

## Comparative Outcomes of Laparoscopic *Versus* Open Surgical Management for Pediatric Congenital Hydronephrosis

Batsukh Demberelnyambuu<sup>1\*</sup>, Olzvoi Amarjargal<sup>1</sup>, Urtnasan Khurelbaatar<sup>1</sup>, Avirmed Shiirevnyamba<sup>2</sup>, Shonkhuuz Enkhtur<sup>1</sup> and Sandag Baatartsogt<sup>1</sup>

<sup>1</sup>National Center for Maternal and Child Health, Mongolia

<sup>2</sup>Mongolian National University of Medical Science, Mongolia

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**\*Corresponding author:** Batsukh Demberelnyambuu, National Center of Maternal and Child Health  
Khuvisgalchdiin Street8 Bayangol district, Ulaanbaatar 16060, Mongolia

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### ABSTRACT

**Background:** Hydronephrosis is recognized as the most frequent congenital urogenital anomaly in the pediatric population. The predominant cause is renal UPJ (ureteropelvic junction) obstruction, affecting roughly one in every 2,000 newborns. This condition arises from a blockage that hampers urine flow within the urinary tract, typically detected as hydronephrosis via imaging techniques. Children's urinary tract obstruction can vary in presentation, being either acute or chronic, partial or complete, and can affect one or both sides. In Mongolia, the criteria for Chronic Kidney Disease (CKD) surgery are determined by a combination of diagnostic measures: ultrasound, excretory urogram, and renal function as assessed by isotope analysis. Specifically, surgical intervention is considered when ultrasound reveals grade **III-V** hydronephrosis, the excretory urogram is at grade **III-IV**, and isotope analysis shows less than 30% excretory function. While laparoscopic surgery is gradually being integrated into pediatric renal surgical practice, open surgery remains selectively preferred, due to financial constraints and a lack of comprehensive research to support the widespread use of laparoscopic methods in pediatric renal surgery

**Objectives:** To evaluate and compare clinical symptoms, diagnostic accuracy, and the outcomes of laparoscopic *versus* open pyeloplasty surgeries.

**Methods:** The study included a case group of 15 children who underwent laparoscopic surgery at the National Medical Center's kidney surgery department between February 2020 and 8 months into 2023. These children were diagnosed with renal calcification and met the study's inclusion criteria.

**Results:** The clinical presentation of hydronephrosis included abdominal pain (n=15, 50.0%), tenderness (n=7, 23.3%), and fever (n=8, 26.7%). Blood tests revealed inflammatory changes in 40.0% (n=12) of cases. Urine analysis showed E.Coli and Enterobacter in 6.7% (n=2) of the cases. Blood biochemistry analysis indicated a

significant decrease in creatinine levels post-surgery, from  $87.3 \pm 14.0$  mmol/L to  $62.7 \pm 8.3$  mmol/L ( $p=0.0001$ ). Severity assessment of renal hydronephrosis revealed 43.3% ( $n=13$ ) moderate cases and 56.7% ( $n=17$ ) severe cases using conventional methods. A new method showed 26.7% ( $n=8$ ) moderate and 73.3% ( $n=22$ ) severe cases. The concordance between methods was 64.5% statically significant ( $p=0.014$ ).

**Conclusions:** The concordance rate between conventional and new severity assessment methods and the absence of significant differences in surgical outcomes highlight the potential for standardized assessment and treatment strategies. The comparable efficacy of laparoscopic and open surgeries suggests a tailored approach to surgery, considering patient-specific factors and surgeon expertise.

**Keywords:** Laparoscopic; Congenital; Hydronephrosis; Pediatric; Invasive

## INTRODUCTION

Hydronephrosis is recognized as the most frequent congenital urogenital anomaly in the pediatric population. The predominant cause is renal UPJ (Ureteropelvic Junction) obstruction, affecting roughly one in every 2,000 newborns. This condition arises from a blockage that hampers urine flow within the urinary tract, typically detected as hydronephrosis via imaging techniques [1]. Early intervention to relieve the obstruction can often swiftly reverse any associated renal dysfunction. However, if Urinary Tract Obstruction (UTO) remains unaddressed, it can inflict irreversible damage to renal tissue, potentially escalating to chronic kidney disease and ultimately, end-stage renal failure [2-4].

