Journal of Pediatric Surgery 50 (2015) 655–658

Contents lists available at ScienceDirect

Journal of Pediatric Surgery

journal homepage: www.elsevier.com/locate/jpedsurg

Advantages of tubeless mini-percutaneous nephrolithotomy in the treatment of preschool children under 3 years old

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ARTICLE INFO

Article history:
Received 16 June 2014
Received in revised form 20 October 2014
Accepted 18 November 2014

Key words:
Mini-percutaneous nephrolithotomy (MPCNL)
Kidney stone
Tubeless
Preschool children

ABSTRACT

Background/Purpose: Tubeless mini-percutaneous nephrolithotomy (MPCNL) for treating renal calculi was introduced in response to concerns over the use of adult nephrolithotomy apparatus in small children. However, it is unclear whether tubeless mini-PCNL (MPCNL) is of any benefit in the treatment of children. This study therefore aimed to assess the possible benefits of MPCNL, as compared to standard PCNL, in preschool children.
Methods: Seventy-eight preschool children under 3 years with renal calculi were randomized into two groups (PCNL and MPCNL). Operative time, hemoglobin decrease, blood transfusion rate, postoperative complications and length of hospital stay in the two groups were statistically compared.
Results: Recovery time was significantly shorter for patients receiving MPCNL than those treated with standard PCNL (4.6 versus 7.7 days, $P < 0.05$).
Conclusions: Treating preschool children with tubeless percutaneous nephrolithotomy has advantages over standard PCNL, including faster recovery and shorter hospital stay.

Causes of renal calculi in young children include anatomical abnormalities, metabolic disorders and urinary tract infections; pediatric nephrolithiasis is increasing globally [1]. The incidence of renal calculi in children varies widely across the world. In developing nations, the rate is approximately 5%–15%, while in developed countries the occurrence is only between 1% and 5% [2]. In 1976, percutaneous pyelolithotomy was introduced by Fernström and Johansson [3], revolutionizing the treatment of renal calculi. In 1985, Woodside et al. [4] were the first to report successful treatment of children with renal calculi using an adult-sized nephroscope. Although Badawy et al. [5] and Callaway et al. [6] showed that it was safe to adopt adult-sized percutaneous nephrolithotomy (PCNL) to treat children, Desai et al. pointed out that more complications and higher blood transfusion were observed in children [7,8]. To reduce complications such as hemorrhage and urinary extravasation, Helal and Jackman and their respective collaborators developed a technique called *mini-perc*. The mini-percutaneous method has been shown to significantly reduce the intraoperative and postoperative hemorrhage, renal parenchymal injury, post-operative pain and length of hospital stay [9,10].

After the PCNL procedure, placement of a nephrostomy tube is needed routinely for adequate urine drainage, and hemostasis, and to facilitate an additional PCNL to clear the residual stones. Bellman et al. [11] proposed a tubeless PCNL process, outlining its possible benefits such as shorter hospital stay, reduced patient discomfort, and lowered postoperative analgesia requirements. These advantageous properties were confirmed by other research groups. Indeed, the totally tubeless PCNL for pediatric population was shown to be safe and effective and to yield no complications; it was proposed as a standard and cost-beneficial procedure [12,13]. However, studies assessing tubeless percutaneous nephrolithotomy in preschool children under 3 years are scarce. Therefore, the current randomized controlled case study aimed to assess the potential advantages of tubeless MPCNL in treating preschool children under 3 years.

1. Materials and methods

1.1. Preparations of the operation

This study utilized a randomized case study design. Preschool children were randomized into MPCNL and standard PCNL groups by generation of a random number table. Surgical nurses randomly selected an envelope containing each patient's group. The envelope was then opened during the surgical procedure. Inclusion criteria were as follows: renal calculi was confirmed by spiral CT; patient's relatives or parents provided a signed informed consent; patient was 7–36 months old; the cumulative diameter of the stone was less than 4.5 cm; no previous use of extracorporeal shock wave lithotripsy (ESWL). Patients were excluded with renal anatomical abnormalities such as rotation of the kidney, ectopic kidneys (anterior to the colon, interior to the liver and spleen), ureteropelvic junction (UPJ) stenosis, pyonephrosis combined with stones, or isolated kidney. Preschool children who had the following conditions intra-operatively or postoperatively were withdrawn from the study as well: severe hemorrhage, severe perforation

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http://dx.doi.org/10.1016/j.jpedsurg.2014.11.042
0022-3468/

of the renal collecting system, and presence of large postoperative residual calculi ≥4 mm.

The study was approved by the Ethics Committee of the First Affiliated Hospital of Xinjiang Medical University.

Before operation, routine medical history review, physical examinations and laboratory inspections were conducted. Preoperative lab tests included blood biochemistry, urinalysis and culture, drug sensitivity test, blood routine test, and coagulation rates. Additional information obtained included age and gender; stone size, location and number; condition of hydronephrosis as detected by spiral CT, B-mode ultrasound and IVU. Antibiotics were administered until sterile urine was obtained.

1.2. Procedure of operation

All patients were placed under general anesthesia. The preschool children were then placed into a lithotomy position and an F4 ureteral catheter was retrograde inserted into the affected renal pelvis through the pediatric cystoscope. A Foley catheter was placed and fixed to the ureteral catheter with surgical threads. Sterile saline was flushed into the kidney through the ureteral catheter to create an artificial hydronephrosis. The preschool child was then moved into a prone position, assuring that the chest and pubis were protected to avoid crushing wounds. After routine disinfection, an 18 G (gauge) biopsy needle was inserted at the posterior axillary line, at the level of the 12th rib and into the targeted renal pelvis. The ureteral catheter was expanded by a fascia dilator to F14 or F16 while the sheath was left in place. The pediatric nephroscope or ureteroscopy was then inserted, and the stones were smashed by holmium laser. The cracked fragments were picked out by clamps or washed out by lavage fluid. Real-time imaging of the affected renal pelvis and its residual stones were observed through B-mode ultrasound and any residual stones were removed completely or the second nephrostomy access tract for lithotripsy was selected for complete clearance.

