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Influencing factors of laparoscopic pelvic urethroplasty in the treatment of children with hydronephrosis

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Abstract. – OBJECTIVE: The purpose of this study was to evaluate the clinical efficacy of laparoscopic pyeloureteroplasty in the treatment of children suffering from hydronephrosis.

PATIENTS AND METHODS: Our pediatric department received 160 children with hydronephrosis from January 2019 through December 2021. These children were randomly assigned to either the control group or the study group with 80 cases in each group. The control group underwent traditional open pyeloureteroplasty, while the study group underwent laparoscopic pyeloureteroplasty. After assessing the results of both groups, the clinical outcomes were compared.

RESULTS: The study group had a significantly shorter operating time, lower intraoperative bleeding rate, and shorter hospital stay than the control group. On the first day after the operation, there was no significant difference between the control and study groups, and on the seventh day after the operation, the study group's OPS was significantly lower than that of the control group. A significant difference was observed after treatment between the study group and the control group in terms of the anteroposterior diameter of the renal pelvis. Both groups' GFR increased significantly with time, and the GFR of the study group was significantly greater than that of the control group at 3 months after the operation, but there was no significant difference at 6 months after the operation. Postoperative adverse effects did not differ significantly between the two groups.

CONCLUSIONS: Pediatric laparoscopic pyeloureteroplasty can reduce intraoperative bleeding, shorten operation time and hospital stay, alleviate postoperative pain, and promote the recovery of postoperative renal morphology and function in children with hydronephrosis, which merits further discussion.

Key Words:
Hydronephrosis, Children, Laparoscopy, Pyeloureteroplasty, Renal function.

Introduction

Children suffering from hydronephrosis have a common malformation of the urinary system. It is estimated that 1% of pregnant women will experience hydronephrosis on color Doppler ultrasound[1]. In most cases, hydronephrosis in children results from congenital ureteropelvic junction obstruction (UPJO), which is the most common cause of congenital hydronephrosis[2]. A hydronephrosis-induced expansion of the renal collecting system may result in the elongation of renal medullary vessels as well as compression and ischemia of the renal parenchyma; as renal tissue gradually shrinks and hardens, kidney function cannot be fully restored[3,4]. In young children, the early symptoms of hydronephrosis are not readily apparent; most patients complain of gastrointestinal discomfort and abdominal masses, and they are diagnosed with irreversible renal damage.

The primary treatment strategy for children with hydronephrosis consists of addressing the underlying cause and removing the obstruction; currently, ureteropelvic junction obstruction is usually treated with detachable pyeloureteroplasty[5]. A detachable pyeloureteroplasty removes the obstructive site, while simultaneously removing the excess renal pelvis, straightening the tortuous ureter, and using the obstruction primarily at the ureteropelvic junction[6]. UPJO is traditionally treated with open disconnection pyeloureteroplasty, which has a success rate of 90 to 100%[7,8]. Modern minimally invasive technology is resulting in the growing popularity of laparoscopic surgery; in recent years, laparoscopic pyeloureteroplasty has become more widely accepted in pediatric surgeries. A study[9] has shown that there is no significant difference between open surgery and laparoscopic surgery with regard to long-term efficacy, and the difficult nature of the laparoscopic

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anastomosis technique as well as the adverse impact of CO_2 pneumoperitoneum on children's hearts and lungs affect the surgical outcome. At our hospital, we have successfully performed several laparoscopic detachable pyeloureteroplasty procedures; detailed clinical experience and research results are described below.

Patients and Methods

Patients

Between January 2019 and December 2021, 160 children with hydronephrosis were admitted to our hospital and randomly assigned to two groups, a control group and a study group, each consisting of 80 cases. Prior to enrollment in this study, all subjects obtained the informed consent of their guardians and signed the informed consent form. In this study, the hospital's ethics committee approved the study protocol (NO.AH-MU-2107710/J), and all procedures were carried out in accordance with the guidelines of the Helsinki Declaration on clinical research.

Inclusion and Exclusion Criteria

Inclusion criteria (all patients who met the following criteria were included in this study):

i. Children under the age of six, regardless of their gender.
ii. Pediatric patients with congenital UPJO that had been diagnosed by B-ultrasound, intravenous urography, and magnetic resonance hydrography 10.
iii. Pediatric patients in need of surgical treatment when conservative treatment is not effective.
iv. Pediatric patients with renal pelvis diameters of 12 mm or greater.
v. Pediatric patients who have no prior abdominal surgery and contraindications to laparoscopic surgery.

