groups. The conclusion drawn was that under spinal regional anesthesia, the PCNL procedure was equally safe and effective as PCNL under GA. In another study of 50 patients who underwent PCNL, regional anesthesia was found to be associated with greater patient satisfaction, less early postoperative pain, and fewer adverse events than general anesthesia.[11] In present study, preoperative and postoperative hemoglobin and hematocrit were no different between the two groups. There is no difference in the blood transfused per patient in between two groups (02.6% vs. 4.71 %, respectively; p=0.498). Post-operative requirement of analgesia in GA and SA group was no significant difference (p=0.068). Regarding hospital stay, Shin TS et al.[15] reported that average hospital stay is approximately 5 to 7 days regardless of anesthesia type. In the present study, hospital stays were 5.30±2.06 days in General anesthesia and 05.02±1.91 days in spinal anesthesia. Mehrabi et al.[8,16] evaluated 160 patients who underwent PCNL under spinal anesthesia in prone position. Blood transfusion was performed for ten patients (6.3%), and six patients complained of mild to moderate headache, dizziness, and mild postoperative low back pain for 2 to 4 days. 10 patients (6.3%) received blood transfusions. Among these patients, 18 patients had hypotension controlled by intravenous ephedrine. Their conclusion was PCNL under spinal anesthesia is an alternative technique to general anesthesia. Complete clearance of calculus or no significant residual calculi larger than 5 mm was achieved in 70% of patients (36). In this present study, peri-operative hypotension more in SA group (19.27%) than GA group (6.6%) with a significant difference (p= 0.023) . SA can result in vasodilation and hypotension following sympathetic block. On the other hand, GA reduced intra thoracic pressure and epidural vein distension, due to spontaneous ventilation, resulting in reduced bleeding. Therefore, the results do not seem to be irrational because SA can inhibit stress hormone secretion better than GA.[12] SA blocks preganglionic sympathetic nerves with many advantages compared to GA, such as redistribution of blood flow to musculoskeletal system, skin, and subcutaneous tissues, as well as reducing blood pressure. Other studies demonstrated better PNCL surgery results, lower blood loss, and lesser side effects (such as nausea, vomiting, and post-operative pain) in SA [12,17] Among these advantages of SA, decreasing blood loss is a main issue of SA in PCNL surgery.[12] T. Tangpaitoon et al.[11] revealed used of the epidural space between L 1-2 as the

level for epidural puncture due to its safety followed by insertion of the tip of an epidural catheter to T-11 level. T-6 level of anesthesia was achieved during the kidney operation. There are some advantages of regional epidural anesthesia group over general anesthesia including less nausea/vomiting ($p = 0.005$), less postoperative pain ($p < 0.01$), less analgesic drugs usage ($p < 0.024$), and more patient satisfaction ($p < 0.007$). Complications of GA such as vascular, pulmonary and neurological complication specially during changing patient's position from lithotomy to prone have been reported.[16] On the other hand, SA is usually associated with hypotension resulting from sympathetic block especially during changing into prone position.[16,18] In the present study, shivering was reported with SA more than GA group while, nausea, vomiting was higher in GA. Complications from the procedure were acceptable. In contrast, hemodynamic instability during changing the patient's position from supine to prone was not found in several reports.[19,20] In prospective randomized study[8] PCNL was performed by standard technique. Intraoperative hypotension, postoperative headache, and low back pain were significantly higher in spinal group, but, compared to SA, the cost of anesthetic drugs was more than five times, and post-operative analgesic consumption about two times in GA group. Finally, authors suggested SA as a safe, effective, and cost-effective method in adult PCNL. In a recent retrospective study[21] involving 1004 subjects, complications were assessed for grades and compared between SA and GA. The GA group exhibited a higher incidence of complications based on the modified Clavien classification. However, not all complications were directly related to anesthesia. In the present study, there was no considerable variation observed among the two groups with respect to the overall post-operative complication rates and no major issues were notified in either group. In terms of operative outcomes, in the present study, initial stone free rate & overall stone free rates were 85.33% and 94.66% in the general anesthesia group and 90.58% and 97.66 % in the spinal anesthesia group, did not represent a significant difference. According to a large-scale study, initial and overall stone-free rates were 69.9% and 88.8%, respectively[15], and another study conducted on 610 patients found corresponding rates of 57.6% and 84.9%, respectively[22]. In this study showed that hypotension was significantly lower in general anesthesia group than spinal group. Postoperative fever rates were significantly greater in the general anesthesia group. Thus, it may be more helpful for patients to implement PCNL under regional anesthesia than general anesthesia in matters of management hypotension & post-operative fever control. There are no significant difference stone-free rates as to compare both the methods of anesthesia from a urologist's perspective. In this study, we found that nausea, vomiting, post-operative fever more in GA whereas perioperative hypotension more in SA . Both methods are similar in terms of operation time, length of hospital stay, stone-free rate and overall complication rate. Therefore, surgeons can freely choose between GA or SA for PCNL without having to worry about the efficacy of the anesthesia method.

## Limitations

The present study was limited by its retrospective design; as such, lack of control of basic patient factors may have introduced bias. The study was performed at a single center, and the general anesthesia group was appreciably smaller than the spinal anesthesia group. In this study, no attempt was made to assess patient satisfaction with treatment.

