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Original Article

Local anesthesia effect of minimally invasive percutaneous nephrolithotomy on systemic inflammatory response and renal function damage

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Abstract: *Objective:* To investigate the clinical data of 80 cases with upper urethral stones and kidney stones under minimally invasive percutaneous nephrolithotripsy and assess the safety, efficacy, feasibility, economic and clinical application value of local anesthesia for this surgery. *Methods:* 80 cases were randomly divided into observation group and control group (40 cases in each group). The observation group underwent minimally invasive percutaneous nephrolithotripsy with local anesthesia, while the control group underwent epidural anesthesia. The expression levels of IL-6 TNF-α, β2-MG, CRP, Cr and BUN were detected on the preoperative morning, immediately after operation and one week after operation. HR, SPO_2, MAP, operation time, intraoperative blood loss, average length of hospital stay and hospital costs, and residual stone rates were compared between the two groups. *Results:* BUN, Cr, β2-MG, IL-6, TNF-α and CRP were not significantly different between the two groups on the preoperative morning ($P>0.05$), but their postoperative expression levels were significantly higher than preoperative levels. One week after surgery, IL-6, TNF-α and CRP of observation group were slightly higher than those of control group. BUN, Cr and β2-MG were lower at one week after surgery than immediately after operation in both groups ($P<0.05$). MAP, HR and SPO_2 were statistically significant preoperatively, intraoperatively and before anesthesia ($P<0.05$). Operation time, blood loss and residual stone rates were not significantly different ($P>0.05$) between the two groups. The average length of hospital stay and hospital costs in the observation group were significantly lower than those of the control group ($P<0.05$). *Conclusion:* Minimally invasive percutaneous nephrolithotripsy under local anesthesia for the removal of kidney stones and upper urethral calculi is worthy of clinical application, because of less intensive systemic inflammatory response, lower total cost and shorter length of hospital stay.

Keywords: Local anesthesia, percutaneous nephrolithotripsy, systemic inflammatory response, renal impairment

Introduction

Minimally invasive percutaneous nephrolithotripsy (MPCNL) is now in extensive clinical use. However, it may implicate a higher risk for patients with severe cardiopulmonary insufficiency or receiving general anesthesia or spinal-epidural anesthesia in contrast to a lower risk for patients receiving local anesthesia. To assess the safety and efficacy of MPCNL under local anesthesia, a prospective comparison study was conducted for patients receiving MPCNL under local anesthesia or spinal-epidural anesthesia at Urology Surgery, Dongguan City Dalang Hospital from August 2012 to August 2014.

Materials and methods

General information

Eighty patients were divided into observation group and control group by using the envelope method (40 cases in each group). Inclusion criteria: calculus diameter of 15-40 mm; failure of extracorporeal shock wave lithotripsy; without urinary tract infection. Exclusion criteria: spinal deformity, thus making the lithotomy position impossible; coagulation disorder; severe cardiopulmonary diseases, diabetes or renal insufficiency; obesity; hypersensitivity to pain.

Patients were fully informed of the anesthetic procedures and signed the informed consent.

The experimental protocol was approved by the ethics committee. The observation group had 26 males and 14 females, aged 22-80 years with an average of 39±11 years. Among them 33 cases had renal calculi and 7 cases had upper ureteral calculi, with the calculi measuring 18-35 mm with an average of 24.4+7.4 mm. The control group had 30 males and 10 females, aged 23-78 years old with an average of 40+12 years. Among them 31 cases had renal calculi and 9 cases had upper ureteral calculi. The calculi were measured 18-33 mm, with an average of 22.3±6.4 mm. The depth of hydronephrosis was 0.8-2.2 cm in the observation group compared to 0.9-1.9 cm in the control group before operation, and the average was 1.5±0.2 cm and 1.2±0-3 cm, respectively. All patients first received antibiotics treatment until the white blood cell count in urine was normal. After that conventional anti-inflammatory treatment was given for 3-5 d to stabilize patient condition. Before operation, all cases were confirmed by ultrasound examination, abdominal plain radiography (KUB) + intravenous pyelography (IVP) or CT scan. Patients who received the second or the third surgery or bilateral surgery were very few and not included. The two groups were matched for age, gender, calculus size and depth of hydronephrosis before operation ($P>0.05$).

