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Is micro-percutaneous nephrolithotomy surgery technically feasible and efficient under spinal anesthesia?

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Abstract The objective of the study was to present the clinical and operative effects of two types of anesthesia on micro-percutaneous nephrolithotomy ("microperc"). We retrospectively reviewed 116 patients who underwent microperc between August 2011 and September 2013. Patients were sorted into one of the two groups according to the type of anesthesia received: general (Group 1, *n*:53) or spinal (Group 2, *n*:63). Perioperative variables (age, stone size, location) and outcomes (operation time, success, complication rate) were evaluated and compared. Although there was a statistically significant difference in the mean age of patients (30.3 ± 22.1 vs. 45.8 ± 14.6, respectively, $p < 0.001$), mean body mass indexes were similar ($p = 0.689$). There was no substantial difference in terms of sizes and localizations of stones in the two groups ($p = 0.970$ and $p = 0.795$). While a significant difference was found in comparison of operative times (59.62 ± 32.56 vs. 40.98 ± 26.45 min, $p < 0.001$), there was no statistically significant difference in mean fluoroscopy times (124.92 ± 84.2 vs. 105.2 ± 61.0 s, $p = 0.441$). Stone-free rates were similar (90.5 % vs. 93.6 %, $p = 0.297$). We found no statistical differences between the two groups with respect to mean hemoglobin drop and hospitalization time ($p = 0.015$ and $p = 0.917$, respectively). The complication rates and analog pain scores were also similar ($p = 0.543$ and $p = 0.365$). Our results show that microperc is a feasible surgical modality in the treatment of kidney stone disease under both spinal and general anesthesia. Spinal anesthesia may be considered for patients at a high risk for general anesthesia, and also may be an alternative for patients who are concerned about and/or fearful of general anesthesia.

Keywords Micropercutaneous nephrolithotomy · Anesthesia · Success · Feasibility

Introduction

Since the introduction of the optic puncture system in renal stone treatment in 2011 [1], micro-percutaneous nephrolithotomy (microperc) procedures have become one of the treatment options for moderate-sized kidney stones. Microperc offers the ability to provide single-step percutaneous renal access under direct vision through a 4.8Fr sheath. Initial reports have suggested that the microperc technique is feasible, safe and efficacious for the small and moderate size kidney stones in selected cases [2–4].

Most urologists prefer general anesthesia for conventional percutaneous nephrolithotomy (PNL) procedures for two reasons: (1) the ability to control the patient's breathing and (2) increased comfort for the surgeon. On the other hand, general anesthesia is more likely to cause severe morbidities, such as drug-induced anaphylaxis, complications associated with endotracheal tube insertion, and cardiovascular and pulmonary complications. A further consideration is that receipt of spinal anesthesia for PNL procedures might facilitate the preparation of PNL surgeries. Although several reports are available addressing clinical outcomes of conventional PNL under spinal anesthesia [5–7], a comparative clinical study has not yet been published for microperc.

Herein, we present our retrospective study evaluating the clinical and operative effects of the type of anesthesia

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(spinal and general) on microperc using data from two centers. We believe that this is the first report comparing types of anesthesia for micro-PNL.

Materials and methods

We retrospectively reviewed kidney stone patients from two referral centers who underwent microperc between August 2011 and September 2013. Our series consisted of patients who met the following criteria: (1) willingness to give individual informed consent prior to surgery, (2) a history of failed shockwave lithotripsy (SWL) and flexible ureteroscopy (F-URS), and (3) moderate-sized stones larger than 1 cm. Patients were evaluated in two groups according to administration of general (Group 1) or spinal (Group 2) anesthesia. For the most part, the type of anesthesia used was based on patient preference. However, spinal anesthesia was used for patients with concerns about general anesthesia and for those with pulmonary conditions that contraindicated general anesthesia. The general anesthesia was used for pediatric population, and patients with a history of severe cardiac conditions such as bradycardia as well as patients unwilling to spinal anesthesia. Perioperative variables (age, stone size, location) and outcomes (operation time, success, complication rate) were retrospectively evaluated and compared.

Patients with positive urine cultures were also treated with appropriate antibiotics preoperatively. Radiological evaluation was confirmed with computed tomography for all patients. Stone size was defined as the stone surface area, and was obtained by multiplying the two longest axes of each stone and summing the values of multiple stones (if present). Operative time was defined as the duration between insertion of the ureteral catheter and removal of the microperc system from the kidney.

