Postnatal imaging of prenatally detected hydronephrosis-when is voiding cystourethrogram necessary?

Visuri, Sofia

2018-10


http://hdl.handle.net/10138/253484
https://doi.org/10.1007/s00467-018-3938-y

Downloaded from Helda, University of Helsinki institutional repository.

This is an electronic reprint of the original article.

This reprint may differ from the original in pagination and typographic detail.

Please cite the original version.
Postnatal imaging of prenatally detected hydronephrosis—when is voiding cystourethrogram necessary?

Sofia Visuri 1,4 · Reetta Kivisaari 3 · Timo Jahnukainen 2 · Seppo Taskinen 4

Abstract

Objective To evaluate whether grade 4–5 vesicoureteral reflux (VUR) can be predicted from renal ultrasound (RUS) findings and perform voiding cystourethroms (VCUGs) only on high-risk patients.

Methods The RUS and VCUG images of infants with prenatally detected hydronephrosis admitted to our institution between 2003 and 2013 were re-evaluated. The UTI episodes were collected retrospectively from patient journals. Patients with complex urinary tract anomalies were excluded.

Results One hundred eighty, 44 female and 136 male, patients (352 renal units (RU)), 23 (30 RU) of them having grade 4–5 VUR, were included. The median age of the patients at the time of the RUS was 1.3 (0.1–3.0) months and the median follow-up time was 2.0 (0.1–11.2) years.

In multivariate analysis, a visible ureter (OR 12.72; CI 5.33–32.04, p < 0.001) and shorter renal length (OR 2.67; CI 1.50–4.86, p < 0.001) in RUS predicted grade 4–5 VUR while a visible ureter predicted UTIs (OR 5.75; CI 2.59–12.66, p < 0.001).

A three-grade risk score for high-grade VUR was developed based on the RUS findings and the patients were categorized into low-, intermediate-, and high-risk groups. The incidence of grade 4–5 VUR was 2.9% in the low-risk, 12.2% in the intermediate-risk, and 52.2% in the high-risk group. The sensitivity and specificity for detecting grade 4–5 VUR were 79 and 82%, respectively.

Conclusions In patients with antenatally detected hydronephrosis, a visible ureter and reduced renal length in RUS are significant risk factors for high-grade VUR. A RUS-based risk scoring would probably reduce the proportion of unnecessary VCUGs.

Keywords Children · Hydronephrosis · Prenatal · Renal ultrasonography · Vesicoureteral reflux

Introduction

Hydronephrosis (HN) is one of the most common abnormal findings in prenatally performed ultrasonographies. Based on current literature, HN is found in about 1–2% of ultrasonography examinations and has a tendency to resolve spontaneously in about 15 to 80% of the cases depending on the severity of pelvic dilation [1–3]. Vesicoureteral reflux (VUR) is found in approximately 15–21% of the cases with prenatally detected HN [4, 5]. High-grade VUR has been associated with an increased risk for urinary tract infections (UTIs) which may further cause renal scarring and morbidity to the patient [6, 7]. Detection of high-grade VUR is therefore considered to be important. In a meta-analysis by Lee et al., no significant correlation between VUR grade and degree of prenatal HN could be found, suggesting that renal ultrasonography (RUS) is probably not sensitive enough to detect gross VUR from other causes of HN [8]. Voiding cystourethrogram (VCUG) has by far remained the golden standard in VUR diagnostics. However, the challenge lies in the question: “On which patients should VCUG be performed?” The recommendations about the postnatal imaging studies in prenatal HN patients have remained controversial [9, 10].
Nguyen et al. have recently published a multidisciplinary consensus statement on prenatal and postnatal urinary tract dilation. This guideline divides the HN patients into three risk groups and recommends that VCUG should be performed on all high-risk patients. In the case of intermediate and low risk, the decision on performing VCUG should be done based on clinical discretion [11].

VCUG is the most common fluoroscopic examination performed on children. VCUG is an informative test; however, it is also an important factor exposing to radiation in pediatric patients [12, 13]. VCUG requires catheterization which causes discomfort and may predispose to UTI. The UTI prevalence after VCUG is reportedly 2–6% [9, 14, 15].

