Comparison of Percutaneous Nephrolithotomy Under Regional versus General Anesthesia: A Meta-Analysis of Randomized Controlled Trials

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Keywords

Percutaneous nephrolithotomy · Anesthesia · Efficacy · Safety · Randomized controlled trials

Abstract

The aim of the present meta-analysis was to systematically examine the literature and to identify the results of randomized controlled trials (RCTs) comparing the efficacy and safety of regional anesthesia (RA) versus general anesthesia (GA) for percutaneous nephrolithotomy (PCNL). An exhaustive electronic literature search of PubMed, Embase, and Web of science was performed until March 2018. Nine prospective RCTs concluding 858 patients comparing the use of RA to GA for PCNL were included. Combined results demonstrated that PCNL under RA could reduce operative time (mean difference [MD] –6.20; 95% CI –10.39 to –2.01), hospital stay (MD –0.59; 95% CI –0.74 to –0.45), visual analgesic score on the first and third postoperative day (MD –2.62, 95% CI –3.04 to –2.19 and MD –0.38; 95% CI –0.58 to –0.18), analgesic requirements (MD –36.84; 95% CI –55.23 to –18.45), and nausea and/or vomiting (relative risk [RR] 0.28; 95% CI 0.13–0.61). There were no significant differences between RA and GA groups in terms of stone-free rate, blood transfusion, and postoperative fever rate. The results of subgroup analysis were basically consistent with the overall findings. Current evidence suggests that RA is an available and safe option in carefully evaluated and selected patients.

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Introduction

Percutaneous nephrolithotomy (PCNL), first reported by Fernstrom and Johansson [1], has gradually become a preferred therapy modality for the management of large and complex urinary stones in the last 2 decades [2–4]. Additionally, PCNL can be used in patients with failed extracorporeal shockwave lithotripsy and ureteral endoscopy [5–7]. Urologists have modified their techniques in recent years to improve safety and efficacy and decrease morbidity. Recently, the PCNL procedure can be safely carried out under both general anesthesia (GA) and regional anesthesia (RA), such as spinal anesthesia (SA), combined spinal epidural anesthesia (CSEA), and epidural anesthesia (EA). Normally, the special advantages of GA in PCNL procedure may be due to its feasibility to control breathing and improve comfort for the patients. However, there are some complications associated with GA such as atelectasis, drug reactions, postoperative nausea, or/and vomiting [8, 9]. Furthermore, the patients cannot accept GA because of several comorbidities or lower costs. In recent years, a large number of randomized controlled trials (RCT) have indicated that under RA has some potential advantages over GA [10, 11], but the conclusions have not been completely consistent. There-

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fore, the purpose of the present meta-analysis was to examine the literature and identify the results of RCTs comparing the efficacy and safety of RA and GA for PCNL in patients with urinary stones.

Materials and Methods

Literature Search Strategy

This study systematically searched PubMed, Embase and Web of science from their inception to March 2018. We searched for articles published only in English. The following keywords were used: “percutaneous,” “nephrolithotomy,” “nephrolithotripsy,” “PCNL,” “anesthesia,” “general anesthesia,” “regional anesthesia,” “epidural anesthesia,” “spinal anesthesia,” “spinal-epidural anesthesia,” “randomized controlled trial,” and “RCT.” Manual searching of references listed at the end of each retrieved articles was also performed to identify additional studies.

Inclusion and Exclusion Criteria

The retrieved articles were gathered and reviewed independently by 2 investigated R.D. and S.H., and any discrepancies were settled by consensus after discussion with a third reviewer (X.L.). Studies were included if they met the following criteria: (1) RCTs; (2) Studies comparing the efficacy and safety of PCNL under RA versus GA; (3) Studies provided accurate data for analysis; (4) Access to full text; (5) at least one of the following clinical outcomes: operative time, hospital stay, Blood transfusion, postoperative analgesic requirement, postoperative pain score, stone free rate, or major complications (Nausea and/or Vomiting, Fever). The exclusion criteria were as follows: (1) review articles, commentaries, letters, or observational studies; (2) non-RCTs; (3) unable to extract adequate data from the publication.