Spinal anesthesia technique

All patients had received intravenous normal saline infusion at 15 mg/kg prior to spinal blockade. Following this medication, 15–20 mg of levobupivacaine was administered through intervertebral gabs L3–L4 or L4–L5 into the subarachnoid space with 25-gauge needle commonly in sitting position. Ephedrine 0.05 g/ml was applied in case of hypotension. Anesthesia was provided up to dermatomal level of T4.

General anesthesia technique

Anesthesia was induced using thiopental 5 mg/kg and fentanyl 2 µg/kg. Tracheal intubation was facilitated with atracurium 0.5 mg/kg. Anesthesia was maintained with isoflurane 0.8–1.2 % and N_2O 50 % in oxygen plus supplemental doses of atracurium 0.1 mg/kg per 30 min. Ventilation was carried out using anesthesia machine ventilator with a tidal volume of 8–10 mL/kg.

Fig. 1 Needle, flexible microfiber optic, three-way adaptor

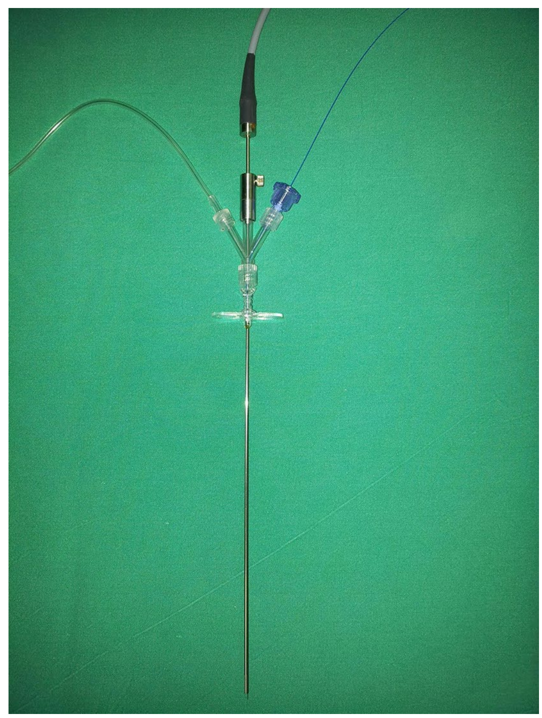

Fig. 2 Microperc system assembly

Microperc technique

All patients underwent microperc in the prone position. A 7Fr ureteric catheter was inserted through the ureter into

Table 1 Demographic values of the patients

	General anesthesia (Group 1)	Spinal anesthesia (Group 2)	p
N	53	63	
Mean age (years)	30.3 ± 22.1	45.8 ± 14.6	<0.001
Mean BMI (kg/m^2)	25.8 ± 7.1	27.0 ± 4.9	0.689
Mean stone size (mm^2)	151.00 ± 75.5	155.08 ± 84.9	0.970
Mean stone number	1.3 ± 0.59	1.4 ± 0.69	0.602
Stone localization			0.332
Lower calyx	25	21	
Middle calyx	4	9	
Upper calyx	2	3	
Pelvis	10	16	
Pelvis + lower calyx	12	14	

the renal pelvis under cystoscopic and fluoroscopic guidance in the lithotomy position. After affixing the ureteric catheter to the urethral catheter, the patient was placed in the prone position. The pelvicalyceal system was filled with diluted contrast agent injected through the ureteric catheter. Percutaneous renal access to the caliceal fornix was attained using a 16 G needle with the C-arm fluoroscopy guidance. Then, inner and outer puncture shafts of the 4.8Fr "all-seeing needle" microperc system (PolyDiagnost, Pfaffenhofen, Germany) were placed and following taking out of the inner shaft, a three-way connector allowing the insertion of 0.9 mm flexible micro-optic, laser fiber and irrigation system was attached to the outer tip of the shaft (Figs. 1, 2). Usually, the stone containing calyx was targeted; if the stone was in the renal pelvis, either middle or lower calyceal puncture was preferred. Stone fragmentation was achieved using a 200-µm Holmium: YAG laser fiber commonly with settings of 0.8 J at 8 Hz (6.4 W). Irrigation was provided using a mechanical pump with foot pedal control. Saline irrigation aids the maintenance of proper vision and removal of the stone debris during the surgery and provides the flush out of the stone fragments and dust particles through the ureteral catheter continuously. After confirmation of stone-free status, the micro-sheath was removed. Operative time was defined as the duration between the insertion of the ureteral catheter and the removal of the microperc system from the kidney.

