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Comparison of the clinical efficacy of sonography-guided percutaneous nephrolithotomy (PCNL) under local and general anesthesia

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Abstract

Objective: This study aimed to compare the effect of percutaneous nephrolithotomy (PCNL) under local infiltration anesthesia (PCNL-LIA) and general anesthesia (PCNL-GA) to treat upper urinary tract calculi on clinical application values.

Methods: Patients were randomly divided into the PCNL-LIA (16 patients) and PCNL-GA (20 patients) groups. Data on safety, cost, complications, rate of residual calculi, and prognosis were compared.

Results: The mean operation time in the PCNL-LIA group was less than that in PCNL-GA group (100±7.7 versus 120±9.0 minutes). The mean length of hospital stay in the PCNL-LIA group was shorter than that in the PCNL-GA group (6.9±0.5 versus 10.5±1.2 days). The rate of patients who required blood transfusion because of blood loss during or after surgery was less in the PCNL-LIN group than in the PCNL-GA group (13% versus 40%). The intervention rate in the PCNL-GA group was higher than that in the PCNL-LIA group. Visual analogue pain scale assessment showed that the PCNL-LIA group showed slightly more pain than the PCNL-GA group.

Conclusion: PCNL-LIA is safer, faster, and more convenient, and it also provides the benefits of a lower rate of blood loss and complications, lower cost, faster recovery, and shorter hospital stay compared with PCNL-GA.

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Introduction

Percutaneous nephrolithotomy (PCNL) is a minimally invasive surgery for treating upper urinary tract calculi.[1] In the initial stage of its development, the PCNL procedure caused serious problems because of bleeding, infection, and other complications.[2] Since this time, the efficacy and safety of PCNL surgery has greatly improved, although there are still concerns about the risk of its complications.[3] In recent years, flexible ureteroscopic technology has gained global recognition, but it cannot completely replace PCNL for treatment of upper urinary tract calculi.[4]

PCNL surgery is mainly performed under general anesthesia or intrathecal anesthesia. There have only been a few reports on conducting PCNL under local infiltration anesthesia (PCNL-LIA).[5,6] Nevertheless, local infiltration anesthesia offers many advantages over other methods of anesthesia. Local infiltration anesthesia is safe and easy to perform, it minimally affects patients' physiological status and behavior, and patients can quickly recover from surgery because they are in complete consciousness during the procedure.[7] This study aimed to compare the clinical effectiveness of PCNL-LIA and PCNL under general anesthesia (PCNL-GA).

Materials and methods

This study included patients who had PCNL and were admitted to our department from January to September of 2017. Patients were randomly divided into two groups of PCNL-LIA and PCNL-GA. The patients were matched for age, sex, calculus size, and depth of hydronephrosis before the operation ($P > 0.05$). For patients in both groups, preoperative urine culture was performed to determine if there was any urinary infection. Preventive use of antibiotics was administered to patients, including cefazolin or cefotiam 1 g in 0.9% saline. Conventional radiography of the kidneys, ureters, and bladder was performed. A computed tomography (CT) examination was performed using the GE Lightspeed VCT 99 (GE Medical Systems, Milwaukee, WI, USA), with a space of 1, slice thickness of 5.0 mm, reconstruction at 1.25 mm, and field of view of 50 cm.

For surgery, patients were placed in the bladder lithotomy position.[8] An indwelling F5 urethral catheter was inserted at the affected side under nephroscopy or ureteroscopy and immobilized (in case of mid- and lower ureteric calculi, pneumatic ballistic lithotripsy was applied to treat the patients accordingly). An indwelling urinary catheter was also applied and immobilized with a urethral catheter. When patients were in the prone position with a high epigastrium, the puncture site was determined ultrasonically between the 11th and 12th ribs or under the 12th rib between the scapular and the posterior axillary lines. The puncture direction, angle, and depth were also estimated.[9,10] In the PCNL-GA group, all operations were performed under general anesthesia. In the PCNL-LIA group, 30 to 60 minutes