Exclusion criteria (the following patients were excluded from the study):

i. Secondary UPJO in pediatric patients.
ii. Pediatric patients with single kidneys, or ectopic kidneys.
iii. Pediatric patients with congenital conditions requiring surgical intervention, such as cardiovascular or respiratory diseases.
iv. Children with coagulation dysfunction.

Surgical Procedures

In order to diagnose UPJO and other urinary system abnormalities, B ultrasound, intravenous urography, and magnetic resonance hydrography were performed before surgery. Under direct vision, a small incision was made on the cephalic side of the navel edge and the peritoneum was cut. Under general anesthesia, the procedure was performed in the lateral decubitus position after indwelling and pressing a catheter.

An artificial pneumoperitoneum was established by the insertion of a 5 mm trocar into the abdominal cavity of patients undergoing laparoscopic surgery (with a pressure of 8 to 10 mmHg). For the purpose of viewing the internal structure of the abdominal cavity, a 5 mm 30-degree laparoscope was used. In the procedure, a 3 mm and 5 mm trocars were inserted, and an additional 3 mm trocar was inserted for withdrawal.

Dissociation of the renal pelvis

Exposed the UPJO by pushing the colon through the anterior renal fusion fascia layer. We opened the perirenal fascia and fat sac in order to expose the lower pole of the kidney, the upper end of the renal pelvis, and the ureter. We then released the fully dilated renal pelvis and UPJO.

Removing the renal pelvis and ureter

This involves cutting off the renal pelvis, sucking up the urine, reducing abdominal cavity pollution, retaining the tongue-shaped flap of the lower pole of the kidney, and removing the lateral ureter 1.2 cm vertically. An absorbable needle of 4-0 was inserted at the lowest valgus at the lower corner of the renal pelvis valve and the cut of the ureter, the stenosis was removed, and the posterior wall was sutured intermittently. A 2.5 mm trocar was implanted under the costal margin of the anterior axillary line in order to place the double J tube. Through the anastomosis, the F7 double J tube with a pre-set guide wire was inserted into the ureter.

Anastomosis

The lower end of the double-J tube is connected to the bladder, and the upper end is connected to the renal pelvis. The dilated renal pelvis was separated from the renal parenchyma by 1.5 cm, and the anterior wall of the renal pelvis and ureter, along with the incision of the upper renal pelvis, were anastomosed; in addition, the kidney was fitted with a drainage tube.

During the open surgical procedure, the child's lumbar spine was incised at an oblique angle, a transverse incision was made in the middle and upper abdomen, and the skin, subcutaneous tissue, and perirenal fat layers were cut layer by layer. The kidney, renal pelvis, the joining of the renal pelvis and the ureter, as well as the renal pelvis cutting, and anastomosis were all performed by the same medical team.

Observation Indicators

Perioperative indicators

A number of perioperative indexes were recorded, including the duration of the operation, of intraoperative bleeding, and the duration of the hospitalization.

Pain score

On the first and seventh post-operative days, pain levels were assessed using the objective pain scale (OPS). A rating of OPS is calculated based on five items, including changes in blood pressure, crying, physical activity, facial expressions, and responses to touch, with the highest rating being 100 points. If the OPS score is 40, it is recommended that patients take painkillers.

Morphological and Functional Changes in the Kidney

An ultrasound examination of the urinary system was performed prior to surgery, three months later and six months after the operation, in order to determine the anterior-posterior diameter of the renal pelvis; renal radionuclide dynamic imaging was used to determine the bilateral renal glomerular filtration rate (GFR).

Statistical Analysis

SPSS 20.0 software (IBM Corp., Armonk, NY, USA) was used as the data analysis software and visualization of the data was carried out using Graphad Prism 9.0 software (La Jolla, CA, USA). Measurement data was expressed as , and independent *t*-test samples were used; enumeration data was expressed as the number of cases (%) and the χ^2 test was used. Statistical significance was assumed at $p<0.05$.

Results

Comparison of General Data

Within the control group, there were 52 males and 28 females, aged (3.80±4.12) years, with 34 left-side operations, 40 right-side operations, and six bilateral operations. There were 44 males and 36 females in the study group, both aged (3.83±3.68) years; there were 28 left-side operations, 41 right-side operations, and 11 bilateral operations. The general data between the two groups was comparable (all $p>0.05$), and there were no significant differences between them. The results are shown in Table I.

Comparison of Perioperative Data

On the basis of the data shown in Table II, in the control group, the operation time was (98.25±15.58) min, the intraoperative blood loss was (47.73±7.65) ml, and the hospital stay

Table I. Comparison of general data.

