Int J Clin Exp Med 2020;13(6):4152-4158
www.ijcem.com /ISSN:1940-5901/IJCEM0109020

Original Article

Effects of ultrasound-guided microchannel percutaneous nephrolithotomy on stress response and renal function

Bin Li[1], Ziqin Ban[2], Lei Luo[1], Xuemei Ding[3], Xiaoning Kang[3], Tongyue Cui[4]

[1]*Department of Urology, Affiliated Hospital of Qingdao University, Qingdao 266003, Shandong, China;* [2]*Health Service Center of Haikou Road Community, Zhuhai Road Street, Shinan District, Qingdao 266075, Shandong, China;* [3]*Department of Operating Room, Affiliated Hospital of Qingdao University, Qingdao 266003, Shandong, China;* [4]*Department of Urology, Changle County People's Hospital, Changle 262400, Shandong, China*

Received February 11, 2020; Accepted March 23, 2020; Epub June 15, 2020; Published June 30, 2020

Abstract: Objective: To analyze the effects of ultrasound-guided microchannel percutaneous nephrolithotomy (mPCNL) on renal function and stress response in patients with kidney stones. Methods: The medical records of 105 patients with kidney stones in our hospital from August 2014 to August 2016 were retrospectively collected and divided into two groups: control group (52 patients + standard percutaneous nephrolithotomy) and observation group (53 patients, mPCNL). The perioperative indicators, stone clearance rate, renal function indicators, oxidative stress indicators, and complications before and after treatment were compared. Results: The observation group showed less intraoperative blood loss, longer operation time, lower stone clearance rate, higher incidence of fever and lower incidence of haemorrhage than the control group. Superoxide dismutase (SOD) and Glutathione peroxidase (GSH-Px) were significantly reduced in the two groups after surgery, and the reduction in the observation group was less than that in the control group (P<0.05). The incidence of septic shock, sepsis and postoperative blood urea nitrogen (BUN) in the observation group were not significantly different from those in the control group (P>0.05). Conclusion: Ultrasound-guided mPCNL for kidney stones showed a high stone clearance rate and has a small effect on renal function, which is beneficial to reduce the stress response and the incidence of haemorrhage.

Keywords: Kidney stones, ultrasound-guided microchannel percutaneous nephrolithotomy, standard channel percutaneous nephrolithotomy, stone clearance rate, renal function, oxidative stress

Introduction

The incidence of kidney stones in the urinary system is high and the symptoms of kidney stones commonly include vomiting and nausea, severe pain in the lower back or abdomen [1]. The causes of kidney stones formation are complex. Usually, the concentration of crystal-forming substances in the urine is increased, or their solubility is reduced. After the crystals are precipitated, they accumulate locally, eventually forming stones [2, 3]. Occupation, eating habits, environment, genetics, race, gender, and age were all risk factors that affect the formation of kidney stones. In recent years, research shows that dietary habits may be the main reason for kidney stone formation [4, 5].

There is a high incidence of kidney stones in China. If not treated in a timely manner, hydronephrosis may be caused, and some patients may even experience uremia [6]. The clinical treatment of kidney stones includes conservative therapies, open surgery, etc., but the treatment effects need to be improved [7].

Percutaneous nephrolithotomy (PCNL) has also been applied in the treatment of kidney stones in recent years [8, 9]. PCNL is minimally invasive, with less intraoperative blood loss and high stone clearance rate [10, 11]. Microchannel and standard channel percutaneous nephrolithotomy are two common types. The success rate of PCNL was closely related to the establishment of percutaneous renal channel. PCNL was previously performed with X-ray guided puncture; it was limited in clinical application due to its high-dose radiation and high incidence of complications. Therefore, ultrasound-guided puncture was usually adopted during surgery [12, 13].

In order to improve the clearance rate of kidney stones and the renal function of patients as well as reduce stress and inflammatory responses, this study used ultrasound-guided microchannel percutaneous nephrolithotomy in the treatment of kidney stones, and its effects were compared with that of standard channel percutaneous nephrolithotomy.