1.3. Other treatments

For the 3 qualified children with bilateral renal calculi, two separate operations were performed after random assignment to the two surgery groups.

The ureteral and Foley catheters were kept for 24 h routinely for both groups. On day 1 postoperatively, blood analyses were carried out. On day 3 postoperatively, B-mode ultrasound of the urinary systems was reexamined for the presence and size of residual stones as well as complications of perirenal effusions or hematomas. The state of the nephrostomy tube of the standard group was also determined by the results of B-mode ultrasound. If no abnormalities such as pain or fever were present 24 h later, the nephrostomy tube could be removed. Residual stones ≤4 mm were considered negligible [14]. CT or B-mode ultrasound of the urinary systems was carried out 1, 3, 6 and 12 months postoperatively to assess the presence of residual stones.

1.4. Statistical analysis

All statistical analyses were performed with SPSS 11.0. A chi-squared test was carried out to compare postoperative complication rates, stone clearance rate, blood transfusion rate and age. Alternatively, the Mann–Whitney U-test was used for analyzing discrete data such as operative time and length of hospital stay. Student's t-test was used for continuous measured values, including stone diameter and hemoglobin levels. $P < 0.05$ indicated statistical significance.

2. Results

Of the 111 children with renal calculi admitted between September 2009 and September 2012, 97 matched the inclusion criteria. A total of 19 patients were excluded for renal anatomical abnormalities, pyonephrosis combined with stones, renal dysfunction or isolated kidney. An additional 8 were withdrawn because of severe intraoperative or postoperative hemorrhage, serious perforation of the renal collecting system, or the presence of postoperative residual stones ≥4 mm. Finally, 70 cases which matched the criteria remained for inclusion in the study (Fig. 1). Characteristics and preoperative indices, including age, stone diameter, stone position and preoperative hemoglobin level, are summarized in Table 1. Of the two groups, 30 kidneys had single calculi of the pelvis or calyx, 5 children had multiple calculi of the pelvis or calyx, and 3 of them had residual stones (≤4 mm). Of the 3 with residual stones, 1 self-discharged the stones after 6 months; the residual stones in the remaining 2 had increased to 1 cm with hydronephrosis, but they both were cured after a second mini-PCNL. In the two groups, 3 kidneys had 2 access tracts. No intraoperative of postoperative blood transfusions were performed. The average patient ages were 20.3 and 20.1 months for the tubeless and standard groups, respectively. The stone clearance rate of the tubeless group was 97.8%; this parameter was 95.3% in the standard group. The mean operative times were 51.97 and 55.00 minutes for the tubeless and standard procedure groups, respectively. Mean stone diameters were 2.32 and 2.40 cm for the tubeless and standard groups, respectively. Mean preoperative hemoglobin level in the tubeless group was 11.2 g/dL; a value of 11.0 g/dL was obtained for this parameter in the standard group. Meanwhile, postoperative hemoglobin decreases were 0.9 ± 0.2 g/dL in patients treated with tubeless MPCNL and 0.8 ± 0.2 g/dL in those receiving the standard procedure. Postoperative fever rate was 5.7% after tubeless MPCNL treatment and 8.6% in patients administered standard PCNL (Table 2). Age, gender, stone diameter, stone clearance rate, postoperative hemoglobin decrease and operative time of the two groups had no statistical significances. Finally, the hospital stay in tubeless MPCNL patients was significantly shorter than that obtained in the standard group (4.6 versus 7.7 days).

3. Discussion

The aim of this study was to examine the possible benefits of utilizing a tubeless MPCNL procedure in children under 3 years for the treatment of renal calculi, as compared to a standard tube placement. The results of this study showed that, while most parameters are similar in the two procedures, recovery time and length of hospital stay were significantly reduced in tubeless MPCNL patients. Placement of a nephrostomy tube is typically required after treating renal calculi with PCNL. If there is no obvious hemorrhage 24–48 h postoperatively, and no signs of residual stones, complications of perirenal effusions or hematomas detected by X-ray KUB or B-mode ultrasound, the nephrostomy tube can be clamped for 24 h. Further, if no subsequent signs of osphyalgia or fever appear, the nephrostomy tube can be removed. Nephrostomy tube placement has been shown to greatly improve postoperative urine drainage, hemostasis, clearing any residual stones in a second PCNL procedure and avoiding any obstructions in the ureter caused by blood clots and stone fragments. The nephrostomy tube placement can, however, also lead to adverse effects, such as increases in postoperative pain and discomfort, longer hospital stays, more analgesia requirements, heavier psychological burdens and deeper fears in the minds of the patients. In 1997, Bellman et al. [11] proposed the concept of tubeless percutaneous nephrolithotomy (PCNL) and subsequently proved that tubeless PCNL did not increase the complications of standard PCNL either intraoperatively or postoperatively, and could reduce the adverse effects caused by nephrostomy tubes. Zeren et al. [7] found that intraoperative and postoperative hemorrhage was the most threatening factors of the tubeless PCNL procedure. Yuan et al. [15] and Ni et al. [16], however, showed the safety and efficacy of tubeless PCNL in treating noncomplex renal calculi in adults via comparisons of average length of hospital stay, postoperative complications, and pain.

Similarly, Zilberman et al. [17] pointed out that tubeless PCNL appeared to be a safe alternative in children. They did caution, however, that nephrostomy tube placement should still be considered in certain