Data Extraction and Quality Assessment

The following data from each included study were extracted independently by 2 reviewers (X.L. and G.H.): first author, publication year, country, interventions, number of patients, age, gender, body mass index, stone size or stone area, and clinical outcomes of interest (operative time, hospital stay, stone-free status, blood transfusion, Intraoperative Hypotension, postoperative pain score (visual analog scale [VAS]), postoperative analgesic requirements nausea and/or vomiting, and fever). Furthermore, the quality of each included study was independently evaluated by 2 investigators (S.H. and R.Z.) according to the Cochrane Collaboration risk-of bias tool [12]. The following domains were included: random sequence generation, allocation concealment, blinding of participants and personnel, blinding of outcome assessment, incomplete outcome data, selective reporting, and other bias. When necessary, any disagreements were solved by discussion with a third reviewer (R.D.).

Statistics and Data Analysis

The data analysis was performed using the fixed-effects model or random-effects model according to statistical heterogeneity with Review Manager Software 5.2. Relative risk (RR) was used to evaluate dichotomous outcomes and continuous outcomes were evaluated using mean difference (MD). All the results were presented as 95% CI. The chi-square test and the I^2 statistic were used

Fig. 1. Flowchart of search strategy for the randomized controlled trials (RCTs). MD, mean difference.

to evaluate the percentage of variance attributable to study heterogeneity. If the heterogeneity did not exceeded 50% ($I^2 < 50\%$), the fixed-effected model was used to calculate pooled estimates. However, when any heterogeneity existed ($I^2 > 50\%$), we applied the random-effects model. Funnel plots were carried out to evaluate publication bias.

Results

Study Characteristics and Quality Assessment

The literature search process is shown in the Figure 1. A total of 238 relevant articles were systematically identified from initial searches of the electronic database. According to the inclusion and exclusion criteria, 135 were excluded after reviewing the titles and abstracts, and 5 articles were further excluded after carefully reading the full text. Finally, 9 RCTs [9–11, 13–18] were included in this meta-analysis and consisted of 428 patients who underwent RA and 430 patient who underwent GA. Table 1 presents the basic characteristics of studies included in the meta-analysis. The review authors’ judgments regarding the risk of bias across all of the RCTs are summarized in Table 2.

Table 1. Characteristics of the studies included in the review

Author, year	Country	Interventions	Patients, <i>n</i>	Age, years, mean $\pm$ SD	Gender, M/F	BMI, kg/m ²	Stone size OR stone area
Elbealy, 2008	Egypt	EA	19	41 $\pm$ 13	19/0	28.1	N/A
		GA	20	39 $\pm$ 15	20/0	27.4	N/A
Karacalar, 2009	Turkey	CSEA	86	48.64 $\pm$ 16	45/41	27.6 $\pm$ 7.2	1,137.78 mm ²
		GA	90	48.32 $\pm$ 15	47/43	27.8 $\pm$ 6.2	598.4 mm ²
Singh, 2011	India	CSEA	32	40.06 $\pm$ 13.41	22/10	N/A	2,195.31 $\pm$ 643 mm ²
		GA	32	39.66 $\pm$ 13.7	18/14	N/A	2,271 $\pm$ 620 mm ²
Tangpaitoon, 2012	Thailand	EA	24	53.04 $\pm$ 13.53	17/7	21.25 $\pm$ 3.21	4.08 $\pm$ 1.64 mm
		GA	26	56.69 $\pm$ 11.32	16/10	21.36 $\pm$ 3.98	3.54 $\pm$ 1.50 mm
Mehrabi, 2013	Iran	SA	58	47.4 $\pm$ 7.6	31/27	24.1 $\pm$ 7.2	32.8 $\pm$ 9.6
		GA	52	43.7 $\pm$ 8.2	35/17	24.1 $\pm$ 5.6	30.9 $\pm$ 10.6
Nouralizadeh, 2013	Iran	SA	50	41.16 $\pm$ 11.2	29/21	N/A	N/A
		GA	50	42.66 $\pm$ 13.61	27/23	N/A	N/A
Movassegghi, 2014	Iran	SA	29	39.6 $\pm$ 9.7	19/10	26.4 $\pm$ 3.8	N/A
		GA	30	46.9 $\pm$ 13.6	19/11	28.1 $\pm$ 4.6	N/A
Moawad, 2015	Egypt	SA	100	44 $\pm$ 11	60/40	27.1 $\pm$ 4.1	31.9 $\pm$ 7.4 mm
		GA	100	43 $\pm$ 11	64/36	27.4 $\pm$ 2.1	33.7 $\pm$ 6.3 mm
Shah, 2016	Nepal	SA	30	36.10 $\pm$ 14.18	13/17	N/A	3.23 $\pm$ 1.36 cm
		GA	30	39.13 $\pm$ 12.45	19/11	N/A	3.75 $\pm$ 1.27 cm

EA, epidural anesthesia; SA, spinal anesthesia; GA, general anesthesia; SEA, spinal-epidural anesthesia; CSEA, combined spinal epidural anesthesia; N/A, not available; BMI, body mass index.