Materials and methods

The medical records of 105 patients with kidney stones in our hospital from August 2014 to August 2016 were retrospectively collected and divided by treatment method. Fifty-two patients were treated with standard channel percutaneous nephrolithotomy (control group, CG), and 53 patients were treated with ultrasound-guided microchannel percutaneous nephrolithotomy (observation group, OG). (1) Inclusion criteria: informed consent of the patient was obtained; Patients had no contraindications for surgery; ASA grade I/II; single or multiple kidney stones confirmed by abdominal CT and color Doppler imaging. The study was approved by the Medical Ethics Committee. (2) Exclusion criteria: patients who have withdrawn from treatment; patients with contraindications to surgery; history of blood transfusion/immunotherapy; combined diabetes and hyperthyroidism; mental disorders; urinary anatomical malformations; renal insufficiency; malignant tumors. This study has been approved by the Ethics Committee of Changle County People's Hospital. All study participants provided written informed consent before participating in the study.

Treatment methods

Surgical treatment was performed at lithotomy position with epidural block. The ureteral catheter was implanted into the bladder via the urethra and guided by soft ureteroscopy. After the ureteral orifice was located, the ureteral catheter was retrogradely inserted in the renal pelvis and fixed properly. Then prone position was adopted with the abdomen elevated, and artificial hydronephrosis was slowly induced through the catheter. According to the specific conditions of the stone site and hydronephrosis, the appropriate puncture points were selected, usually at the 11th intercostal, the 12th subcostal area, the infrascapular line, and the posterior axillary line. Renal calyx puncture was performed, and guided by B-mode ultrasound. The puncture needle was inserted into the calyx where the stone was located. After the puncture was completed, the zebra urological guidewire was inserted along the puncture needle. A 9 mm skin incision was made and expanded with a fascial dilator. The OG was expanded from 8F to 18F and the CG was expanded from 8F to 24F. A tubular plastic sheath was placed to establish the channel. After crushing, the stones were rinsed away with saline. The stone disintegration was observed by ultrasound.

Outcome measurement

1) The perioperative indicators. 2) Stone clearance rate was observed using an ultrasound system. 3) Renal function indexes: 2 ml fasting venous blood was collected from two groups 1 d before and 1 d after surgery, and centrifuged at 3000 r/min for 15 min to obtain the supernatant and stored at -70°C. Scr and BUN were measured by enzyme-linked immunosorbent assay and performed according to the kit instructions. The kit was purchased from Shanghai Yuchun Biotechnology Co., Ltd. 4) Oxidative stress indicators: 2 ml fasting venous blood was collected 1 d before and 1 d after surgery, centrifuged at 3000 r/min for 15 min, the supernatant was obtained, and stored at -70°C. GSH-Px and SOD were measured in the same way as renal function indexes. 5) Complications between the two groups were compared.

Statistical analysis

SPSS 22.0 software was used for data analysis. Measurement data (Means ± standard deviations) that confines to normal distribution was examined by t-test. Otherwise, Mann-Whitney U test was used. [N (%)] was used to indicate count data and examined by X^2 test. $P<0.05$ indicated that the difference was statistically significant.

Results

Comparison of baseline data

There was no difference in the terms of gender, age, stone diameter, location and type between two groups ($P>0.05$) (**Table 1**).

Table 1. Baseline data [n (%)]/($\bar{x}$ ± s)

Baseline data		OG (n=53)	CG (n=52)	t/X^2	*P*
Gender	Male	20 (37.74)	21 (40.38)	1.352	0.245
	Female	33 (62.26)	31 (59.62)		
Age (year)		46.23 ± 2.19	46.28 ± 2.17	0.246	0.907
Stone diameter (cm)		3.28 ± 0.63	3.32 ± 0.65		
Stone location					
Left		29 (54.72)	27 (51.92)	0.082	0.774
Right		24 (45.28)	25 (48.08)		
Stone type					
Renal pelvis stone		26 (49.06)	24 (46.15)	0.025	0.996
Staghorn stone		12 (22.64)	13 (25.00)		
Multiple renal stones		15 (28.30)	15 (28.85)		