Postoperative pain was assessed with a visual analog scale. Barring complications, patients were routinely discharged after removal of the urethral and ureteral catheters. All patients underwent a radiological assessment with plain radiography on the first postoperative day and at their one-month follow-up appointment. Success was defined as no residual fragment on CT images on the first month of follow-up. Postoperative complications were evaluated using the Clavien grading system [9].

Data analysis was performed using the SPSS statistical package (ver16.0 J; SPSS, Inc., Chicago, IL, USA). Patient and operative-related parameters were compared between the groups using the Mann–Whitney U test for numerical variables, and the Chi squared test for categorical variables. P values less than 0.001 for the Mann–Whitney U test were considered statistically significant.

Results

A total of 116 patients were evaluated, including the general anesthesia group (Group 1, $n = 53$) and the spinal anesthesia group (Group 2, $n = 63$). Although there was a statistically significant difference in the mean ages of patients (30.3 ± 22.1 vs. 45.8 ± 14.6, respectively, $p < 0.001$), the mean body mass indices of the two groups were similar (25.8 ± 7.1 vs. 27.0 ± 4.9 kg/m^2, $p = 0.689$). There was no statistically significant difference in terms of sizes and localizations of stones in the two groups ($p = 0.970$ and $p = 0.795$). The demographic values for the patients are summarized in Table 1.

While a statistically significant difference was found in operative times for the two groups (59.62 ± 32.56 vs. 40.98 ± 26.45 min, $p < 0.001$), there was no significant difference in mean fluoroscopy times (124.92 ± 84.2 vs. 105.2 ± 61.0 s, $p = 0.441$). We also found no statistical differences in the groups with regard to mean hemoglobin drop and hospitalization time (1.14 ± 0.49 vs. 0.91 ± 0.72 mg/dL, $p = 0.015$ and 34.4 ± 17.8 vs. 33.5 ± 15.4 h, $p = 0.917$, respectively). Blood transfusion was not required for any of the patients in either group.

Stone-free rates were 90.5 % (48/53) in Group 1 and 93.6 % (59/63) in Group 2, but the difference was not statistically significant ($p = 0.297$). Intercostal punctures were performed in two patients in each group while remaining patients underwent a subcostal puncture. Meanwhile, pleural injury was not observed in any of the patients although one of them was through 10th intercostal space. The complication rates were similar in both groups (9.5 vs. 9.4 %,

Table 2 Comparison of postoperative outcomes

	General anesthesia	Spinal anesthesia	p
Operative time (min)	59.62 ± 32.56	40.98 ± 26.45	<0.001
Fluoroscopy time (s)	124.92 ± 84.2	105.2 ± 61.0	0.441
Hospitalization (h)	34.4 ± 17.8	33.5 ± 15.4	0.917
Hemoglobin drop (g/dL)	1.14 ± 0.49	0.91 ± 0.72	0.015
Visual analog scores	2.9 ± 1.7	3.0 ± 1.3	0.365
Stone-free rate (n, %)	48/53 (90.5)	59/63 (93.6)	0.297
Sites of access[a]			0.582
Lower	40	45	
Middle	9	15	
Upper	4	3	
Complications (n, %)	5 (9.3 %)	6 (9.4 %)	0.543
Urinary tract infection (Clavien I)	–	1	
Renal colic requiring D-J stent insertion (Clavien III)	3	3	
Impairments of instruments	–	2	
Saline extravasation requiring percutaneous abdominal drainage (Clavien IIIa)	2	–	

[a] According to calyceal system

$p = 0.543$). In Group 2, all procedures were completed with spinal anesthesia alone. No general anesthesia and no additional sedation were required for any patients in that group. In Group 2, a total of 6 complications were observed postoperatively, including (1) complications due to instrument impairments during surgery for two of the patients, (2) renal colic requiring stent insertion (Clavien grade IIIa) in three patients and (3) urinary tract infection (Clavien grade I) in one patient. In Group 1, five complications were seen postoperatively, including (1) abdominal drainage (Clavien grade IIIa) due to serious extravasation in two patients and (2) renal colic requiring stent insertion (Clavien I) in three patients. Postoperative analog pain scores were also statistically similar in both groups (2.9 ± 1.7 vs. 3.0 ± 1.3, $p = 0.365$). The clinical and operative outcomes are summarized in Table 2.