## Conclusions

In patients undergoing PNCL, spinal anesthesia is associated with hypotension and lower rate of post-operative fever. Spinal anesthesia is an alternative technique for PCNL with the same efficacy and safety compared to general anesthesia.

## Conflicts of interest

The authors have no conflicts of interest to disclose.

## References


1.Aravantinos E, Karatzas A, Gravas S, et al.:Feasibility of Percutaneous Nephrolithotomy under ssisted Local Anaesthesia: A Prospective Study on Selected Patients with Upper Urinary Tract Obstruction. Eur. Urol. 2007; 51(1): 224–228

2. Türk C, Neisius A, Petrik A, et al.:EAU Guidelines on Urolithiasis. Eur. Assoc. Urol. 2018; 2018:1–87.

3. Nelson CP, Pace KT Jr, Pearle MS, et al.:Surgical Management of stones. Am. Urol. Assoc. 2016; (April): 1–50.

4. Karaolides T, Moraitis K, Bach C, et al.:Positions for percutaneous nephrolithotomy: Thirty-five years of evolution. Arab. J. Urol. 2012; 10(3): 307–316.

5.Birowo P, Tendi W, Widyahening IS, et al.:Supine versus prone position in percutaneous nephrolithotomy: A systematic review and meta-analysis. F1000Res. 2020; 9:1–21

6. Gonen M, Basaran B: Tubeless percutaneous nephrolithotomy: Spinal versus general nesthesia. Urol. J. 2014; 11(1): 1211–1215.

7.Shah R, Thapa AS, Lamichhane N, et al.:Safety and efficacy of spinal anaesthesia in percutaneous nephrolithotomy. J. Nepal Med. Assoc. 2016; 55(204): 61–66.

8.Mehrabi S, Zadeh AM, Toori MA, et al.:General versus spinal anesthesia in percutaneousnephrolithotomy.Urol.J.2013;10(1): 756–761.

9. Lojanapiwat B, Prasopsuk S. Upper-pole access for percutaneous nephrolithotomy: comparison of supracostal and infracostal approaches. J Endourol 2006;20:491-4

10. Lingeman JE, Matlaga BREA: Surgical management of upper urinary tract calculy.Wein AJ, Kacoussi LRNA, editors. Campbell Walsh Urology. 9th ed. Philadelphia: Saunders Elsevier; 2007; p. 1431–507.

11.Tangpaitoon T, Nisoog C, Lojanapiwat B. Efficacy and safety of percutaneous nephrolithotomy (PCNL): a prospective and randomized study comparing regional epidural anesthesia with general anesthesia. Int Braz J Urol 2012;38:504-11

12. Javaid Iqbal, Jan Mohammad Rather, Sobia Manzoor:General Vs Spinal Anesthesia in PCNL Surgery', International Journal of Current Advanced Research, 2022;11(01), pp. 34-37. DOI: http://dx.doi.org/10.24327/ijcar.2022.37.0007

13. Rozentsveig V, Neulander EZ, Roussabrov E, Schwartz A, Lismer L, Gurevich B, et al. Anesthetic considerations during percutaneous nephrolithotomy. J Clin Anesth. 2007; 19(5) : 351 -5 [DOI][PubMed]

14. Kuzgunbay B, Turunc T, Akin S, Ergenoglu P, Aribogan A, Ozkardes H. Percutaneous nephrolithotomy under general versus combined spinal-epidural anesthesia. J Endourol 2009;23:1835–8.

15. Shin TS, Cho HJ, Hong SH, Lee JY, Kim SW, Hwang TK. Complications of percutaneous nephrolithotomy classified by the modified Clavien grading system: a single center's experience over 16 years. Korean J Urol 2011;52:769-75

16. Mehrabi S, Karimzadeh Shirazi K. Results and complications of spinal anesthesia in percutaneous nephrolithotomy. Urol J 2010;7(1):22–5.

17. Kehlet H. The stress response to surgery: release mechanisms and the modifying effect of pain relief. Acta Chir Scand Suppl. 1989; 550 : 22 -8

18.Movasseghi G, Hassani V, Mohaghegh MR, Safaeian R, Safari S, Zamani MM, Nabizadeh R. Comparison between spinal and general anesthesia in percutaneous nephrolithotomy. Anesth Pain Med 2014;4(1):e138

19.Saied MM, Sonbul ZM, El-Kenawy M and Atallah MM. Spinal and interpleural bupivacaine for percutaneous nephrolithotomy. Middle East J Anaesthesiol. 1991;11(3):259-264.

20.Singh I, Kumar A and Kumar P. “Ambulatory PCNL” (tubeless PCNL under regional anesthesia)--a preliminary report of 10 cases. Int Urol Nephrol. 2005;37(1):35-37.

21.Cicek T, Gonulalan U, Dogan R, Kosan M, Istanbulluoglu O, Gonen M, et al. Spinal anesthesia is an efficient and safe anesthetic method for percutaneous nephrolithotomy. Urology. 2014;83(1):50-55.

22. Kwon T, Bang JK, Kim SC, Shim M, Ha SH, Hong B, et al. Percutaneous nephrolithotomy: a single center experience of 610 cases. Korean J Urol 2009;50:669-74.