In the present study, we studied all patients with prenatally diagnosed HN referred to our unit. Our primary aim was to evaluate whether the patients would benefit from undergoing VCUG, as we hypothesized that postnatally performed RUS is able to identify patients with high-grade (4–5) VUR. Secondarily, we evaluated whether an increased risk of UTI can be identified based on RUS findings.

Materials and methods

The study protocol was approved by the ethics committee at our hospital.

All patients with urinary tract anomalies (ICD-10: Q60.0–Q64.9 and N13.0–N13.9) were electronically searched from the database of our unit. All patient charts were manually examined and patients with postnatally diagnosed HN were excluded.

The inclusion criteria were persistent HN (anteroposterior diameter (APD) of the renal pelvis >7 mm) and/or a visible distal ureter on postnatal RUS examination. Syndromatic patients and patients with ureteroceles, urethral obstruction, or complex urogenital abnormalities were excluded. A total of 192 patients were identified. Twelve patients were excluded due to lacking follow-up imaging data; the final number of patients was thus 180. RUS was performed on all patients and VCUG on 142 (79%) patients. VCUG was performed according to our protocol at the age of 4 weeks on all patients with (1) visible ureter on RUS, (2) renal pelvis APD ≥10 mm, (3) reduced size of kidney in association with HN, or (4) bilateral HN or after clinical consideration. VUR grade was classified using the international classification for classifying VUR [16].

Based on our previous study, only patients with grade 4–5 VUR had a significantly increased risk of UTI [14]. The study population was therefore divided into two groups: (1) patients with grade 0–3 VUR and (2) patients with grade 4–5 VUR.

The information about age, gender, UTI, and timing of urological procedures was collected. The data was collected from birth until the latest visit at our unit, or in patients with a surgical procedure, until the first operation. All RUS results and images were re-evaluated together with an experienced pediatric radiologist (RK). The information about kidney length, renal pelvic APD, Society of Fetal Urology (SFU) grade of HN Society for Fetal Urology (SFU) grading system of pediatric hydronephrosis [17]), diameter of distal ureter (if visible), and renal parenchyma was evaluated from the RUS images. The renal parenchyma was evaluated from the mid-coronal section of the kidneys and classified as either normal or reduced. Dysplastic kidneys were excluded from the analysis. A kidney was defined as dysplastic, if multiple cysts were visualized or corticomedullary differentiation could not be seen in a non-hydronephrotic high-echogenic kidney. In the final scoring, the ureter was classified as visible or invisible and renal length was categorized into three categories: (1) >53 mm (>0 SD), (2) 46–53 mm (0–(−1) SD), and (3) <46 mm (< (−1) SD). In two patients with HN, the length of the contralateral kidney was not available.

The criteria of UTI were (1) any bacterial growth in sterile suprapubic aspiration, (2) a bacterial count of 100,000 or more colony-forming units per milliliter (CFU/mL) and significant pyuria (>100 × 10E9/L) in voided samples (clean-catch urine sample or two consecutive bag samples (n = 7)). In two cases, the diagnosis was based on one bag sample. In both of these cases, there was a significant growth of E. coli, pyuria (>250–2063 × 10E9/L), fever (>38.5 °C), and clinical symptoms suggesting UTI. UTI was defined as febrile if the patient had fever ≥38.5 °C. Infants younger than 3 months of age were treated as febrile UTI even in the case of normal body temperature [18].

Continuous antibiotic prophylaxis was started in patients with renal pelvic APD ≥10 mm or non-refluxing hydroureter until the first year of life and in patients with grade 3–5 VUR until they were toilet trained.

Statistical analyses were done with SPSS statistical package (IBM SPSS statistics 22) and R (R package version 3.3.3). We used Fisher’s exact test for cross-tabulation of categorical variables. The risk of VUR and UTI was studied by univariate and multivariate logistic regression analysis and presented with ROC (receiver operating characteristic) curves. AUC (area under the curve) was also calculated.

