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## National Trends in Followup Imaging after Pyeloplasty in Children in the United States

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### Abstract

**Purpose**—Radiographic followup after pyeloplasty for the correction of ureteropelvic junction obstruction is not well defined in children. We characterize trends in frequency and modality of postoperative imaging after open and minimally invasive pediatric pyeloplasty.

**Materials and Methods**—Using the MarketScan® database, we identified patients 0 to 18 years old undergoing pyeloplasty between 2007 and 2013. Followup imaging was classified as functional (diuretic renography, excretory urography) or nonfunctional (ultrasound, computerized tomography, magnetic resonance imaging). We excluded patients with less than 24 months of postoperative enrollment in MarketScan. Multivariate logistic regression was performed to determine associations between demographic variables and imaging use patterns.

**Results**—We identified 926 patients with a mean  $\pm$  SD followup of  $3.6 \pm 1.3$  years, of whom 30% underwent minimally invasive pyeloplasty. Overall 5.9% of patients had no postoperative imaging available. Within the first 6 months postoperatively 853 patients (91%) underwent at least 1 imaging study and 192 (24%) underwent renography. Within the first 12 months postoperatively 91% of patients underwent at least 1 imaging study, most commonly ultrasound. After 12 months almost a third of the patients were not followed with imaging. Of the 71% undergoing imaging most underwent ultrasound. Younger age and female gender were independently associated with frequent imaging (at least yearly) on multivariate logistic regression.

**Conclusions**—Following pediatric pyeloplasty there is variation in modality and frequency of imaging followup. The majority of patients are followed with renal ultrasound, with less frequent use of functional imaging. Almost a third of patients do not undergo followup imaging after 1 year.

### Keywords

diagnostic imaging; hydronephrosis; kidney; pediatrics; ureteral obstruction

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Success after pyeloplasty for the repair of ureteropelvic junction obstruction in children has been routinely defined by a combination of clinical and radiographic criteria. Despite high

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reported success rates,<sup>1</sup> there are no established recommendations to guide imaging surveillance modality, timing or duration after pediatric pyeloplasty.

A recent study among privately insured adults revealed that 1 of 8 did not undergo postoperative imaging after pyeloplasty.<sup>2</sup> Overall duration of imaging was shorter than expected, with approximately half of patients undergoing imaging after 1 year. We hypothesize that in children there is wide variation in imaging protocols. We characterize trends in frequency and modality of followup imaging after open and minimally invasive pediatric pyeloplasty.

## METHODS

### Data Source

The MarketScan database contains longitudinal records from United States employer based commercial health plans.<sup>3</sup> The data set contains more than 196 million unique patients from 1995 onward. In addition to outpatient visits, the database includes records of approximately 50% of all hospital discharges in the United States. Socioeconomic data, including income and ethnicity, are not available. Patients are deidentified from the database. Institutional review board approval was not obtained for this study.

### Sample Population

Patients undergoing pyeloplasty from 2007 to 2013 were identified using CPT (Current Procedural Terminology) codes 50400 (pyeloplasty), 50405 (complicated pyeloplasty-congenital kidney abnormality, secondary pyeloplasty, solitary kidney, calycooplasty) and 50544 (laparoscopic pyeloplasty). Patients were excluded if they were 19 years or older at surgery or if there was less than 24 months of enrollment data after the index surgery so that insurance coverage status was maintained in the postoperative period. This criterion was applied to ensure that if there was lack of imaging, it was not due to change in insurance status.

### Patient and Hospital Characteristics

Characteristics evaluated included age at surgery, gender, number of comorbidities, use of a minimally invasive approach, year of surgery, hospital region, insurance status (HMO or nonHMO) and length of stay. Age in years was divided into the categories 0 to 2, 3 to 6, 7 to 13 and 14 to 18. Use of a minimally invasive approach was identified by CPT code 50544. Length of stay was divided into the categories 1 to 2, 3 to 5 and 6 or more days. Secondary interventions, including stent/drain procedures, endoscopic correction and repeat pyeloplasty, were identified using CPT and ICD-9-CM codes (see supplementary Appendix, <http://jurology.com/>).