Children's UTO can vary in presentation, being either acute or chronic, partial or complete, and can affect one or both sides. The etiology of UTO can be either congenital or due to trauma, with the majority of hydronephrosis cases in children being congenital. The obstruction is more commonly found in the upper ureter, accounting for 90% of cases.

In Mongolia, the criteria for Chronic Kidney Disease (CKD) surgery are determined by a combination of diagnostic measures: ultrasound, excretory urogram, and renal function as assessed by isotope analysis. Specifically, surgical intervention is considered when ultrasound reveals grade III-V hydronephrosis, the excretory urogram is at grade III-IV, and isotope analysis shows less than 30% excretory function. While CKD stages I-II are managed medically under a nephrologist's care, stages III-IV typically necessitate reconstructive surgery. These surgical procedures, boasting a success rate of 94%, can be performed through either traditional open or minimally invasive laparoscopic techniques, including reconstructive surgery to alleviate pelvic urinary obstruction. For stage V CKD, nephrectomy remains the course of action [1,3,5].

Despite the rapid advancement of laparoscopic procedures in global renal surgery over the past three decades, its adoption in pediatric surgery within Mongolia remains limited, largely available in more developed nations. The reasons include the substantial learning curve for surgeons, the lack of technical equipment, and the high costs associated with endoscopic procedures. The National Medical Center's Nephrology Department specializes in pediatric renal surgery, treating approximately 950-1100 children annually, with about 5% undergoing surgery for UTO [6]. Prior to 2014, all procedures were conducted via open surgery. Post-2014, with the procurement of

endoscopic surgical tools and specialized training for physicians, laparoscopic techniques for ureteral resection and grafting in cases of urothelial obstruction have been introduced. While laparoscopic surgery is gradually being integrated into pediatric renal surgical practice, open surgery remains selectively preferred, due to financial constraints and a lack of comprehensive research to support the widespread use of laparoscopic methods in pediatric renal surgery. Aim of the study is to evaluate and compare clinical symptoms, diagnostic accuracy, and the outcomes of laparoscopic *versus* open pyeloplasty surgeries.

## **MATERIALS AND METHODS**

### **Study designs**

The study was designed comparative study to evaluate various parameters such as duration of surgery, postoperative bleeding, pain, wound healing, hospital stay, and surgical complications between laparoscopic and open surgical approaches in pediatric patients with hydronephrosis.

The study included a case group of 15 children who underwent laparoscopic surgery at the National Medical Center's kidney surgery department between February 2020 and 8 months into 2023. These children were diagnosed with renal calcification and met the study's inclusion criteria. The open surgery group comprised 15 children, matched by diagnosis and treatment period, who underwent open surgery.

### **Participants and setting**

The study included a case group of 15 children who underwent laparoscopic surgery at the National Medical Center's kidney surgery department between February 2020 and Aug 2023. These children were diagnosed with renal calcification and met the study's inclusion criteria. The open surgery group comprised 15 children, matched by diagnosis and treatment period, who underwent open surgery.

#### **Inclusion Criteria for the Laparoscopy surgery group**

- Age between 0-18 years.
- Confirmed diagnosis of hydronephrosis (BM).
- A severity score of 5-8 points or higher, based on the scoring method for kidney disease.
- Consent from parents or guardians to participate in the study.
- Undergoing laparoscopic surgery.

#### **Inclusion Criteria for the Open surgery group**

- Age between 0-18 years.
- Confirmed diagnosis of hydronephrosis (BM).
- A severity score of 5-8 points or higher, based on the scoring method for kidney disease.
- Consent from parents or guardians to participate in the study.
- Undergoing open surgical treatment.

### **Statistical analysis**

Research data was digitized using Windows Excel and analyzed with SPSS version 21.0. After establishing the variables' characteristics and distributions, descriptive statistics, including means for normally distributed

continuous variables and medians for non-normally distributed ones, were calculated. The Student's T-test, Fisher Exact test, and non-parametric tests were utilized to compare the two groups' parameters and to test quantitative hypotheses. Associations between factors were assessed with a significance level set at  $p \leq 0.05$ .

### Ethics

Ethical Approval for the study was granted by the Medical Ethics Committee under the Ministry of Health at meeting №137 on December 26, 2019, following guidelines from the National Institute of Health.