before surgery, intramuscular injection of 50 to 75 mg pethidine hydrochloride and 25 mg promethazine hydrochloride was performed. Subsequently, 5 to 20 mL of 1% lidocaine was injected at the puncture site and along the appropriate direction until reaching the depth of the renal fascia to induce local infiltration anesthesia.[5] Once ideal anesthesia was achieved, retrograde injection of normal saline solution through the previously placed urethral catheter was performed to enlarge the renal pelvis and calices. Targeted renal calyceal fornix puncture with an 18G needle, which was guided by Sonix GPS navigation (Ultrasonix, Richmond, BC, Canada), was performed and confirmed. After a zebra guide wire or J tip guide wire was embedded, the skin at the puncture site was cut to 1 cm and a F10–F20 fascial dilator was applied for gradual dilation. A channel was established with an indwelling of F22 peel-away sheath. An 8.5 to 11.5 Wolf nephroscope (Richard Wolf Inc., Vernon Hills, IL, USA) was used to identify the calculi from the pelvis and calices, which were then crushed with the Swiss EMS V Lithoclast Master (EMS Inc., Nyon, Switzerland). At a perfusion pressure <30 mmHg, a 3.3-mm ultrasound probe was used to crush and clear low-density calculi. A 1.6-mm ballistic probe was used to fragment high-density calculi, which were then crushed and cleared with an ultrasound probe. Crushed calculi could also be removed with a perfusion pump combined with forceps. Finally, an F5DJ stent was inserted into the ureter at the affected side and an indwelling F16 or F18 nephrostomy tube was positioned. This was followed by conventional fluid infusion and application of antibiotics to prevent infection.[5]

The visual analogue scale (VAS) was used to assess the pain level of the patients. A score of 0 represents no pain and a score of 10 represents pain as bad as it could be.[11] We defined complex calculi according to the following three criteria: multiple calculi (based on CT images, two or more calculi and a major calculus with a diameter >1.5 cm); calculus in multiple renal calyces; and staghorn renal calculus.

Ethics and consent

This study was approved by the Medical Ethics Committee of Renmin Hospital, Susong, Anhui Province, China. Written consent from the patients involved in this study was obtained (reference number: Songyizi(2017)#9). A copy of the approved consent document can be provided upon request made to the corresponding author of the manuscript. Data included in this manuscript are available in our department, and they can be disclosed for academic study on the basis of patients' consent about the privacy of their clinical data.

Results

The PCNL-LIA group comprised 16 patients, aged 41 to 77 years, with 11 men and five women. Among them, four patients had upper urethral calculi, eight had complex renal calculi (one case with both renal and urethral calculi), three had simple renal calculi, and two had renal combined with urethral calculi. Three patients were administered propofol (intravenous) as auxiliary anesthesia. All surgeries were conducted with a single channel, and 14 patients had the puncture site between the 11th and 12th ribs, and two had the puncture site under the 12th rib. VAS assessment showed that 13 patients had a score <7, while three patients had a score >8. One patient had a reoperation because of bleeding complications in the procedure (the patient finally chose general anesthesia). Two patients had postoperative bleeding and received blood transfusion (hemoglobin threshold: hemoglobin was reduced to 20 g/L before and after the operation,

or postoperative hemoglobin levels were <70 g/L). One patient received 2 units of concentrated red blood cells, and the other patient received 4 units of concentrated red blood cells. One patient received interventional treatment and three patients had residual stones. The operation time was 45 to 200 minutes, the hospital stay was 4 to 20 days, and the total cost was $1957 to -$6711 USD.

The PCNL-GA group comprised 20 patients aged 38 to 82 years, with nine men and 11 women. Among them, one patient had upper urethral calculi, 16 had complex renal calculi (two cases with both renal and urethral calculi), and three patients had simple renal calculi. All surgeries were conducted with a single channel. A total of 17 patients had the puncture site between the 11th and 12th ribs, and three patients had the puncture site under the 12th rib. VAS assessment after surgery showed that 18 patients had a score <7, while two patients had a score >8. Two patients received interventional treatment. Ten patients had residual stones. The operation time was 50 to 195 minutes, the hospital stay was 2 to 21 days, and the total cost was $2164 to $5608 USD. General anesthesia complications, such as delayed awakening, postoperative restlessness, tooth damage or bleeding, and a sore throat, occurred in nine of 20 patients.