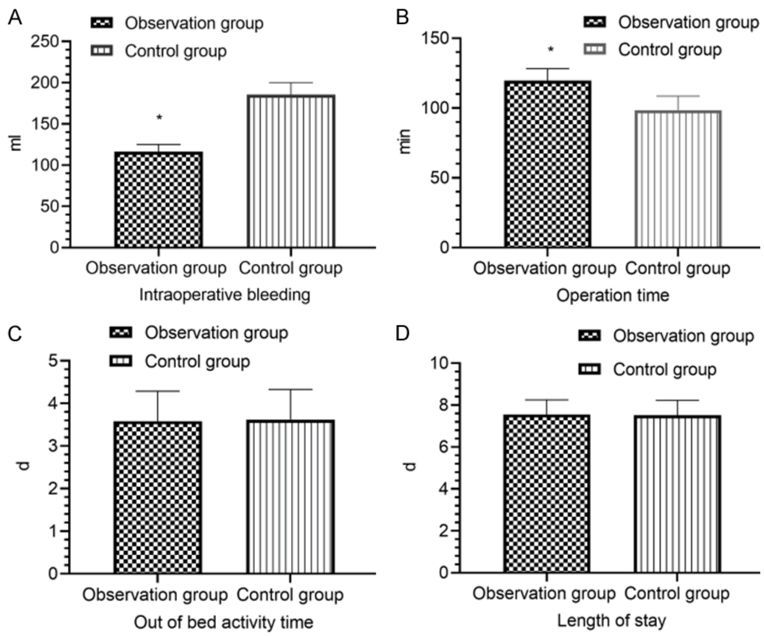

Figure 1. Comparison of surgical indicators between the two groups. The intraoperative blood loss in the OG was less than that of the CG, and the operation time was longer than that of the CG, P<0.05. * indicates comparison with the control group, P<0.05.

Comparison of surgical indicators between the two groups

The intraoperative blood loss in the OG was (110.25 ± 5.85) ml, which was less than (175.12 ± 8.16) ml in CG. The operation time was (113.56 ± 9.98) min in OG, which was longer than the (91.26 ± 7.15) min in CG (P<0.05). The time to get out of bed and the length of hospital stay in the OG were (3.08 ± 0.15) d and (7.05 ± 0.89) d, respectively, which showed no significant difference with (3.12 ± 0.13) d and (7.02 ± 0.87) d in the CG (P>0.05) (**Figure 1**).

Comparison of stone clearance rate between two groups

The stone clearance rate in OG was 90.57% (48/53), which was higher than the 63.46% (33/52) in CG (P<0.05) (**Figure 2**).

Comparison of renal function indicators between the two groups

The Scr in the OG and CG before surgery was (208.46 ± 9.63) μmol L and (208.96 ± 9.58) μmol/L, the difference was not statistically significant (P>0.05). The Scr in the OG and CG after surgery was (195.63 ± 8.15) μmol/L and (195.69 ± 8.12) μmol/L, the difference was not statistically significant (P>0.05) (**Figure 3**).

The BUN in in the OG and CG before surgery was (17.58 ± 4.15) μmol/L and (17.62 ± 4.12) μmol/L, the difference was not statistically significant (P>0.05). The BUN in the OG and CG after surgery was (16.15 ± 3.05) μmol/L and (16.12 ± 3.02) μmol/L, the difference was not statistically significant (P>0.05) (**Figure 4**).

Comparison of oxidative stress indicators between the two groups

There was no statistically significant difference in GSH-P and SOD before surgery between the two groups (P>0.05). Both GSH-Px and SOD decreased after surgery in both groups, and the reduction was smaller in the OG than in CG (P<0.05) (**Tables 2** and **3**).