Methods

At 30 min before operation, intramuscular injection of 75 mg pethidine hydrochloride injection and 25 mg promethazine hydrochloride was performed for the observation group. In lithotomy position, the bladder was emptied and 10 ml of 1% lidocaine was injected transurethrally using a syringe. After 5 min, a 5F ureteral catheter was inserted retrograde to the depth of about 2 cm on the affected side under the cystoscope. The tail of the catheter was connected to a 20 ml needle for the injection of 5-10 ml of 1% lidocaine. The cystoscope was withdrawn with the indwelling and mobilization of catheter and ureter. Then in prone position, the puncture site and direction were determined ultrasonically between the 11^{th} rib or under the 12^{th} rib between the scapular and the posterior axillary lines. Local infiltration anesthesia was induced by the injection of 15-20 ml of 1% lidocaine at the puncture site and along the appropriate direction until reaching the depth of the renal fascia. The channel for MPCNL (16F) was established under the ultrasound with the indwelling of 16F peel-away sheath. Wolf8/9.8F rigid ureteroscope was used to flush out the stones, which were then crushed using pneumatic lithotripsy or Holmium laser lithotripsy. Ureteral catheter was withdrawn after operation, with conventional indwelling of double-J catheter and renal stoma drainage catheter.

Combined spinal-epidural anesthesia was performed for the control group. The same procedures of MPCNL and puncture were used as with the observation group. The indwelling and removal of the double-J catheter and renal stoma drainage catheter were also the same as the observation group.

Observation indicators

Serum levels of interleukin-6 (IL-6), tumor necrosis factor-α (TNF-α), C-reactive protein (CRP), β2-microglobulin (β2-MG), Cr and BUN were measured for the two groups on the preoperative morning, immediately after operation and 1 week after operation. These were the indicators of systemic inflammatory response and renal impairment under different anesthetic techniques. The effect of anesthesia on circulation during and after the operation was assessed by electrocardiography. Moreover, operation time, intraoperative blood loss, hospital stay, total hospital costs and residual stone rates were compared.

Postoperative follow-up

Residual stones were revealed by reexamination using KUB or CT scan on the next day after operation. Patients with complete removal of calculi had no bleeding, lumbago or fever. The renal stoma drainage catheter was removed 2-3 d after operation for the observation group. If there were residual stones, the patients would receive further treatment depending on the size of calculi. Conservative treatment was adopted if calculi were smaller than 4 mm. The second surgery was recommended if calculi were bigger than 5 mm. The double-J catheter was removed 2-3 weeks after operation.

Statistical analysis

SPSS 13.0 software was used for statistical analysis and the results were expressed as

Table 1. Comparison of operation time, intraoperative blood loss, hospital stay, hospital costs and residual stone rates between the two groups

Group	Case	Operation time	Intraoperative blood loss	Hospital stay (d)	Hospital costs	Residual stone rates (%)
Observation group	40	60.1±23.1	89.3±30.3	3.1±1.0	6225±182	7.50
Control group	60	62.3±24.1	90.5±32.1	5.5±2.3	11001±298	8.26
Test value		t=1.45	t=1.53	t=13.01	t=22.31	X^2=0.33
P value		0.380	0.360	0.048	0.028	0.560

Table 2. Effect of different anesthetic techniques on circulation

Observation indicator	Case	Preoperative morning	After anesthesia	Intraoperative	Immediately after surgery
Observation group	40				
MAP		63.50±11.40	58.06±10.32*	59.32±11.64*	65.21±9.25
SPO_2		98.37±2.76	95.37±1.98*	92.37±4.76*	97.37±2.02
HR		65.76±10.71	66.76±12.08	69.71±9.54*Δ	64.76±11.28
Control group	40				
MAP		61.98±9.86	57.97±10.58*	58.32±8.72*	65.79±10.21
SPO_2		99.37±1.87	96.29±1.76*	93.37±7.31*	97.98±2.16
HR		67.88±7.32	66.89±9.08	75.42±10.75*Δ	65.36±12.67