Patients' characteristics and their calculi status are shown in Table 1. Representative images of a patient standing and sitting are shown in Figure 1. The operation time in the PCNL-LIA group tended to take less time than that in the PCNL-GA group (100±7.7 versus 120±9.0 minutes, P=0.053) (Figure 2a). Notably, this time referred to the overall operation time, and the access time and nephoscopy time were not separately recorded. Hospital stay in the PCNL-LIA group was significantly shorter than that in the PCNL-GA group (6.9±0.5 versus 10.5±1.2 days, P<0.01) (Figure 2b). The mean cost in the PCNL-LIA group was significantly less than that in the PCNL-GA group ($2609±$140 versus $3239±$211 USD, P<0.05) (Figure 2c).

Patients in the PCNL-LIA group lost less blood than did those in the PCNL-GA group (13% versus 40%) (Figure 3). Patients in the PCNL-GA group required more postoperative intervention than did those in the PCNL-LIA group (10% vs 6%) (Figure 3). Patients in the PCNL-LIA group had less postoperative residual stones than did those in the PCNL-GA group (19% versus 50%), and the complexity of their calculi was slightly different (50% versus 80%) (Figure 3). VAS assessment showed that patients in the PCNL-LIA group experienced slightly more pain than did patients in the PCNL-GA group (6.0 ±2.0 versus 5.0±1.0).

Discussion

PCNL is an effective minimally invasive surgery for renal and upper urethral calculi

Table 1. Patients' characteristics and calculi status.

Group	Number of patients	Age (years)	Male/female	Upper ureteral calculi	Complex renal calculi	Simple renal calculi	Renal-ureteral calculi
PNCL-LIA	16	41–77	11/5	4	8	3	2
PNCL-GA	20	38–82	9/11	1	16	3	0

PCNL-LIA: percutaneous nephrolithotomy under local infiltration anesthesia; PCNL-GA: percutaneous nephrolithotomy under general anesthesia.