Comparison of complications between the two groups

The septic shock and sepsis rates in the OG were 1.89% and 3.77%, respectively, which exhibited no significant difference with 3.85% and 5.77% in CG (P>0.05). The fever rate in OG

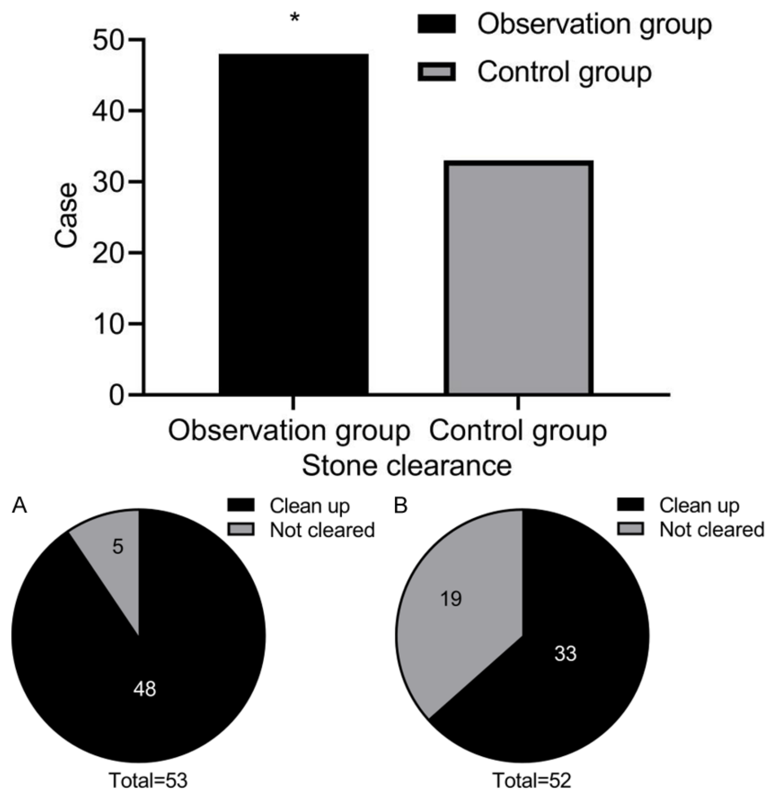

Figure 2. Comparison of stone clearance rate between the two groups. The stone clearance rate of the observation group was 90.57% (48/53), which was higher than the control group's 63.46% (33/52), P<0.05. * indicates comparison with the control group, P<0.05.

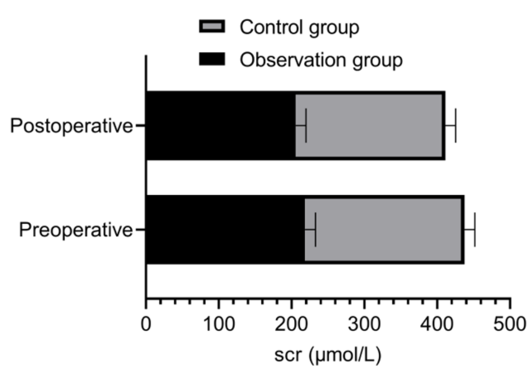

Figure 3. Comparison of Scr before and after surgery in the two groups. Comparing the Scr before surgery in the two groups, P>0.05; Comparison of the Scr after surgery in the two groups, P>0.05.

was 18.87%, which was higher than 3.85% in CG.

The incidence of hemorrhage in OG was 3.77%, which was lower than 28.85% in CG (P<0.05) (**Table 4**).

Discussion

Kidney stones are abnormal accumulation of crystalline substances such as cystine, uric acid, oxalic acid, and calcium in the kidney, and there is no significant difference in the incidence of kidney stones between the left and right sides [14]. Unhealthy lifestyles and dietary habits have resulted in more and more patients with kidney stones which seriously affect patients' quality of life as well as physical and mental health [15]. PCNL is a common surgical method for kidney stones treatment. It evolved under multiple development stages. The 24F/36F channel of traditional PCNL was gradually replaced with 24F/36F [16, 17].