## RESULTS

### Participant demographics

The study encompassed children from various age groups: 0-4 years (n=16, 53.3%), 5-10 years (n=10, 33.3%), and those older than 11 years (n=4, 13.3%). The mean age was calculated to be 6.1 years  $\pm$  4.0 years. The cohort predominantly consisted of males (n=25, 83.3%) with females representing a smaller fraction (n=5, 16.7%). Participants were primarily from Ulaanbaatar (n=21, 70.0%), with a significant local population also participating (n=9, 30.0%) (Table 1).

**Table 1:** Baseline characteristics of the study subjects.

	Measurement	n (%)	95% CI.
Age group	0-4 year	16 (53.3)	34.3-71.7
	5-10 year	10 (33.3)	17.3-52.8
	11 above year	4 (13.3)	3.8-30.7
Gender	Male	25 (83.3)	65.4-93.3
	Female	5 (16.7)	5.6-34.7
Location	Urban	21 (70.0)	50.6-85.3
	Rural	9 (30.0)	14.7-49.4
Total	30(100)		

### Diagnosis and familial history

Half of the hydronephrosis cases (n=15, 50.0%) were diagnosed during pregnancy, with the remaining cases (n=15, 50.0%) identified post-birth. A vast majority of participants (n=24, 80.0%) were unsure of any familial history of the disease, while 20.0% (n=6) confirmed no familial affliction. Kidney disease occurrence was more frequent in the left kidney (n=24, 80.0%), followed by the right kidney (n=4, 13.3%), and both kidneys in a minority (n=2, 6.7%) (Table 2-4).

**Table 2:** Diagnosis and Familial History.

	Measurement	n (%)	95% CI
When the disease was first diagnosed	Fetus	15 (50.0)	31.3-68.7
	After birth	15 (50.0)	31.3-68.7
Familial hystory	Never got sick	6 (20.0)	7.0-38.6
	Don't know	24 (80.0)	61.4-92.3
Hydronephrosis	Right	4 (13.3)	3.8-30.7
	Left	24 (80.0)	61.4-92.3
	Both	2 (6.7)	0.8-22.1
Total	30(100)		

**Table 3:** Laboratory findings of the study.

Measurement	n (%)	95% CI
There are inflammatory changes in the general blood test		
Inflammatory change	12(40.0)	22.7-59.7
Without inflammation	18(60.0)	40.6-77.3
Changes in urine bacteriological analysis		
No bacterial growth	18(60.0)	40.6-77.3
E. Coli	10(33.3)	17.3-52.8
Enterobacter	2(6.7)	0.8-22.1
Urinary tract infection		
Once	18(60.0)	40.6-77.3
Multiply times	10(33.3)	17.3-52.8
Consistent pain	2(5.3)	0.8-22.1
Total	30(100)	

**Table 4:** Creatinine level of study participants.

Measurement	Creatinine mg/dl		P-value
	Mean $\pm$ s.d.	95% CI	
Before surgery	0.87 $\pm$ 0.14	0.56-1.1	0.0001a
After surgery	0.62 $\pm$ 0.08	0.50-0.08	

<sup>a</sup> p-value calculated with the Paired T- test

### Clinical characteristics and laboratory findings

The clinical presentation of included abdominal pain (n=15, 50.0%), tenderness (n=7, 23.3%), and fever (n=8, 26.7%). Blood tests revealed inflammatory changes in 40.0% (n=12) of cases. Urine analysis showed E.Coli and Enterobacter in 6.7% (n=2) of the cases. Blood biochemistry analysis indicated a significant decrease in creatinine levels post-surgery, from 87.3 mmol/L  $\pm$  14.0 mmol/L to 62.7 mmol/L  $\pm$  8.3 mmol/L (p=0.0001) (Table 5).

**Table 5:** Assessment congenital hydronephrosis by comparing traditional and new methods.

No		Measurement	Number (%)	Kappa %	P value
1	Traditional method	Mild	-		
		Moderate	13 (43.3%)	64.50%	0.014b
		Severity	17(56.7%)		
2	New method	Mild	-		
		Moderate	8 (26.7%)		
		Severity	22 (73.3%)		
	Total	30(100%)			

<sup>b</sup> p-value was calculated with the Kappa test

### Pre-diagnosis and disease severity

Severity assessment of renal hydronephrosis revealed 43.3% (n=13) moderate cases and 56.7% (n=17) severe cases using conventional methods. A new method showed 26.7% (n=8) moderate and 73.3 (n=22) severe cases. The concordance between methods was 64.5% statically significant (p=0.014) (Table 6,7).