### Radiographic Followup

CPT and ICD-9-CM codes were used to identify postoperative imaging studies, which included abdominal and renal ultrasound, abdominal CT, abdominal MRI, renography and IVP (supplementary Appendix <http://jurology.com/>). Imaging type was categorized as functional (renogram or IVP) or nonfunctional (ultrasound, CT or MRI). CT and MRI can

provide information on renal function and excretion. However, the billing codes do not allow determination of whether delayed contrast imaging was used. Therefore, in this study these tests were categorized as nonfunctional imaging.

### Statistical Analysis

Associations between demographic variables and at least annual radiographic followup were determined using unadjusted and adjusted multivariate logistic regression. Stepwise regression was used to determine inclusion variables for the final adjusted model. Exploratory analysis using the chi-square test was performed to determine univariate associations between demographic variables and lack of imaging after pyeloplasty. Statistical analysis was performed using Stata®, version 12.1, with 2-sided p value less than 0.05 considered statistically significant.

## RESULTS

A total of 926 children were identified with a mean  $\pm$  SD followup of  $3.6 \pm 1.3$  years. Patient demographics are listed in table 1. A minimally invasive approach was used in 10.2% of patients 0 to 2 years, 14.6% of those 3 to 6, 31.8% of those 7 to 13 and 43.4% of those 14 to 18 years old (30% of patients overall). Complicated pyeloplasty (CPT 50405) was performed in 43% of patients. A secondary procedure was required in 13.7% of patients.

Figure 1 shows the proportion of patients undergoing imaging studies by postoperative time interval. Overall 5.9% of patients underwent no postoperative imaging. In the first 12 months 91% underwent at least 1 imaging study, of which ultrasound was most commonly performed. The most common interval during which renography was performed was 0 to 6 months (192 of 816 patients, 14%). After 12 months 29% of all children did not undergo further imaging.

Figure 2 demonstrates the proportion of patients undergoing functional and/or nonfunctional imaging by postoperative time interval. Use of functional imaging, including IVP and renography, was most common during the 0 to 6-month interval (26%). However, nonfunctional imaging was more commonly used overall. The proportion of patients with no imaging during each interval increased from 12% in the 0 to 6-month period to 69% after 3 years.

On univariate analysis year of surgery, geographic region, HMO insurance status, length of stay and need for secondary procedures were not statistically significantly associated with frequent performance of imaging (at least yearly) after pyeloplasty. On multivariate analysis patients 7 to 13 years old (HR 0.52, 95% CI 0.35–0.77) or 14 to 18 years old (HR 0.30, 95% CI 0.20–0.47) were less likely to undergo at least annual imaging compared to those 0 to 2 years old (table 2). Use of a minimally invasive approach was associated with not undergoing imaging at least yearly on univariate analysis (HR 0.70, 95% CI 0.52–0.94). However, this finding did not remain significant on multivariate analysis (HR 1.10, 95% CI 0.77–1.57). Female gender was independently associated with a greater likelihood of undergoing imaging at least yearly (HR 1.52, 95% CI 1.11–2.08).

On exploratory analysis age 14 to 18 years was the only factor associated with lack of imaging after pyeloplasty ( $p < 0.001$ ). In this age group 14.5% of patients did not undergo imaging, compared to 4.2% of those 0 to 2 years, 1.9% of those 3 to 6 years and 5.2% of those 7 to 13 years old. On univariate analysis gender, minimally invasive approach, year, region, HMO status and length of stay were not associated with lack of imaging.

## DISCUSSION

We identified variations in the intensity and type of imaging followup after pediatric pyeloplasty. Of the patients 5.9% did not undergo following imaging after the index surgery, and almost a third were not followed radiographically beyond 1 year according to data captured in MarketScan. Ultrasound is the most common imaging modality used after pyeloplasty, while a small but sizable proportion of patients undergo functional studies, most commonly renography. Younger children and girls are more likely to undergo routine followup.

Older children are less likely to undergo imaging after pyeloplasty, although it is not clear why. It is possible that younger children have more scheduled interaction with health care providers, or that imaging is performed less routinely after use of a minimally invasive approach, which is more common in older children. Furthermore, imaging may be performed more frequently in younger children because they are less able to articulate the presence of symptoms. It is also possible that younger children, particularly those less than 2 years, were operated on as a result of prenatal screening findings and did not initially present with symptoms. These children would be less likely to experience flank pain or other pain symptoms in the event of treatment failure, so clinicians may have used imaging as the window into success. Older children may have been first diagnosed with obstruction based on symptoms such as pain. Thus, absence of pain postoperatively may have led clinicians to minimize postoperative imaging.