Haider first reported ultra-fine channel PCNL, which is mainly used for the treatment of 2-3 cm kidney stones [18].

Studies have shown that the width of the PCNL channel is not only related to the surgical procedures, the amount of bleeding and the operation time, but also related to the occurrence of complications, stress response, and renal function [19, 20]. For this reason, ultrasound-guided microchannel percutaneous nephrolithotomy and standard channel percutaneous nephrolithotomy were used respectively in this study.

The results of this study show that the OG has a longer operation time than the control group, but the intraoperative blood loss is less than that of CG (P<0.05). The reason is that narrower surgical channel makes the operation more difficult to perform, thus the operation time is prolonged [21]. Secondly, the fascia is less dilated in microchannel percutaneous nephrolithotomy, so the intraoperative blood loss is less [22]. Stone clearance rate is a crucial indicator to evaluate the success of kidney stone surgery. In this study, the stone removal rate in the OG was 90.57% (48/53), which was

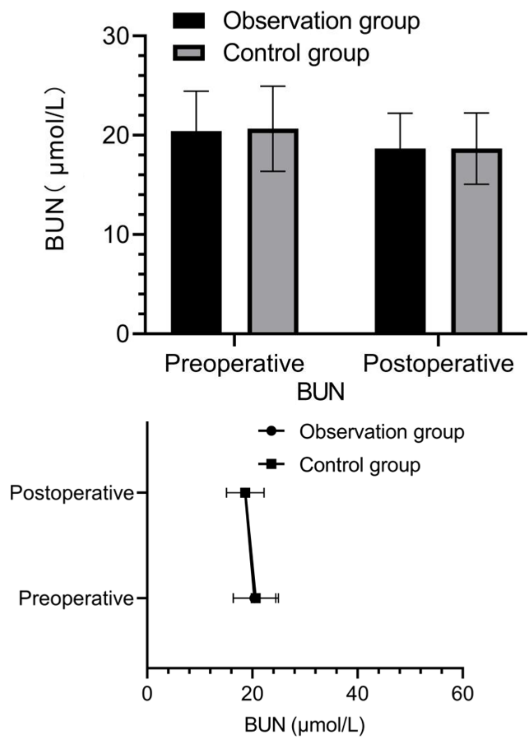

Figure 4. Comparison of BUN before and after surgery in the two groups. Comparison of the BUN before surgery in the two groups, P>0.05; Comparison of the BUN after surgery in the two groups, P>0.05.

higher than the CG's 63.46% (33/52) (P<0.05), suggesting that mPCNL has a higher stone clearance rate. This may be because the caliber of the microchannel is relatively small, which is conducive to puncture, and the size and location of the stones were more clearly determined.

Renal function indexes are clinically accepted indicators for evaluating renal function. In theory, compared with PCNL, mPCNL should have less impact on renal function. However, results of this study showed that compared with preoperative indicators, changes in postoperative Scr and BUN were not significant in the two groups, and there was no significant difference in the postoperative Scr and BUN between the two groups, suggesting that the two surgical methods have produced small effects on renal function. That may because the two surgical methods used in the study were minimally invasive, and their effects are all small, so there is no significant difference in renal function indexes after surgery [23, 24].

Table 2. GSH-Px before and after surgery ($\overline{x} \pm s$, U/L)

Grouping	Before	After
CG (n=52)	461.52 ± 12.52	400.12 ± 5.16$^{\#}$
OG (n=53)	461.58 ± 12.49	428.69 ± 5.88$^{\#,*}$
t	0.024	26.081
P	0.981	0.000

Note: $^{\#}$indicates comparison with pre-operation, P<0.05; *indicates comparison with control group, P<0.05.

Table 3. SOD before and after surgery ($\overline{x} \pm s$, U/ml)

Grouping	Before	After
CG (n=52)	88.65 ± 8.52	60.15 ± 7.157$^{\#}$
OG (n=53)	88.69 ± 8.49	68.96 ± 7.56$^{\#,*}$
t	0.024	12.909
P	0.981	0.000

Note: $^{\#}$indicates comparison with pre-operation, P<0.05; *indicates comparison with control group, P<0.05.