**Table 6:** Laparoscopic and open surgery length of stay and comparison of lost blood.

Measurement	Total n (%)	Laparoscopic surgery n (%)	Open surgery n (%)	P value
Amount of blood lost				
0-50 under ml	28 (93.3)	15 (100)	13 (86.7)	0.483c
51-100 ml	2 (6.7)	-	2 (13.3)	
Hospital stay days, median (range)	13.3 ± 5.1 (7-24)	12.8 ± 5.2 (7-23)	15.0 ± 5.0 (7-24)	0.266 a
Double J tube put				
Yes	27 (90.0)	12 (40.0)	15 (50.0)	0.224 c
No	3 (10.0)	3 (10.0)	-	
Whether a catheter is placed in the bladder				
Yes	6 (20.0)	6 (20.0)	-	0.017c
No	9 (30.0)	9 (30.0)	15 (50.0)	
Total	30(100)	15(50.0)	15(50.0)	

<sup>a</sup> p-value calculated with the T- test, <sup>c</sup> p-value was calculated with the Fisher Exact test

**Table 7:** Comparison of results of laparoscopy and open surgery.

Measurement	Laparoscopic surgery		Open surgery		P value
	Average ± sd	95% CI	Aver ± sd	95% CI	
The duration time of surgery	162.3 ± 65.5	97-227.0	96.0 ± 21.0	75.0-117.0	0.002a
Amount of blood lost (ml)	30.0 ± 16.0	14.0-46.0	34.0 ± 14.0	20.0-48.0	0.473a
Bed days	12.8 ± 5.2	7.6-18.0	15.0 ± 5.0	10.0-20.0	0.266a

<sup>a</sup> p-value calculated with the T- test

### Surgical approaches and outcomes

Anderson-Hines reconstructive surgery was employed for upper ureteral obstruction. The surgeries were equally divided between laparoscopic (n=15, 50.0%) and open (n=15, 50.0%) approaches. Ureteral stent tubes and Foley catheters were used in various proportions in both surgery types. The mean surgery duration was longer in the laparoscopic group (162.3 min ± 65.5 min *vs.* 96.0 min ± 21.0 min in open surgery, p=0.002). Blood loss and hospital stay duration were not significantly different between the groups (Table 8).

**Table 8:** Outcomes postoperative pain, and early postoperative complications.

Measurement	Total n (%)	laparoscopic surgery n (%)	Open surgery n (%)	P value
Post-operative pain				
Moderate painful	10 (33.3)	4 (13.3)	6 (20.0)	0.7
Severity painful	20 (66.7)	11 (36.7)	9 (30.0)	
Early postoperative complications				
No complications	28 (93.3)	13 (43.3)	15 (50.0)	0.483
Wound infection	1 (3.3)	1 (3.3)	-	
Urination between stitches	1 (3.3)	1 (3.3)	-	
Total	30(100)	15(50.0)	15(50.0)	

<sup>c</sup> p-value was calculated with the Fisher Exact test

### Post-operative outcome by surgery approaches

Postoperative complications were minimal, with no significant differences between the surgical methods ( $p=0.343$ ). The laparoscopic group exhibited more significant improvements in renal parenchymal thickness and reduction in renal pelvis dilatation compared to the open surgery group, with both changes being statistically significant ( $p=0.0001$ ) (Figure 1,2).

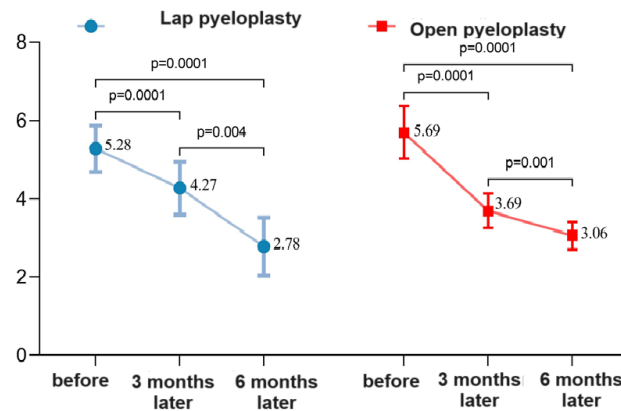


Figure 1: Result of Ultrasound pyelectasis.