Contemporary series on pediatric pyeloplasty have revealed high success rates, although differing protocols exist regarding imaging surveillance (table 3).<sup>4–20</sup> This variation in post-pyeloplasty imaging impacts health care expenditures and affects the amount of radiation exposure in children. To our knowledge, there has been no formal study evaluating the cost-effectiveness of routine followup imaging after pyeloplasty. Such a study would need to account for the sequelae of symptomatic failures and the costs associated with silent obstruction, including chronic kidney disease.

While routine diuretic renograms in the early postoperative period have been shown to predict failure after pyeloplasty in children,<sup>21</sup> there is greater awareness regarding minimizing radiation risks related to imaging, particularly in pediatric patients.<sup>22</sup> The use of renograms in adults is associated with an effective dose of 1.8 to 3.3 mSv.<sup>23</sup> This dose is roughly equivalent to a chest CT in a 5-year-old child.<sup>22</sup> In the present study 32% of pediatric patients underwent renography. The concern over radiation dose may explain why this finding contrasts with what has been observed in the adult population after pyeloplasty, where there is greater reliance on renograms, especially in the first year. In a similar study of adults undergoing pyeloplasty renograms comprised 53% and 44% of all imaging tests

performed in the 0 to 6-month and 6 to 12-month intervals, respectively.<sup>2</sup> Of this population 65% underwent minimally invasive pyeloplasty and 54% underwent imaging after the first year.

The use of routine, repeated renograms in the postoperative period has been challenged.<sup>24–27</sup> Pohl et al reported that among patients with a nonobstructive diuretic renogram ( $t_{1/2}$  less than 20 minutes) at 3 months there were no late failures.<sup>24</sup> In renal units with improvement in drainage but  $t_{1/2}$  greater than 20 minutes drainage patterns at 12 months continued to improve. When there was no improvement in drainage at 3 months, reoperation may have been required. Psooy et al demonstrated in 77 renal units followed more than 5 years that after a nonobstructive renogram at 1 year subsequent recurrent obstruction is unlikely.<sup>25</sup> This latter observation may explain why only 71% of patients underwent any imaging beyond the first year. In this data set performance of renography within the first 6 months postoperatively had no impact on the likelihood of imaging being performed after 1 year.

More recently several groups have questioned whether even early postoperative renography is necessary after pediatric pyeloplasty.<sup>28–30</sup> Use of a sentinel ultrasound instead has been advocated to determine if renography is necessary. Almodhen et al reported on 97 patients who underwent 101 pyeloplasties with a mean followup of 4.5 years.<sup>28</sup> Of the 91 kidneys with improvement on postoperative ultrasound 2 (2%) exhibited an obstructive pattern on renography, although both spontaneously improved during followup. Hydronephrosis was downgraded in 46 kidneys, and none of these kidneys exhibited an obstructive postoperative scan. Of the 10 kidneys with worsened or no improvement on postoperative ultrasound 4 (40%) had an obstructive renogram, of which 2 were treated with a subsequent procedure.

Cost et al observed similar findings in 49 patients undergoing open pyeloplasty who underwent ultrasound and renography at 3 months.<sup>29</sup> Of the 42 children with stable or improved hydronephrosis 41 had stable function and 1 had low function (32% split function) preoperatively but remained stable (21% split function) at longer followup. Of the 7 remaining patients with increased hydronephrosis 2 had worse renal function. Park et al confirmed in 215 patients with at least 5 years of followup that if there was improvement in hydronephrosis, there was no subsequent worsening of hydronephrosis thereafter.<sup>30</sup> The initial improvement was observed in 90% of children in the first 12 months. It is the practice of our pediatric institution to obtain ultrasounds within the first 3 months postoperatively and yearly thereafter for 3 to 5 years, and to reserve renograms for patients with worsening hydronephrosis postoperatively.