Table 2. Quality assessment of the included studies

Author, year	Random sequence generation	Allocation concealment	Blinding of participants and personnel	Blinding of outcome assessment	Incomplete outcome data	Selective reporting	Other bias
Elbealy, 2008	Yes	Unclear	No	No	Unclear	No	Yes
Karacalar, 2009	Yes	Unclear	Yes	Yes	No	Yes	Yes
Singh, 2011	Yes	Unclear	No	No	Unclear	Yes	Yes
Tangpaitoon, 2012	Yes	Unclear	No	No	No	Yes	Yes
Mehrabi, 2013	Yes	Unclear	No	No	Unclear	Yes	Yes
Nouralizadeh, 2013	Yes	Unclear	No	No	No	No	Yes
Movassegghi, 2014	Yes	Unclear	No	No	Unclear	No	Yes
Moawad, 2015	Yes	Unclear	No	No	Unclear	No	Yes
Shah, 2016	Yes	Unclear	No	No	No	Yes	Yes

Operative Time

Nine studies [9–11, 13–18] evaluated the operative time. The overall summary effect showed that the RA group required less operative time than GA group with a statistically significant difference (MD –6.20 min; 95% CI –10.39 to –2.01; $p = 0.0002$; $I^2 = 84\%$), which was

pooled using the random-effects model due to the higher heterogeneity rate observed among the studies (Fig. 2a).

A subgroup analysis was performed to compare the effect of 3 regional analgesic styles (SA, CSEA, and EA) and GA on operative time. The MDs for the CSEA versus GA,

Fig. 2. Forest plots and meta-analysis of (a) operative time, (b) hospital stay and (c) blood transfusion.

(For figure 2c see next page.)

EA versus GA and SA versus GA groups were -2.75 min (95% CI -15.59 to 10.08 ; $p = 0.67$; 2 studies), -0.98 min (95% CI -2.15 to 0.20 ; $p = 0.10$; 2 studies) and -8.41 min (95% CI -11.71 to -5.11 ; $p < 0.00001$; 5 studies) respectively.

Hospital Stay

As shown in Figure 2b, 5 studies [9, 13–16] reported hospitalization data. The pooled analysis of these studies via the fixed-effect model revealed that the RA group was charged with a shorter hospital stay than the GA group (MD -0.59 days; 95% CI -0.74 to -0.45 ; $p < 0.00001$; $I^2 = 34$).

A subgroup analysis was performed to compare the effect of 3 regional analgesic styles (SA, CSEA, and EA) and GA on hospital stay. The MDs for the CSEA versus GA, EA versus GA and SA versus GA groups were -0.68 days (95% CI -0.85 to -0.51 ; $p < 0.00001$; 2 studies), -0.42 days (95% CI -0.151 to 0.67 ; $p = 0.45$; 1 study) and -0.28 days (95% CI -0.61 to 0.04 ; $p = 0.09$; 2 studies) respectively.

Blood Transfusion

Six of the included studies [10, 11, 13–16] reported data regarding the blood transfusion. The pooled analysis with the fixed-effects model showed no significant differ-

ence in the blood transfusion rate between the RA and GA groups (RR 0.85; 95% CI 0.51–1.41; $p = 0.53$; $I^2 = 0$; Fig. 2c).

A subgroup analysis was performed to compare the effect of 3 regional analgesic styles (SA, CSEA, and EA) and GA on blood transfusion rate. There was no obvious difference in blood transfusion rate when SA versus GA (RA 0.92; 95% CI 0.51–1.67; $p = 0.79$; 4 studies), or CSEA versus GA (RR 0.80; 95% CI 0.24–2.71; $p = 0.72$; 1 study), EA versus GA (RR 0.54; 95% CI 0.11–2.69; $p = 0.45$; 1 study).

Stone-Free Status

As shown in Figure 3a, 6 studies [9, 10, 13–16] reported the stone-free status. The pooled analysis with fixed-effects model showed no significant difference in the stone-free status between the RA and GA group (MD 1.07; 95% CI 0.99–1.16; $p = 0.10$; $I^2 = 21\%$).