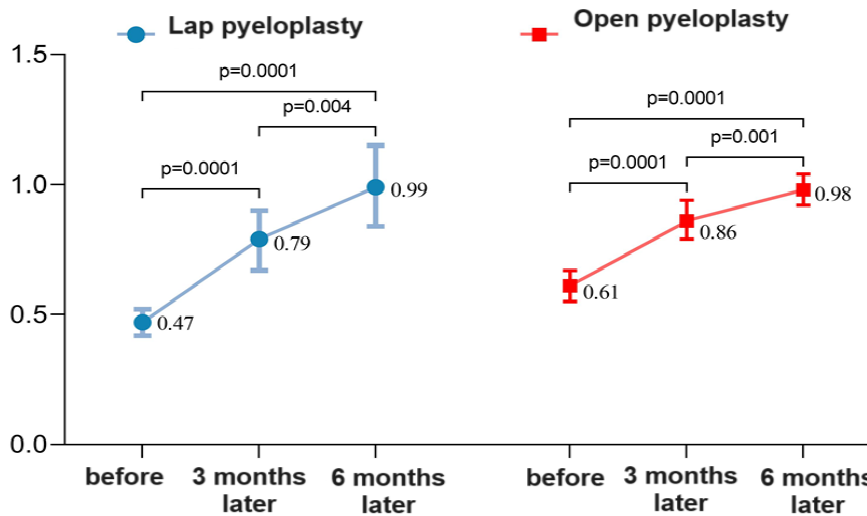


Figure 2: Result of Ultrasound parenchyma.

## DISCUSSION

Recent trends in urinary tract rehabilitation favor minimally invasive surgery. Among these, the Anderson-Hynes procedure is recognized as the standard due to its effective outcomes. In the past decade and a half, there has been a significant shift from open surgery to laparoscopic methods for repairing pelvi-ureteral strictures with a high success rate of more than 90% regardless of the methods [7-10]. Since its inception in 1993, laparoscopic approaches, utilizing small-scope laparoscopes, have matched the success rates of open surgery, ranging from 80 to 100 percent

[11]. These laparoscopic techniques not only offer the ability to excise ureteral strictures during surgery if needed but also yield benefits like reduced pain, lower analgesic usage, shorter hospital stays, and quicker return to daily activities. In more than 95% of cases, this technique is successful [12]. For laparoscopic reconstructive surgeries, both anterior abdominal and posterior approaches are employed. Our research utilized the anterior approach in half of the cases, acknowledging its benefits in providing excellent visibility of internal organs and differentiation areas, albeit with risks of organ damage and adhesions. The posterior approach offers easier access to the urinary tract but lacks clarity on the structure of abdominal organs and is limited in space [6].

Studies like those by Silarly Moore in 2006 showcase low complication rates and high success of around 97%. Jarrett and colleagues in 2002 reported an average operative time of 4.2 hours, minimal blood loss, and an average hospital stay of 3.3 days, which reflects an improvement over time. Marcin Polok et al. [13] reported that the median hospital stay time was similar in all groups ( $p > 0.05$ ) and was 4 days (range: 2–17) in LP, *versus* 3 days (range: 2–11) in OP cases. Other studies in the literature report hospital stays different longer OP cases than LP cases [14,15]. In our study, the median hospitalization time was different in both groups OP cases was longer than the LP group. In some cases, additional measures such as vasopressors were necessary, yet the efficacy remained high. In the most studies reported that advantages of open pyeloplasty are a significantly shorter operation time and an easier operative technique [13]. The most difficult step of the laparoscopic pyeloplasty is the anastomosis that requires advanced laparoscopic skills and more experience [15,16]. Despite laparoscopic surgery generally taking longer, the duration time in our study was consistent with the global average reported in other research. Comparatively, open surgery duration was shorter. Patients were not discharged until the nephrostomy catheter had been removed. Polok M (2020) studies report that OP patients a JJ catheter was used (90.8%), yet for LP cases it was only used in 62.1% of patients ( $p < 0.05$ ) [13], reason for not using the JJ stent in the LP group could be that it is time consuming and not always easy [13,14]. In the present study, the using the JJ stent was 100% in OP group.