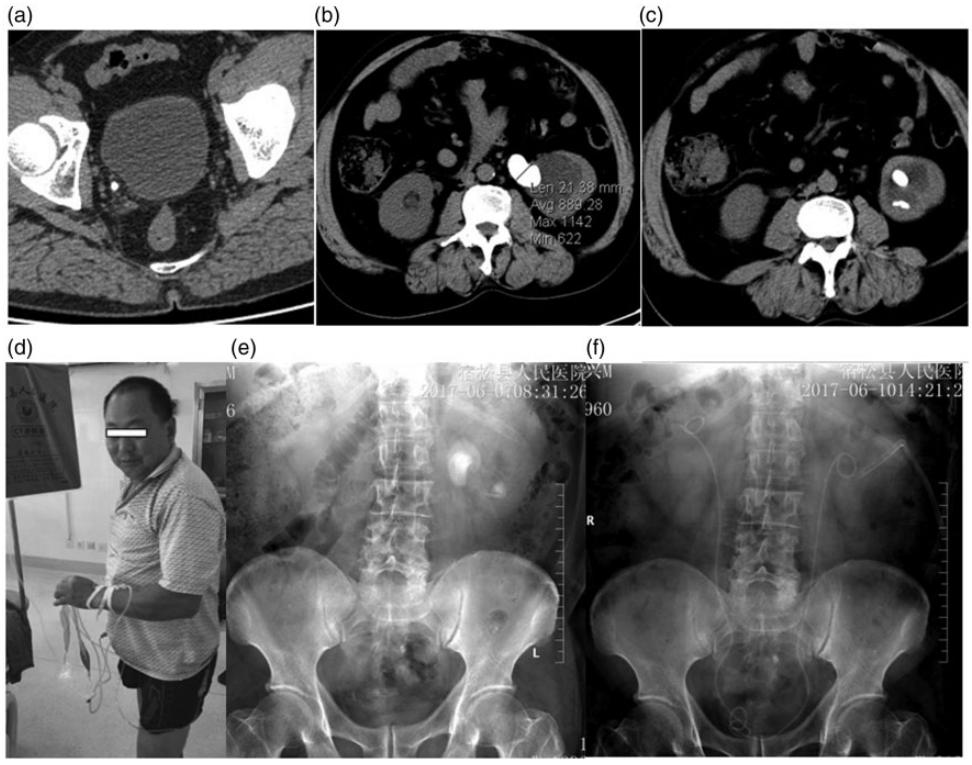

Figure 1. Representative images of the patients. (a, b, c, and e) Preoperative computed tomography and radiography of the kidneys, ureters, and bladder show multiple calculi in the left kidney, along with calculi at the lower part of the right ureter. (d) A patient answered questions and walked immediately after operation. The visual analogue pain scale level was 5. (f) Postoperative radiography of the kidneys, ureters, and bladder shows good fragmentation and removal of calculi. The operation time was 180 minutes. No auxiliary intravenous anesthesia method was used and the patient was discharged from our hospital at day 7.

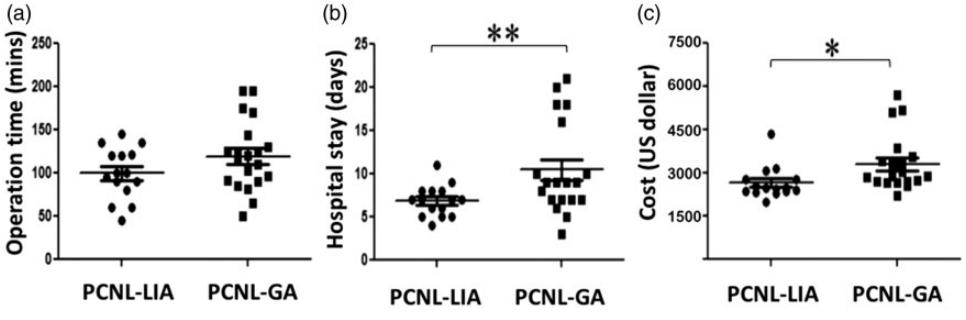

Figure 2. Comparison of three clinical application values between the two anesthesia methods. (a) The operation time (minutes) was compared between the PCNL-LIA and PCNL-GA groups. (b) The hospital stay (days) was compared between the PCNL-LIA and PCNL-GA groups. (c) Costs were converted to US dollars and compared between the PCNL-LIA and PCNL-GA groups. PCNL-LIA: percutaneous nephrolithotomy under local infiltration anesthesia; PCNL-GA: percutaneous nephrolithotomy under general anesthesia.

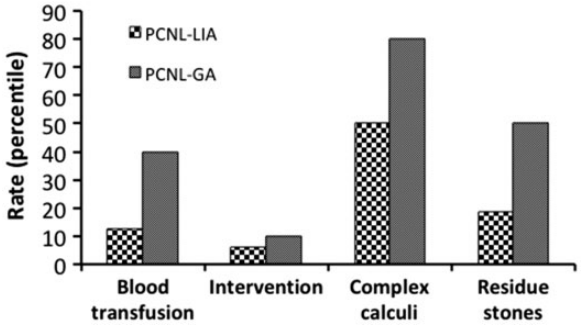

Figure 3. Evaluation of efficacy of surgery between the two groups of patients. Percentile comparisons of the rate of blood transfusion, intervention, complex calculi, and residual stones between the PCNL-LIA and PCNL-GA groups are shown. These data are descriptive percentile rate comparisons. Therefore, statistical methods were not applicable, and no P values for comparison (significance) were provided. PCNL-LIA: percutaneous nephrolithotomy under local infiltration anesthesia; PCNL-GA: percutaneous nephrolithotomy under general anesthesia.