A subgroup analysis was performed to compare the effect of 3 regional analgesic styles (SA, CSEA, and EA) and GA on stone-free status. There was no evidence of a significant difference in stone-free status when SA versus GA (RR 1.06; 95% CI 0.96–1.18; $p = 0.26$; 3 studies), or

Fig. 3. Forest plots and meta-analysis of (a) stone-free status, (b) VAS on the 1st, 2nd, and 3rd postoperative day. (For figure 3b see next page.)

CSEA versus GA (RR 1.07; 95% CI 0.92–1.25; $p = 0.36$; 2 studies), EA versus GA (RR 1.12; 95% CI 0.89–1.41; $p = 0.34$; 1 study).

Postoperative Pain Scores

Four studies [9, 13, 15, 17] reported postoperative pain scores estimated using the VAS. On analysis of these available data, it was found that the RA group had statistically significant lower postoperative pain scores at 24 h after surgery (MD -2.44 ; 95% CI -3.25 to -1.64 ; $p < 0.00001$) and at 72 after surgery (MD -0.38 ; 95% CI -0.58 to -0.18 ; $p = 0.0002$). However, there was no statistically significant difference between the 2 groups at 48 h after surgery (MD -0.82 ; 95% CI -0.206 to 0.42 ; $p = 0.20$; Fig. 3b).

Postoperative Analgesia Requirements

As shown in Figure 4a, 6 studies [9–11, 13, 17, 18] reported data regarding postoperative analgesia requirements. The pooled analysis with fixed-effects model showed that the postoperative analgesic requirement for

the RA group was significantly lower than that for the GA group (MD -36.84 ; 95% CI -55.23 to -18.45 ; $p < 0.0001$; $I^2 = 98\%$).

A subgroup analysis was performed to compare the effect of 2 regional analgesic styles (SA and CSEA) and GA on postoperative analgesia requirements. The MDs for the CSEA versus GA and SA versus GA groups were -142.60 (95% CI -163.40 to -121.80 ; 2 studies) and -7.19 (95% CI -12.39 to -1.99 ; $p = 0.007$; 3 studies) respectively.

Nausea and/or Vomiting

Six studies [9, 10, 14–17] reported nausea and/or vomiting data. The pooled analysis with fixed-effects model showed that the RA group had a potential lower risk of nausea and/or vomiting than the GA group (RR 0.28; 95% CI 0.13–0.61; $p = 0.001$; $I^2 = 40\%$; Fig. 4b).

A subgroup analysis was performed to compare the effect of 3 regional analgesic styles (SA, CSEA, and EA) and GA on nausea and/or vomiting rate. The RRs for the EA versus GA, SA versus GA and CSEA versus GA groups

were 0.18 (95% CI 0.02–1.39; $p = 0.10$; 1 study), 0.22 (95% CI 0.06–0.88; $p = 0.03$; 4 studies) and 0.42 (95% CI 0.25–0.69; $p = 0.0006$; 1 study) respectively.

Fever

There were 4 studies [9, 10, 14, 16] that evaluated the fever rate. The pooled analysis with the fixed-effects model revealed no significant difference between the RA and the GA group (RR 0.77; 95% CI 0.51–1.17; $p = 0.22$; $I^2 = 0$; Fig. 4c).

A subgroup analysis was performed to compare the effect of 2 regional analgesic styles (SA and CSEA) and GA on the fever rate. The RRs for SA versus GA and CSEA versus GA were 0.55 (95% CI 0.23–1.28; $p = 0.16$; 3 studies) and 0.89 (95% CI 0.56–1.43; $p = 0.63$; 1 study) respectively.

Publication Bias

A funnel plot was conducted to qualitatively evaluate the reliability of publication bias among the studies that compared surgical durations between the RA and GA

Fig. 4. Forest plots and meta-analysis of (a) analgesic requirement, (b) nausea and/or vomiting and (c) fever.
(For figure 4b see next page.)

groups. The funnel plot shown in Figure 5 is almost symmetrical, indicating no potential evidence of publication bias in the included studies.

Discussion

In recent years, great efforts have been made to decrease morbidity and improve efficacy and surgical outcomes of PCNL; however, the real impact of the anesthesia-type on PCNL outcomes has not been clarified precisely by urologists and anesthesiologists.