Note: *P<0.05, compared with the preoperative level; ΔP<0.05, compared between the groups.

mean ± standard deviation. *t*-test was used for comparing the means of the two samples and analysis of variance for comparing the means of multiple samples. Counts were analyzed by chi-square test and P<0.05 was considered significant difference.

Results

Surgery procedures were smoothly performed for all cases. The two groups showed no significant difference in operation time, intraoperative blood loss and residual stone rates (P>0.05). Observation group had an obvious reduction in hospital stay and total hospital costs (P<0.05), compared with the control group (**Table 1**). For each group, mean artery pressure (MAP) and oxygen saturation (SPO_2) were significantly different after anesthesia and during surgery compared with the preoperative levels (P<0.05). HR was also significantly different after anesthesia compared with the preoperative level, and the two groups also showed significant difference in HR (P<0.05). However, MAP, SPO_2 and HR were not significantly different for either group on the preoperative morning and immediately after operation or between two groups (P>0.05) (**Table 2**). Besides, on the preoperative morning, the two groups showed no significant difference in BUN, Cr, β2-MG, IL-6, TNF-α or CRP (P<0.05). For each group, the serum levels of the above indicators immediately after operation were much higher compared with those preoperatively. One week after operation, serum levels of IL-6, TNF-α and CRP in the control group were higher than those of the observation group. The serum levels of BUN, Cr and β2-MG at 1 week after operation were considerably lower than the preoperative levels (P<0.05) (**Table 3**).

Discussion

MPCNL under local anesthesia is much less traumatic and associated with a lower risk of anesthesia. Local anesthesia using lidocaine works fast and durably. Renal pain is more often caused by traction and rise of intrapelvic pressure than cutting and cauterization [1], which means local anesthesia is sufficient to achieve the desired effect. Since the patients are awake under local anesthesia, surgery can be suspended or terminated at any point if necessary (but not among our cases). For MPCNL, appropriate anesthetic technique should be chosen according to patient condition on the premise of reducing operation time as much as possible [2]. At present, most PCNL procedures in China are performed under general anesthesia or epidural anesthesia, which means higher

Table 3. Effects of different anesthetic techniques on systemic inflammatory response

Group	Case	BUN (mmol/L)	Cr (μmol/L)	B2-MG (mg/L)	IL-6 (pg/ml)	TNF-α (pg/ml)	CRP (mg/L)
Observation group	40						
Preoperative morning		6.67±0.73	201.50±34.51	0.75±0.08	201.35±50.89	20.23±18.55	8.38±1.25
Immediately after surgery		8.73±0.92*	213.30±38.44*	0.94±0.10*	230.46±55.31*,Δ	41.46±23.54*,Δ	10.12±1.95*,Δ
1 week after surgery		3.94±0.51*	144.45±22.36*	0.37±0.02*	58.32±9.67*,Δ	22.45±14.36*,Δ	3.38±0.75*,Δ
Control group	40						
Preoperative morning		6.52±0.71	200.10±33.18	0.78±0.09	205.32±58.53	21.02±18.36	8.47±1.68
Immediately after surgery		9.85±0.95*	217.60±39.09*	1.09±0.11*	249.33±59.29*,Δ	50.21±19.49*,Δ	15.34±1.97*,Δ
1 week after surgery		3.87±0.56*	159.59±25.98*	0.31±0.02*	74.52±26.32*,Δ	25.59±15.98*,Δ	6.37±1.12*,Δ

Note: *P<0.05, compared with the preoperative level; ΔP<0.05, compared between the groups.

costs and longer time to recover from anesthesia [3]. Moreover, these two anesthetic procedures are associated with a higher risk for patients with chronic cardiopulmonary diseases. Liu et al. [4] argued that MPCNL under local anesthesia had the following advantages: reducing the risk otherwise associated with general anesthesia or intraspinal anesthesia; faster recovery from anesthesia, shorter hospital stay and simple procedures of local infiltration anesthesia, thus requiring no professional staffs or equipments. Addressing the defects of insufficient muscular relaxation and shorter anesthetic duration, potentiated anesthesia can be used [5]. Most patients are satisfied with local anesthesia procedures due to the above benefits.