In terms of demographics, hydronephrosis incidence is about 1 in 1,000-2,000 live births. Consistent with this, our study found a higher prevalence in males, with a male-to-female ratio aligning with past research [17]. Obstruction at the UPJ is found more commonly in boys than in girls, especially in the newborn period, with up to twice as many cases diagnosed in boys. As many as 67% of cases involve the left kidney in the newborn period, and bilateral cases (synchronous and asynchronous) are observed in 10% to 40% of cases, most of which are noted in infants younger than 6 months; however, fewer than 5% of patients require bilateral repair because of spontaneous resolution in a significant number of cases [18]. Anatomically, a preference for the left side for urinary tract narrowing is observed, which our findings support.

In the literature, the success rate for transperitoneal LP and retroperitoneal OP is 83% to 97% and is comparable in both groups [19,20]. In the present study, postoperative renal function improves in all children of our study. Importantly, postoperative kidney function improved in nearly all cases, with laparoscopic surgery showing even better outcomes. It also presented advantages like less pain and faster healing, despite a slightly higher rate of complications such as wound infection and urine leakage at the suture site.



Our findings suggest that while both laparoscopic and open surgeries are effective for treating upper urinary tract obstruction in children, laparoscopic surgery might offer a better postoperative experience. Additionally, when evaluating kidney disease severity in children, there was a 64.5% agreement between traditional and newer methods, indicating the potential need for updated assessment techniques, particularly in moderate cases where accurate evaluation is crucial.

This study presents a comprehensive analysis of pediatric hydronephrosis management, encompassing demographic characteristics, clinical presentations, and surgical outcomes. The predominance of males and the higher incidence in the left kidney align with existing literature. The observed improvement in postoperative creatinine levels signifies the potential efficacy of surgical intervention. Notably, the comparison between laparoscopic and open surgery revealed no statistically significant difference in terms of intraoperative blood loss or hospital stay, despite laparoscopic surgery being lengthier. Importantly, the renal parenchymal thickness and the reduction in renal pelvis dilatation post-surgery suggest a favorable anatomical and functional recovery in both surgical methods.

The demographic data underscore the importance of considering age and gender disparities in hydronephrosis studies. The 50% prenatal diagnosis rate points to a need for improved prenatal screening protocols. The concordance rate between conventional and new severity assessment methods and the absence of significant differences in surgical outcomes highlight the potential for standardized assessment and treatment strategies. The comparable efficacy of laparoscopic and open surgeries suggests a tailored approach to surgery, considering patient-specific factors and surgeon expertise.

The study's limitations include (1) There is little mention of prenatal diagnose in the study (2) Morphological changes during congenital hydronephrosis are not included (3) Short-term postoperative renal function was determined (4) Costs for laparoscopic and open surgery are not included. The last limitation of this study is the sample size. The sample size was relatively small, which may limit the generalizability of the findings.

#### **Future research direction**

Further research should aim at enhancing prenatal diagnosis rates through advanced imaging techniques and genetic markers to facilitate earlier intervention strategies. Moreover, the development of a standardized severity grading system could lead to more uniform treatment protocols. Investigating the long-term renal function post-surgery would provide insights into the chronic implications of hydronephrosis and its management. Additionally, exploring the cost-effectiveness and patient quality of life between laparoscopic and open surgical interventions could inform clinical decision-making. Future studies with larger sample sizes and longer follow-up periods are necessary to validate these findings and to determine the best practices for pediatric hydronephrosis treatment. The potential for non-surgical management or less invasive approaches also warrants investigation. Finally, as the study highlights a strong male predominance, exploring the underlying reasons for this gender difference could provide novel insights into the pathophysiology of the disease.

## CONCLUSION

The observed improvement in postoperative creatinine levels signifies the potential efficacy of surgical intervention. Notably, the comparison between laparoscopic and open surgery revealed no statistically significant difference in terms of intraoperative blood loss or hospital stay, despite laparoscopic surgery being lengthier. Importantly, the kidney parenchymal thickness and the reduction in renal pelvis dilatation post-surgery suggest a favorable anatomical and functional recovery in both surgical methods.

The demographic data underscore the importance of considering age and gender disparities in hydronephrosis studies. The 50% prenatal diagnosis rate points to a need for improved prenatal screening protocols. The concordance rate between conventional and new severity assessment methods and the absence of significant differences in surgical outcomes highlight the potential for standardized assessment and treatment strategies. The comparable efficacy of laparoscopic and open surgeries suggests a tailored approach to surgery, considering patient-specific factors and surgeon expertise.

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