Discussion

Over the years, technology has advanced with the goal of achieving the highest possible stone-free rate and lowest morbidity rate for the treatment of renal stones [8, 10]. The microperc technique is a technological refinement based on improvements in the optical and puncture system. This modality has been suggested for moderate size renal calculi, along with other approaches, such as SWL or F-URS, in recently published clinical trials [3, 4, 11]. Moreover, these initial reports have suggested that microperc is feasible, safe and efficacious for small and moderate size kidney stones with comparable success and complication rates [3, 4].

Besides the surgical technique, itself, anesthesia administration is an important factor affecting surgical outcomes and anesthesia-related complications. Many patients report being fearful of general anesthesia. Nevertheless, general anesthesia is commonly preferred for PNL procedures, owing to the ability to control the patient's breathing and increased comfort for surgeon. However, general anesthesia is more likely than other types of anesthesia to cause severe morbidities, such as drug-induced anaphylaxis, complications associated with endotracheal tube insertion, and cardiovascular and pulmonary complications [12–15].

Several published clinical trials compare spinal and general anesthesia in conventional PNL. In a randomized clinical trial, Nouralizadeh and colleagues found comparable surgical outcomes and similar complication rates for both anesthesia methods in standard PNL [6]. In another study, Kuzgunbay et al. [7] analyzed the results of PNL for the management of kidney stone disease under combined spinal–epidural anesthesia versus general anesthesia. The authors found no significant differences in operative time, irrigation fluids, fluoroscopy time, hemoglobin, hospitalization time and stone-free rates. Although these initial reports have suggested no significant differences between spinal and general anesthesia, some authors emphasized the opposite. In a large PNL series of 180 patients, Karacalar et al. [16] compared patient satisfaction and pain scores for a spinal–epidural block versus general anesthesia, and reported better patient satisfaction and lower pain scores for spinal–epidural anesthesia. Recently, Cicek et al. [5] reported a comparison of general and spinal anesthesia in a large series of standard PNL. The authors mentioned shorter hospitalization, operation, and fluoroscopy durations for spinal anesthesia and a greater frequency of major complications for general anesthesia.

The advantage of microperc with an optic puncture system is that the fiber optic display shows images for all layers, from the skin to the collective system, without a large dilatation, commonly in a single step. Owing to this capability, safe access can be achieved without harming surrounding organs and without causing major bleeding. The current 116 patients' study is the first and largest microperc series to compare general and spinal anesthesia. Our findings show that microperc can be performed successfully under either spinal or general anesthesia.

The only significant difference was that operative time was reduced for the spinal anesthesia group. The time of initiative preparation stages of PNL procedures might be increased under general anesthesia due to positioning difficulties. The difference might be related to increased duration while patients were turning to prone position due to the difficulties in general anesthesia such as trying to keep the endotracheal tube in place and/or putting bumper pads under patients after insertion of ureteric catheter. In addition, the mobilization of the kidney while the patient is breathing under spinal anesthesia might affect the duration time needed for laser fragmentation. The mean hemoglobin change and success rates were similar in each type of anesthesia. There was also no significant difference with regard to hospitalization time and visual analog scores. This may be due to the minimally invasive nature of microperc technique, which may provide less pain and a shorter period of hospitalization regardless of the type of anesthesia used.

Complications may occur when patient's position is changed from supine to prone, due to displacement of the tracheal tube used in general anesthesia. Previous studies commonly reported tongue injuries, ventilation disorders, and neurological conditions such as brachial plexus [12, 13]. We did not see these complications in our series. Furthermore, complication rates were also similar under both general and spinal anesthesia. Technical complications due to impairments of optical instruments were observed in two cases where spinal anesthesia was being used. The issues were managed by converting to conventional PNL. Three patients underwent double-J stent insertions due to persistent renal colic (Clavien IIIa); urinary tract infection (Clavien I) was seen postoperatively in one patient in the spinal anesthesia group. Two pediatric patients underwent abdominal drainage (Clavien IIIa) due to serious saline extravasation; renal colic requiring stent insertion (Clavien I) was seen postoperatively in three patients in general anesthesia.

The present study has several limitations. The absence of information about anesthesia time prior to starting surgery and the retrospective nature of the study are the main limitations. Despite these factors, we believe that this study contributes to the literature and presents the feasibility, both spinal and general anesthesia for this new treatment modality.

Conclusions

Our results show that microperc is a feasible surgical modality in the treatment of kidney stone disease under either spinal or general anesthesia. Spinal anesthesia may be considered for the patients for whom general anesthesia is contraindicated, and may also be an alternative for patients who are concerned about and/or fearful of general anesthesia.

Conflict of interest The authors declare that they have no conflict of interest.

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