MPCNL under local anesthesia was finished for all cases in this paper. However, we observed a reduction in MAP and SPO_2 after anesthesia compared with the preoperative levels, while HR increased obviously, probably due to the following reasons: As the patients were transferred from lithotomy position to prone position, there was a reduction in effective circulating blood volume, resulting in the decline of blood pressure [6, 7]. The shift of position induced blood redistribution and affected returned blood volume and cardiac output; In prone position, the patients were elevated in the kidney region and the abdominal pressure rose due to gravitation. As a result, the blood returning to the inferior vena cava was affected and the returned blood volume decreased; In prone position, the abdomen was compressed, the respiration was restricted and the ventilation decreased, leading to CO_2 retention, decrease of SpO_2 and increase of HR [8]. Therefore, intraoperative monitoring of respiration and circulation is necessary and blood vessel dilation should be performed if necessary. To stabilize the circulation, ephedrine or atropine can be injected [9, 10].

CRP, TNF-α and IL-6 are the most sensitive markers and mediators of stress response, involved in the regulation of local and systemic inflammatory response and stress response in acute stage [1]. They are considered as indicators of surgery-related injury. The serum levels of CRP, TNF-α and IL-6 in the observation group were markedly lower than those of the control group, which may be related to the injury caused by combined spinal-epidural anesthesia. Some patients with low compliance were given analagesics or sedatives, which may add to the inflammatory response. Lidocaine injected for the observation group can inhibit the activity of several immunocompetent cells as well as the chemotaxis, adhesion and respiratory burst of granulocytes. These roles imply the anti-inflammatory effect of local anesthetics. Serum levels of CRP, TNF-α and IL-6 were positively correlated to operation time, surgical trauma and postoperative complications [11]. Intraoperative detection of β2-MG, Cr and BUN showed that the severity of renal injury was irrelevant to the anesthetic technique. The intraoperpative levels of β2-MG, Cr and BUN were obviously higher than those of the preoperative levels, probably as a result of vasoconstriction and increased release of vasoactive substances during surgery. Stress led to increased release of catecholamine, contraction of renal small arteries and reduced blood supply or blood redistribution of kidney. All of these changes are associated with a risk of ischemia and hypoxia of the kidney, leading to depolarization of negative changes on the glomerular basement membrane, disrupted charge barrier and increased filtration of proteins of moderate molecular weight. Epidural anesthesia weakens neuroendocrine response triggered by sur-

gery through the influence on sympathetic nerve-adrenal gland and hypothalamus-pituitary gland-adrenocortical axis. This is the mechanism by which the renal damage caused by strong stress and inflammatory response during surgery is partially mitigated [12, 13]. During lithotripsy, bacteria contained in the calculi would be released by repeated flushing under high perfusion pressure, leading to the opening of renal small arteries and lymph space and absorption of the perfusate. This is an important reason for the damage of nephrons. As excess water enters the blood circulation, the circulation is overburdened and the tissue edema further aggravates the renal damage. About one week after surgery, renal obstruction, calculi or infections were generally relieved with progressive restoration of renal function.

To conclude, MPCNL under local anesthesia for the removal of renal calculi and upper ureteral calculi induced less systemic inflammatory response, causing lower costs and requiring shorter hospital stay, compared with MPCNL under spinal-epidural anesthesia. This procedure is worthy of clinical popularization.

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Disclosure of conflict of interest

None.

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