	Control group	Study group	t/χ^2	*p*
N	80	80		
Gender (Male/Female)	52/28	44/36	1.667	0.197
Age (years old)	3.80±4.12	3.83±3.68	0.049	0.961
Operation side			2.064	0.356
Left	34	28		
Right	40	41		
Both	6	11		

Table II. Comparison of perioperative data ($\bar{\chi}$ ±s).

	Operation time (min)	MBV (ml)	LOS (day)
Control group (n=80)	98.25±15.58	47.73±7.65	10.28±2.64
Study group (n=80)	82.51±11.58	32.48±5.86	7.15±2.06
t	7.253	14.15	8.365
p	<0.001	<0.001	<0.001

Note: LOS = Length of study, MBV = Mean bleeding volume.

Table III. Comparison of OPS scores ($\bar{\chi}$ ±s) points.

	Pain day 1	Pain day 7
Control group (n=80)	58.24 ± 11.28	12.51±3.26
Study group (n=80)	57.26±10.41	9.17±1.54
T	0.571	8.291
P	0.568	<0.001

was (10.28±2.64) days. For the study group, the operation duration was (82.51±11.58) min, the intraoperative blood loss was (32.48±5.86) ml, and the hospital stay was (7.15±2.06) days. Compared to the control group, the operation time, intraoperative bleeding, and hospital stay of the study group were significantly lower (all $p<0.05$).

Comparison of OPS Scores

As illustrated in Table III, the OPS score of the control group was (58.24±11.28) one day after the operation and (12.51±3.26) seven days later. The study group's OPS score was (57.26±10.41) one day after the operation and (9.17±1.54) seven days later. One day after operation, OPS did not differ significantly between the two groups ($p=0.568$), and seven days after operation, OPS of the study group was significantly lower than that of the control group ($p<0.05$).

Comparison of Anteroposterior Diameters of Renal Pelvis in Ultrasonography

Table IV illustrates that the anteroposterior diameter of the renal pelvis in the control group was (3.05±0.54) cm before treatment and (0.81±0.19) cm after treatment; in the study group, the anteroposterior diameter of the renal pelvis was (2.92±0.47) cm before treatment and (0.73±0.16) after treatment. A significant difference was observed in the anteroposterior diameter of the renal pelvis between the study and control groups ($p<0.05$).

Table IV. Comparison of anteroposterior diameters of renal pelvis on ultrasonography ($\bar{\chi}$ ±s) points.

	Before treatment	After treatment
Control group (n=80)	3.05±0.54	0.81±0.19
Study group (n=80)	2.92±0.47	0.73±0.16
t	1.624	2.881
p	0.106	0.005

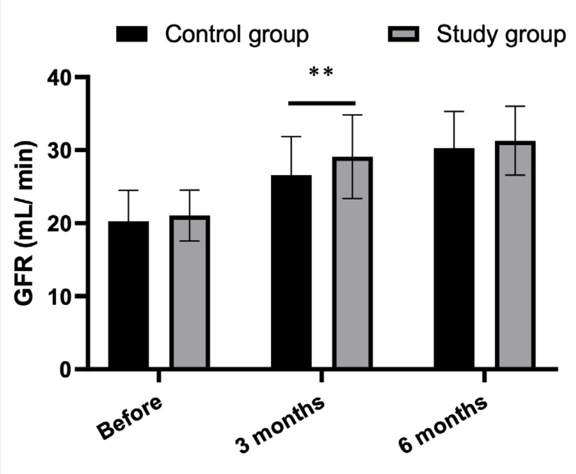

Figure 1. Comparison of postoperative renal function, ** indicated ($p<0.01$).

Comparison of Postoperative Renal Function Between the Two Groups of Patients

As can be seen in Figure 1, the GFR of the control group was (20.25±4.26) ml/min before treatment, (26.59±5.26) ml/min 3 months after treatment, and (30.28±5.02) ml/min 6 months after treatment. In the study group, the GFR was (21.05±3.49) ml/min before treatment, (29.11±5.72) ml/min 3 months after treatment, and (31.29±4.72) ml/min 6 months after treatment; significant increases in GFR were observed in both groups over time ($p<0.05$). 3 months after the operation, the study group had a significantly higher GFR than the control group ($p<0.05$) and six months later there was no significant difference ($p>0.05$).