GSH-Px and SOD are commonly used stress indicators. In this study, the GSH-Px and SOD were reduced in two groups after surgery, suggesting that both groups of patients had a surgical stress response. However, the reduction in GSH-Px and SOD in the OG was smaller than that in the CG, suggesting that compared with PCNL, mPCNL has a lower stress response. The reason may be that mPCNL had a smaller opening and a relatively smaller impact on the surrounding renal blood vessels. In addition, the amount of intraoperative blood loss was less, so the body's stress level was lower [25]. The incidence of hemorrhage in the OG was lower than that in CG (P<0.05). This may be resulted from the narrow channel and the light expansion intensity.

In summary, ultrasound-guided microchannel percutaneous nephrolithotomy for kidney stones showed a high rate of stone clearance, had small impacts on renal function, reducing the stress response and hemorrhaging. However, because there are only a small number of subjects included in this study and the results obtained are not sufficiently representative, comprehensive studies with larger sample sizes, longer follow-up time will be conducted.

Table 4. Comparison of complications between the two groups [n (%)]

Grouping	Cases	Fever	Hemorrhage	Septic shock	Sepsis
CG	52	2 (3.85)	15 (28.85)	2 (3.85)	3 (5.77)
OG	53	10 (18.87)*	2 (3.77)*	1 (1.89)	2 (3.77)
X^2		5.851	12.160	0.363	0.231
P		0.016	0.000	0.547	0.631

Note: *indicates comparison with the control group, $P<0.05$.

Disclosure of conflict of interest

None.

Address correspondence to: Tongyue Cui, Department of Urology, Changle County People's Hospital, No. 278, Limin Street, Changle 262400, Shandong, China. Tel: +86-13863619525; E-mail: utbxqk@163.com

References

[1] Mehta M, Goldfarb DS and Nazzal L. The role of the microbiome in kidney stone formation. Int J Surg 2016; 36: 607-612.

[2] Peerapen P and Thongboonkerd V. Caffeine in kidney stone disease: risk or benefit? Adv Nutr 2018; 9: 419-424.

[3] Bonzo JR and Tasian GE. The emergence of kidney stone disease during childhood-impact on adults. Curr Urol Rep 2017; 18: 44.

[4] Devarajan A. Cross-talk between renal lithogenesis and atherosclerosis: an unveiled link between kidney stone formation and cardiovascular diseases. Clin Sci (Lond) 2018; 132: 615-626.

[5] Hsi RS, Sanford T, Goldfarb DS and Stoller ML. The role of the 24-hour urine collection in the prevention of kidney stone recurrence. J Urol 2017; 197: 1084-1089.

[6] Pucci ND, Marchini GS, Mazzucchi E, Reis ST, Srougi M, Evazian D and Nahas WC. Effect of phyllanthus niruri on metabolic parameters of patients with kidney stone: a perspective for disease prevention. Int Braz J Urol 2018; 44: 758-764.

[7] Okada A, Hamamoto S, Taguchi K, Unno R, Sugino T, Ando R, Mizuno K, Tozawa K, Kohri K and Yasui T. Kidney stone formers have more renal parenchymal crystals than non-stone formers, particularly in the papilla region. BMC Urol 2018; 18: 19.

[8] Shadman A and Bastani B. Kidney calculi: pathophysiology and as a systemic disorder. Iran J Kidney Dis 2017; 11: 180-191.

[9] Vaughan LE, Enders FT, Lieske JC, Pais VM, Rivera ME, Mehta RA, Vrtiska TJ and Rule AD. Predictors of symptomatic kidney stone recurrence after the first and subsequent episodes. Mayo Clin Proc 2019; 94: 202-210.

[10] Daudon M, Frochot V, Bazin D and Jungers P. Drug-induced kidney stones and crystalline nephropathy: pathophysiology, prevention and treatment. Drugs 2018; 78: 163-201.