Therefore, we conducted a meta-analysis to evaluate the effect of anesthesia-type on the PCNL. Our analysis identified one study published during the 2 years since previous recent meta-analyses [19, 20]. The clinical utility of the 2 previous meta-analyses [19, 20] is uncertain due to in both included RCTs and retrospective study or cohort study with an increased risk of bias. In this present study, data from 858 patients who underwent PCNL from 9 RCTs were analyzed to compare the safety of GA and RA. It is well established that PCNL under RA was associated with significantly shorter operative time and hospital stay. Furthermore, lower postoperative pain

scores, lower nausea and/or vomiting, and reduced analgesic requirements were observed in the RA group, and there was no obvious statistically significant difference in the postoperative fever rate, stone-free status rate, and blood transfusion rate. These results strongly indicated that PCNL under RA has some potential advantages over GA. The mean operative time was significantly shorter in the RA group than in GA group in our analysis. However, there was high heterogeneity ($I^2 = 84\%$) observed among the studies. We speculated that the high heterogeneity may be due to each study calculated operative time using different criteria, and several studies did not state a clear definition of the operative time involved. Furthermore, the surgeon's experience and patient characteristics were likely the primary factors influencing operative time [21].

Sugihara et al. [22] reported that longer operative time was associated with a higher risk of severe complications after PCNL. This meta-analysis showed that the frequency of nausea and vomiting in the RA group were lower than that in the GA group. Moreover, PCNL under RA has been indicated to be associated with decreased postoperative pain, which was further verified by lower analgesic requirements in the RA

c

Fig. 5. Funnel plot for detecting the publication bias of the studies represented in our meta-analysis.

group. Patients possibly will get better quality of life and sooner recovery if the postoperative complications are lesser.

Therefore, the results of this meta-analysis indicated that the hospitalization period was significantly reduced in the RA group, which may be associated with well-tolerated early mobilization and lesser pain during the postoperative period. The hospitalization period plays a vital role in the evaluation of PCNL under RA. A shorter hospitalization period could decrease the costs of treatment and improve the quality of health care.

Although our meta-analysis indicates that RA offers several potential merits over GA, RA still has some defects. For example, there are many contraindications to RA, including raised intracranial pressure, and soft tissue or skin infection at the position of needle insertion. Furthermore, if the operative time is too long, the prone position leads to unbearable pain for patients under RA. Therefore, these are reminders of careful evaluation of a patient who will undergo PCNL before he or she can accept RA as the anesthesia method. Additionally, several potential limitations of our meta-analysis should be mentioned. First, we did not restrict the specific size of the stone as inclusion criteria because of the lack of data in some articles. Second, due to lack of adequate data in some studies, we did not evaluate other possible complications, except for those aforementioned results, including urinary leakage, postoperative headache, intraoperative hypotension, and so on. Third, there is no unifica-

tion of the category and specifications of postoperative analgesia, which may result in a potential bias. Four, some included studies applied a tubeless technique, which may have an effect on the postoperative VAS score compared with patients who underwent the standard PCNL. Finally, although all of the included studies were RCTs, some of them did not elucidate the randomization, blinding allocation, and concealment methods, which might have resulted in a high risk of publication and reporting bias.

Conclusion

Despite the aforementioned limitations, the results of this meta-analysis indicated that both RA and GA are effective anesthetic techniques for PCNL in carefully selected patients. RA had similar efficacy to GA in terms of postoperative fever rate, stone-free status rate, and blood transfusion rate. Moreover, several potential advantages, such as shorter operative time and hospital stay, lower postoperative pain, reduced analgesic requirement, and nausea and/or vomiting, were observed in the RA group. We consider that RA might be an alternative to GA with experience and careful patient selection. However, larger high-quality multi-center long-term RCTs are required to validate our results in the future.

Disclosure Statement

The authors declare that they have no conflicts of interest to disclose.

Author Contribution

RM Deng and SF Hu contributed to the design of the article. GM Huang and RP Zhong contributed to the analysis of data. X.L. and S.H. wrote the manuscript S.F.H. All authors reviewed the manuscript.

References

- 1 Fernstrom I, Johansson B: Percutaneous pyelolithotomy. A new extraction technique. *Scand J Urol Nephrol* 1976;10:257–259.
- 2 Kim SC, Kuo RL, Lingeman JE: Percutaneous nephrolithotomy: an update. *Curr Opin Urol* 2003;13:235–241.
- 3 Geraghty RM, Jones P, Somani BK: Worldwide trends of urinary stone disease treatment over the last two decades: a systematic review. *J Endourol* 2017;31:547–556.