The purpose of imaging after pyeloplasty is to diagnose obstruction early so that interventions may prevent further nephron loss. Recommendations regarding frequency and type of imaging performed cannot be made based on this study design. We advocate investigation of the cost-effectiveness of post-pyeloplasty imaging and standardization of an imaging protocol after pyeloplasty for ureteropelvic junction obstruction, similar to what already exists for surveillance of oncologic conditions after treatment.

Our findings must be interpreted in the context of the limitations of our study design. Although cases coded as complicated pyeloplasty were known, this data set did not contain

specific operative details, such as laterality, case complexity and symptoms. CPT codes do not provide information on the different pyeloplasty approaches beyond simple, complicated or laparoscopic techniques. For instance an uncomplicated robotic pyeloplasty may be coded as either 50400 or 50544. In addition, we expect that around the time of pyeloplasty failure more unscheduled and unanticipated imaging studies are performed, which may confound the estimates of a routine, protocol driven followup. Use of an employer based insurance database may limit the generalizability of our findings, especially in patients without insurance coverage.

## CONCLUSIONS

Among a nationally representative pediatric population there is variation in the intensity and type of imaging followup after pyeloplasty. Ultrasound is the most commonly used surveillance modality overall. A nontrivial subset of patients undergoes no postoperative imaging or is lost to followup. Beyond 12 months after pyeloplasty only two-thirds of patients undergo any subsequent imaging. Younger children and girls are more likely to undergo routine imaging, suggesting that there may be different assumptions about the presentation of failure in these groups.

## Abbreviations and Acronyms

<b>CT</b>	computerized tomography
<b>HMO</b>	health maintenance organization
<b>IVP</b>	excretory urography
<b>MAG3</b>	<sup>99m</sup> technetium mercaptoacetyltriglycine
<b>MRI</b>	magnetic resonance imaging
<b>RS</b>	renal scan
<b>US</b>	ultrasound

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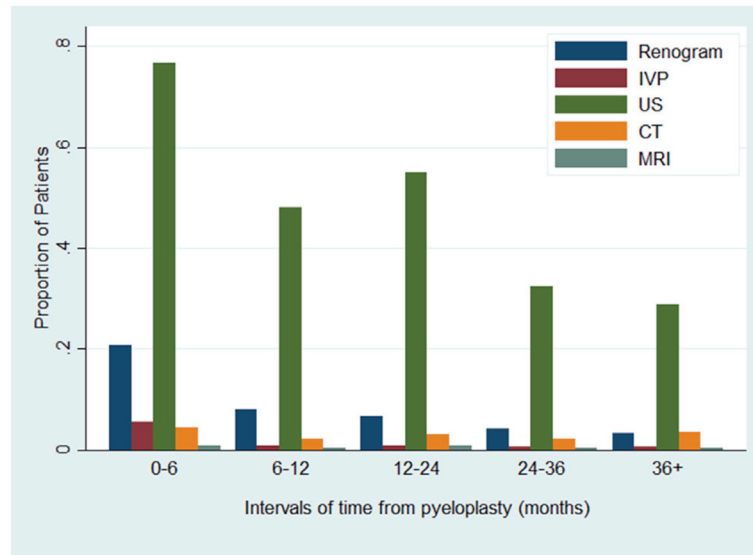
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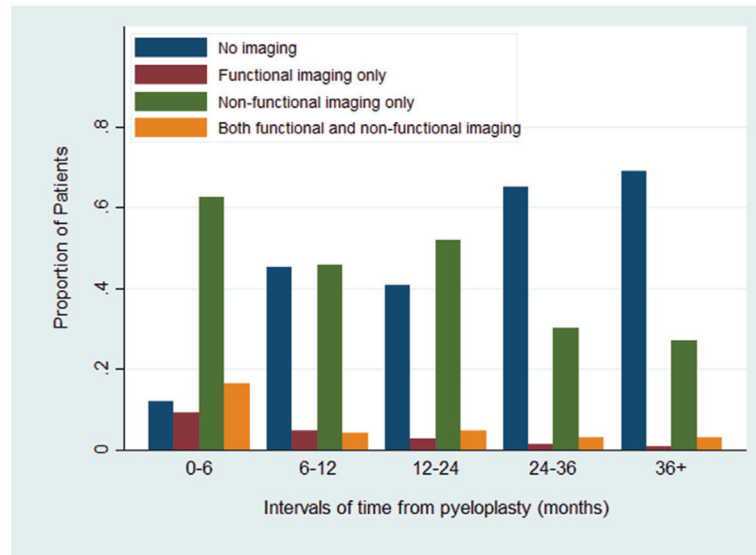
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**Figure 1.** Imaging use through time after pyeloplasty by imaging type. Patients may have undergone multiple types of imaging in same period.