Comparison of Postoperative Complications

During the follow-up period, the control group experienced 1 case of incision infection, 4 cases of urinary leakage, and 4 cases of other complications, which constituted a total of 11.25% (9/80) post-operative complications. A total of 6.25% (5/80) complications occurred in the study group, consisting of 0 cases of incisional infection, 3 cases of urinary leakage, and 2 cases of other complications. The number of postoperative complications did not differ significantly between the two groups ($p>0.05$). The results are presented in Table V.

Table V. Comparison of postoperative complications (n,%).

	Incision infection	Urinary leakage	Others	Totally adverse events
Control group (n=80)	1	4	4	9 (11.25)
Study group (n=80)	0	3	2	5 (6.25)
χ^2				1.252
p				0.263

Discussion

The main cause of hydronephrosis in children is UPJO, and the obstruction should be removed as soon as possible in order to facilitate the recovery of the child's renal function[11]. By performing a pyeloureteroplasty, the ureteropelvic junction and excess renal pelvis wall at the lesion site are removed, a funnel-shaped ureteropelvic link is established, and myogenic peristalsis is again restored; the success rates of the operation is high[12]. A pyeloureteroplasty is the gold standard treatment for UPJO and includes both laparoscopic and open surgery; surgical laparoscopy is a newly developed minimally invasive method and will undoubtedly be in demand in the future as surgical methods continue to develop, in the past, many open operations have been replaced by it. More and more people begin to use laparoscopic surgery to treat UPJO[13]. However, it is important to note, that laparoscopic pyeloureteral reconstruction involves removing the renal pelvis and ureter, suturing and then reconstructing this continuity, placing double J tubes, and other operating techniques, which are significantly more difficult than traditional open surgery. As a result, it is more difficult to popularize and apply due to the high technical requirements[14].

This study found that laparoscopic pyeloureteroplasty significantly reduced intraoperative bleeding, reduced the length of the surgery and the length of the hospital stay, relieved postoperative pain, and promoted rapid recovery of renal morphology and function. The following points should be considered in laparoscopic surgery in conjunction with surgical experience and literature analysis. Firstly, it is vital to improve preoperative evaluation and differentiate between endogenous, exogenous, and functional luminal obstruction; the procedure of dismembered pyeloplasty should not be blindly chosen. If the blood supply range for the affected area is limited and the adhesion is released, free vessels are able to relieve the ureteropelvic junction obstruction[15]. This is particularly effective for extrinsic obstructions such as vagal and accessory branches that are predominant in the cortex of the lower pole of the kidney. With ureter growth and development, congenital mucosal folds may disappear, and obstructions may resolve by themselves[16,17]. Secondly, hydronephrosis caused by UPJO can be treated relatively easily, particularly if there have been no recurring infections, as there is less adhesion between tissues and a small incision can be made for the surgery[18].

Thirdly, in order to maximize the chances of success of the surgery, we should not be satisfied with the release of mechanical compression alone, but also remove the damaged renal tissue and the junctions, in order to properly reconstruct the funnel-shaped renal pelvis[19].

Finally, the space around the renal pelvis in children is very narrow; it is essential to expose the entire renal pelvis during the operation to avoid dislocations of the renal pelvis during suturing and cutting, which may negatively influence peristaltic wave transmission, and to reduce the risk of renal function loss as a consequence of injury to the posterior renal artery. At the same time, attention should be paid to the choice of operation time. According to a study[20], the efficacy of early operation in pediatric UPJO is not superior to that of a late operation.

Furthermore, open surgery has made rapid progress over the past few years. Not all patients are suitable for laparoscopy; therefore, it is necessary to examine the patient comprehensively and determine the best surgical technique.

Conclusions

When a child suffers from hydronephrosis, a pyeloureteroplasty is the preferred treatment. In addition to reducing intraoperative bleeding, reducing operating time and hospital stay, and alleviating postoperative pain, it promotes the recovery of postoperative renal morphology and function. It is anticipated that laparoscopic urethroplasty will enjoy a wider range of clinical applications with the continued development and improvement of laparoscopic technology.

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Conflict of Interest

All authors declare that they have no conflict of interest.

Authors' Contributions

Chao Yang and Yongsheng Cao wrote the main manuscript text. Bo Peng, Han Chu and Zhiqiang Zhang prepared figures and tables. All authors reviewed the manuscript. All authors have read and approved the manuscript.

Availability of Data and Materials

The datasets used and analyzed during the current study are available from the corresponding author on reasonable request.

Informed Consent

All subjects or guardians of the patients enrolled in the study signed an informed consent form and were informed of the purpose, content, and use of the study.

Ethics Approval

This clinical study protocol has been approved by the Ethics Committee of Anhui provincial Children's Hospital (Approval No. 2020-02-2312).

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