- 4 Ganpule AP, Vijayakumar M, Malpani A, Desai MR: Percutaneous nephrolithotomy (PCNL) a critical review. *Int J Surg* 2016;36:660–664.
- 5 Stening SG, Bourne S: Supracostal percutaneous nephrolithotomy for upper pole caliceal calculi. *J Endourol* 1998;12:359–362.
- 6 Lojanapiwat B, Prasopsuk S: 2006 Upper-pole access for percutaneous nephrolithotomy: comparison of supracostal and infracostal approaches. *J Endourol* 2006;20:491–494.
- 7 Jun-Ou J, Lojanapiwat B: Supracostal access: does it affect tubeless percutaneous nephrolithotomy efficacy and safety? *Int Braz J Urol* 2010;36:171–176.
- 8 Kuzgunbay B, Turunc T, Akin S, Ergenoglu P, Aribogan A, Ozkardes H: Percutaneous nephrolithotomy under general versus combined spinal-epidural anesthesia. *J Endourol* 2009;23:1835–1838.
- 9 Karacalar S, Bilen CY, Sarihasan B, Sarikaya S: Spinal-epidural anesthesia versus general anesthesia in the management of percutaneous nephrolithotripsy. *J Endourol* 2009;23:1591–1597.
- 10 Mehrabi S, Mousavi Zadeh A, Akbartabar Toori M, Mehrabi F: General versus spinal anesthesia in percutaneous nephrolithotomy. *Urol J* 2013;10:756–761.
- 11 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:e13871.
- 12 Higgins JP, Altman DG, Gotzsche PC, Juni P, Moher D, Oxman AD, Savovic J, Schulz KF, Weeks L, Sterne JA: The Cochrane Collaboration's tool for assessing risk of bias in randomised trials. *BMJ* 2011;343:d5928.
- 13 Singh V, Sinha RJ, Sankhwar SN, Malik A: A prospective randomized study comparing percutaneous nephrolithotomy under combined spinal-epidural anesthesia with percutaneous nephrolithotomy under general anesthesia. *Urol Int* 2011;87:293–298.
- 14 Shah R, Thapa AS, Lamichhane N, Kc SR: Safety and efficacy of spinal anaesthesia in percutaneous nephrolithotomy. *JNMA J Nepal Med Assoc* 2016;55:61–66.
- 15 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;38:504–511.
- 16 Nouralizadeh A, Ziaee SA, Hosseini Sharifi SH, Basiri A, Tabibi A, Sharifiaghdas F, Kilani H, Gharaei B, Roodneshin F, Soltani MH: Comparison of percutaneous nephrolithotomy under spinal versus general anesthesia: a randomized clinical trial. *J Endourol* 2013;27:974–978.
- 17 Moawad HE, El Hefnawy AS: Spinal vs. general anesthesia for percutaneous nephrolithotomy: a prospective randomized trial. *Egypt J Anaesthesia* 2015;31:71–75.
- 18 Elbealy E, Rashwan D, Kassim SA, Abbas S: A comparison of the effects of epidural anesthesia, lumbar paravertebral block and general anesthesia in percutaneous nephrolithotomy. *J Med Sci* 2018;8:170–176.
- 19 Pu C, Wang J, Tang Y, Yuan H, Li J, Bai Y, Wang X, Wei Q, Han P: The efficacy and safety of percutaneous nephrolithotomy under general versus regional anesthesia: a systematic review and meta-analysis. *Urolithiasis* 2015;43:455–466.
- 20 Hu H, Qin B, He D, Lu Y, Zhao Z, Zhang J, Wang Y, Wang S: Regional versus general anesthesia for percutaneous nephrolithotomy: a meta-analysis. *PLoS One* 2015;10:e0126587.
- 21 Xun Y, Wang Q, Hu H, Lu Y, Zhang J, Qin B, Geng Y, Wang S: Tubeless versus standard percutaneous nephrolithotomy: an update meta-analysis. *BMC Urol* 2017;17:102.
- 22 Sugihara T, Yasunaga H, Horiguchi H, Fujimura T, Nishimatsu H, Kume H, Ohe K, Matsuda S, Fushimi K, Homma Y: Longer operative time is associated with higher risk of severe complications after percutaneous nephrolithotomy: analysis of 1511 cases from a Japanese nationwide database. *Int J Urol* 2013;20:1193–1198.