**Figure 2.** Imaging use through time after pyeloplasty by functional (renogram, IVP) or nonfunctional (ultrasound, CT, MRI) imaging type.

**Table 1**

## Patient demographics

	No. Pts (%)
Age group (yrs):	
0–2	403 (43.5)
3–6	157 (17.0)
7–13	194 (20.9)
14–18	172 (18.6)
Gender:	
Male	625 (67.5)
Female	301 (32.5)
Operative approach:	
Open	652 (70.4)
Minimally invasive	274 (29.6)
Surgery yr:	
2007	152 (16.4)
2008	192 (20.7)
2009	200 (21.6)
2010	213 (23.0)
2011	156 (16.8)
2012	13 (1.4)
Region:	
Northeast	169 (18.3)
North central	260 (28.1)
South	285 (30.8)
West	183 (19.8)
Unknown	29 (3.1)
HMO:	
Yes	781 (84.3)
No	125 (13.5)
Unknown	20 (2.2)
Length of stay (days):	
1–2	703 (75.9)
3–5	200 (21.6)
6+	23 (2.5)
Need for secondary procedure(s):	
No	799 (86.2)
Yes	127 (13.7)

**Table 2**

Association between demographic factors and at least yearly radiographic followup

	<b>No. Annual Screening (%)</b>		<b>Unadjusted OR (95% CI)*</b>	<b>Multivariate OR (95% CI)†</b>
	<b>Yes</b>	<b>No</b>		
Age (yrs):				
0–2	304 (49)	99 (33)	Reference	Reference
3–6	111 (18)	46 (15)	0.79 (0.52–1.19)	0.78 (0.51–1.18)
7–13	121 (19)	73 (24)	<b>0.54 (0.37–0.78)</b>	<b>0.52 (0.35–0.77)</b>
14–18	88 (14)	84 (28)	<b>0.34 (0.23–0.50)</b>	<b>0.30 (0.20–0.47)</b>
Gender:				
Male	407 (65)	218 (72)	Reference	Reference
Female	217 (35)	84 (28)	<b>1.38 (1.02–1.87)</b>	<b>1.52 (1.11–2.08)</b>
Operative approach:				
Open	455 (73)	197 (65)	Reference	Reference
Minimally invasive	169 (27)	105 (35)	<b>0.70 (0.52–0.94)</b>	1.1 (0.77–1.57)

Values in boldface represent significant ORs ( $p < 0.05$ ).

\* Year of surgery, geographic region, HMO insurance status, length of stay and need for secondary procedures did not show statistically significant associations with annual screening status.

† Adjusted for age, gender and operative approach.