[11] Marien TP and Miller NL. Characteristics of renal papillae in kidney stone formers. Minerva Urol Nefrol 2016; 68: 496-515.

[12] Kittanamongkolchai W, Mara KC, Mehta RA, Vaughan LE, Denic A, Knoedler JJ, Enders FT, Lieske JC and Rule AD. Risk of hypertension among first-time symptomatic kidney stone formers. Clin J Am Soc Nephrol 2017; 12: 476-482.

[13] Xu LHR, Adams-Huet B, Poindexter JR, Maalouf NM, Moe OW and Sakhaee K. Temporal changes in kidney stone composition and in risk factors predisposing to stone formation. J Urol 2017; 197: 1465-1471.

[14] Wong Y, Cook P, Roderick P and Somani BK. Metabolic syndrome and kidney stone disease: a systematic review of literature. J Endourol 2016; 30: 246-53.

[15] Mitra P, Pal DK and Das M. Does quality of drinking water matter in kidney stone disease: a study in West Bengal, India. Investig Clin Urol 2018; 59: 158-165.

[16] Ghani KR, Andonian S, Bultitude M, Desai M, Giusti G, Okhunov Z, Preminger GM and de la Rosette J. Percutaneous nephrolithotomy: update, trends, and future directions. Eur Urol 2016; 70: 382-96.

[17] Wei C, Zhang Y, Pokhrel G, Liu X, Gan J, Yu X, Ye Z and Wang S. Research progress of percutaneous nephrolithotomy. Int Urol Nephrol 2018; 50: 807-817.

[18] Haider R, Regnier P, Roustan FR, Severac F, Treacy PJ, Mendel L, Bodokh Y, Tibi B, Prader R, Traxer O, Chevallier D, Amiel J and Durand M. Percutaneous nephrolithotomy for kidney stones in elderly patients: meta-analysis of results and complications. Prog Urol 2017; 27: 58-67.

[19] Ruhayel Y, Tepeler A, Dabestani S, MacLennan S, Petrik A, Sarica K, Seitz C, Skolarikos A, Straub M, Turk C, Yuan Y and Knoll T. Tract sizes in miniaturized percutaneous nephrolithotomy: a systematic review from the european as-

sociation of urology urolithiasis guidelines panel. Eur Urol 2017; 72: 220-235.

[20] Wu WJ and Okeke Z. Current clinical scoring systems of percutaneous nephrolithotomy outcomes. Nat Rev Urol 2017; 14: 459-469.

[21] Alsmadi J, Fan J, Zhu W, Wen Z and Zeng G. The influence of super-mini percutaneous nephrolithotomy on renal pelvic pressure in vivo. J Endourol 2018; 32: 819-823.

[22] Gao XS, Liao BH, Chen YT, Feng SJ, Gao R, Luo DY, Liu JM and Wang KJ. Different tract sizes of miniaturized percutaneous nephrolithotomy versus retrograde intrarenal surgery: a systematic review and meta-analysis. J Endourol 2017; 31: 1101-1110.

[23] Nouralizadeh A, Simforoosh N, Shemshaki H, Soltani MH, Sotoudeh M, Ramezani MH, Nikravesh M, Golshan A and Ansari A. Tubeless versus standard percutaneous nephrolithotomy in pediatric patients: a systematic review and meta-analysis. Urologia 2018; 85: 3-9.

[24] Loftus CJ, Hinck B, Makovey I, Sivalingam S and Monga M. Mini versus standard percutaneous nephrolithotomy: the impact of sheath size on intrarenal pelvic pressure and infectious complications in a porcine model. J Endourol 2018; 32: 350-353.

[25] Patel NH, Schulman AA, Bloom JB, Uppaluri N, Phillips JL, Konno S, Choudhury M and Eshghi M. Device-related adverse events during percutaneous nephrolithotomy: review of the manufacturer and user facility device experience database. J Endourol 2017; 31: 1007-1011.