in addition to conventional open surgery. Currently, most PCNL surgeries are carried out under general anesthesia or intrathecal anesthesia.[6] There have been few reports of PCNL being carried out under local infiltration anesthesia.[5,11] However, general anesthesia can cause many complications, including aspiration pneumonia, restlessness and sleeplessness, a sore throat or damage to the respiratory system, tooth damage or bleeding, delirium, and delayed wake-up.[12] In our practice, all complications from general anesthesia were remedied with immediate medical attention, and some required further evaluation, examination, treatment, and observation. These procedures took time, which may explain why patients in the PCNL-GA group had a significantly longer hospital stay before they were discharged compared with those in the PCNL-LIA group. Local infiltration anesthesia has fewer complications compared with general anesthesia or intrathecal anesthesia. Additionally, because patients under local infiltration anesthesia are conscious, it is much easier and safer to conduct, has less influence on patients' physiological functions, and patients recover faster. However, local infiltration anesthesia is not a reasonable choice for pediatric patients, psychiatric patients, or patients without consciousness. Because of the advantages of this type of anesthesia, we conducted the current study to examine the feasibility of PCNL under local infiltration anesthesia.

At 30 to 60 minutes before PCNL-LIA surgery, patients received 50 to 75 mg pethidine hydrochloride and 25 mg promethazine hydrochloride, followed by 5 to 20 mL of 1% lidocaine injection during the operation for local infiltration anesthesia. Notably, the application dose and time point of anesthesia medicines should be determined by their half-life and maximum tolerated dose. Lidocaine injection during the operation should reach the renal fascia, and paying attention to complete anesthesia of rib periosteum nerves if the puncture site is located between the 11th and 12th ribs is especially important. The combination of sedative and analgesic drugs with local anesthesia drugs can increase patients' tolerance threshold to the pain of surgery. Intramuscular premedication of 0.5 mg atropine can obtain better analgesic and antineuropathic effects, and auxiliary application of propofol as a

sedative drug can help achieve ideal anesthetic results for PCNL surgery. Therefore, applying propofol for patients for whom local anesthesia alone cannot have a satisfying effect is important. In the PCNL-LIA group in our study, three patients were administered propofol as an auxiliary intravenous anesthesia drug because they could not tolerate the pain induced by a prolonged surgery time for clearing complicated calculi.

Visceral nerves are highly sensitive to dilation, but relatively insensitive to cutting.[13] In our study, we used the air-pressure ballistic ultrasonic lithotripsy method, which has the advantage of low intrapelvic pressure with efficient stone fragmenting and removal. Therefore, patients' pain induced by renal dilation was significantly reduced when low perfusion pressure was maintained (<30 mmHg), and liquid reflux and the spread of infection were reduced. Some researchers believe that there is no significant difference between minimally invasive PCNL and standard PCNL in clinical efficacy and safety on removing kidney staghorn calculi.[14] Therefore, in our study, we used the F22 standard channel for PCNL in both groups, which produced smooth irrigation and reduced perfusion pressure. Additionally, we believe that a successful renal calyceal fornix puncture and channel dilation at the first time are important. Otherwise, issues such as bleeding, channel loss, and some other problems would prolong the time to identify the channel and stones. This would make the kidney stretched, over-flushed, and over-dilated, and generate more pain, making it intolerable to the patients. Finally, we found that the male patient ratio in the PCNL-LIA and PCNL-GA groups was different (Table 1). The reason for this result is not well understood. One possible explanation for this finding is that cooperation is better in men in terms of pain tolerance.

There are some limitations of our study. One limitation is that we did not compare PCNL-LIA with PCNL under intrathecal anesthesia. We only recorded the overall operation time. The complexity of calculi in patients needs to be closely examined between the two groups. Nevertheless, our pilot study provides critical clinical data on the PCNL-LIA procedure.

In summary, through retroactive comparison of PCNL-GA and PCNL-LIA, we found the following: (1) PCNL-LIA is more convenient and easier to perform than PCNL-GA because patients are conscious and capable of cooperating with the medical team; (2), under local anesthesia, patients recover faster with a shorter hospital stay; and (3) PCNL-LIA is also safer than PCNL-GA, with fewer complications during and after surgery. PCNL-LIA is an invaluable improvement for medical treatment of renal and urethral calculi because of its lower cost and better results for patients compared with general anesthesia.

Declaration of conflicting interest

The authors declare that there is no conflict of interest.

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