**Table 3**  
Selected contemporary series on pediatric pyeloplasty including at least 50 cases

References	Approach (No.)	Age (yrs)	Followup (mos)	Definition of Success	% Success	Imaging Followup Protocol
Chacko et al <sup>4</sup>	Laparoscopic transperitoneal (52)	Mean 4.3	Mean 20	Absence of symptoms + improved hydronephrosis (US) or improved drainage (RS)	98	–
Maheshwari et al <sup>5</sup>	Laparoscopic transperitoneal (82)	Mean 7.1	Mean 41.6	Absence of obstruction on RS	92	–
Szaway et al <sup>6</sup>	Laparoscopic transperitoneal (70)	Median 1.7	Median 24	–	98	US every 3 mos; MAG3 at 3 mos, 12 mos
Sweeney et al <sup>7</sup>	Laparoscopic transperitoneal (112)	Mean 9.4	Mean 15.3	Symptoms and/or radiographic evidence of obstruction	97	–
Olsen et al <sup>8</sup>	Robotic retroperitoneal (67)	Mean 7.9	Median 12.1	Absence of symptoms and/or decreased intrarenal pelvis anteroposterior diameter (US), or unchanged or improved differential function (RS)	94	US + RS at 3 mos, 12 mos
Minnillo et al <sup>9</sup>	Robotic transperitoneal (155)	Mean 10.5	Mean 31.7	Improved symptoms, improved hydronephrosis (US) and/or improved drainage parameters (RS)	96	US at 1 mo, 3 mos, then yearly; MAG3 if recurrent symptoms or not improved on US
Zhou et al <sup>10</sup>	Laparoscopic retroperitoneal (62)	Mean 3	Mean 24	–	98	IVP + US at 3 mos, 6 mos, then yearly
Bianc et al <sup>11</sup>	Laparoscopic retroperitoneal (104)	Mean 6.2	Median 25.2	Decreased or resolved hydronephrosis (US) + improved drainage with residual less than 50% at 20 mins after furosemide administration with stable differential function (RS)	96	US 1 mo after stent removal (6 wks), every 3 mos for 1 yr, then yearly for 5 yrs; MAG3 or magnetic resonance urography if no significant improvement on US, recurrent symptoms or significant preop asymmetrical function
Piaggio et al <sup>12</sup>	Laparoscopic transperitoneal (37) vs open (41)	Mean 5.1 vs 3.7	Mean 6.3 vs 24	Symptom resolution, marked reduction of hydronephrosis (US) or improved drainage curve (RS)	97 Vs 83	–
Valla et al <sup>13</sup>	Laparoscopic retroperitoneal (45) vs open (45)	Mean 5.8 vs 1.8	Mean 25 vs 38	Symptom improvement + improved hydronephrosis (US) or renal drainage/function (RS)	97 Vs 96	US at 3–6 mos, then yearly; RS at 1 yr
Braga et al <sup>14</sup>	Laparoscopic transperitoneal (41) vs open (67)	Mean 7.9 vs 8.1 (flank), 7.3 (dorsal)	Mean 28 vs 49 (flank), 47 (dorsal)	Symptom resolution, improved hydronephrosis (US) and/or decreased t1/2 at last clinical appointment (RS)	95 Vs 96	Routine US; RS reserved for prolonged, persistent or worsening hydronephrosis and/or recurrent symptoms
van der Toorn et al <sup>15</sup>	Laparoscopic transperitoneal (57) vs open (57)	Mean 8.1 vs 7.8	Mean 12 vs 72 min	Symptom resolution, no conversion/reintervention, decreased hydronephrosis (US) and/or improved drainage (RS)	98 Vs 95	US + RS in first 50 pts, then renogram omitted if US showed decreased hydronephrosis
Garcia-Aparicio et al <sup>16</sup>	Laparoscopic transperitoneal (26) vs open (32)	Mean 0.4	–	Improved hydronephrosis (US)	100	US at 1 mo, 6 mos, 12 mos; MAG3 at 6 mos

References	Approach (No.)	Age (yrs)	Followup (mos)	Definition of Success	% Success	Imaging Followup Protocol
Lee et al <sup>17</sup>	Robotic transperitoneal (33) vs open (33)	Mean 7.8 vs 7.6	Mean 10 vs 21	Symptom resolution, significant + persistent improvement of hydronephrosis (US) and/or t1/2 less than 10 mins (RS)	94 Vs 100	–
Sorensen et al <sup>18</sup>	Robotic transperitoneal (33) vs open (33)	Mean 9.2 vs 8.2	Mean 17 vs 19	Symptom resolution, improved hydronephrosis with renal growth (US) and/or improved drainage (RS)	97	–
Barbosa et al <sup>19</sup>	Robotic transperitoneal (58) vs open (154)	Median 7.2 vs 1.2	Median 33 vs 31	Hydronephrosis improved (US) by at least 2 grades (0–5 scale)	74 Vs 70	US at 0–6 mos, 6–12 mos, after 12 mos; MAG3 if no improvement on US
Riachy et al <sup>20</sup>	Robotic transperitoneal (46) vs laparoscopic transperitoneal (18)	Mean 8.8 vs 8.1	Median 22 vs 43	Absence of symptoms; hydronephrosis improved by at least 1 grade (US), stable US with symptom resolution or t1/2 less than 10 mins (RS)	100 Vs 88	–