Results

General findings

Altogether, 180 patients (352 renal units (RU)), 34 of them having any grade of VUR, were included. The RUS examination was performed at median age of 1.3 (range 0.1–3.0) months and the median follow-up time was 2.0 (range 0.1–11.2) years. Forty-one patients had an operative intervention at a median age of 1.1 (range 0.1–5.7) years. Twenty-one patients had at least one UTI at a median age of 0.7 (0–4.8) years (Table 1). Seventeen (81%) of the UTIs were febrile
(fever ≥ 38.5 °C). Of the four patients, classified as afebrile UTI, one had 38.3 °C fever and CRP 102 mg/L and two of the patients were ≤ 35 days at the time of the infection and had elevated CRP. Finally, only one patient had cystitis. All the male patients were uncircumcised.

One patient with unilateral grade 4 VUR had a horseshoe kidney. Five patients, two of them having VUR 1–3, had a multicystic dysplastic kidney (MCDK) on the contralateral side. Three patients had a single kidney, and one of them had grade 4 VUR.

### Parameters predicting VUR

VCUG was performed in 142 patients (278 RU). The 38 patients whom VCUG was not performed on were excluded from the analysis. Grade 4–5 VUR appeared in 30 RU (10.8%) and grade 1–3 VUR in 22 RU (7.9%). Univariate analysis was performed to evaluate the risk of grade 4–5 VUR using the following parameters: (1) renal length, (2) renal pelvic APD, (3) SFU grade 0–2 versus grade 3–4, (4) visibility of the distal ureter, and (5) reduction of renal parenchyma. According to univariate analysis, a visible distal ureter was the most important risk factor differentiating patients with high-grade VUR (OR 13.57; CI 5.96–32.40, p < 0.001) from patients with grade 0–3 VUR. Small renal length (OR 2.71; CI 1.48–5.25, p = 0.002) and SFU grade 3–4 (OR 2.52; CI 1.15–5.45, p = 0.019) were also significant risk factors for high-grade VUR. The pelvic diameter and parenchymal thickness did not differ between those of the RU with grade 4–5 and those of the RU with grade 0–3 VUR (Table 2).

A multivariate analysis was further used for the parameters that were significantly associated with an increased risk of grade 4–5 VUR. For the analysis, the renal length was divided into three categories: (1) > 53 mm (> 0 SD), (2) 46–53 mm (0–(− 1) SD), and (3) < 46 mm (< (− 1) SD). A visible ureter and renal length significantly predicted grade 4–5 VUR (OR 12.72; CI 5.33–32.04, p < 0.001 and OR 2.67; CR 1.50–4.86, p < 0.001, respectively); however, SFU grade did not reach statistical significance in predicting grade 4–5 VUR (p = 0.134).

### Scoring

A scoring system based on the multivariate model was developed to predict the VUR risk. The methodological guideline was referred from the article published by Han et al. [19]. The risk score takes into account renal length, as described above, and visibility of the ureter (yes/no). The risk score was used to categorize the patients into (1) low-, (2) intermediate-, and (3) high-risk groups. In the low-risk group, the incidence of grade 4–5 VUR was 2.9%; in the intermediate-risk group, 12.2%; and in the high-risk group, 52.2% (Table 3). The true positive rate (sensitivity) and the false positive rate (1-specificity) of the risk scoring to identify RU with grade 4–5 VUR were analyzed by ROC curve analysis. The AUC for the model was 0.817 (95% CI 0.722–0.912) (Fig. 1).

In our material, grade 3 VUR appeared in 15 RU. In five cases (33%), it was associated with grade 4–5 VUR on the contralateral side. Six (40%) of the RU with grade 3 VUR settled into the intermediate- or high-risk groups.

### Parameters predicting UTI

Twenty-one of a total of 180 patients had UTI. VCUG was not performed on 38 patients, none of them having a history of UTI. Univariate analysis was used to evaluate the risk for UTI. The variables included in the analysis were the same as those in prediction of high-grade VUR.

A visible distal ureter in RUS was the only significant factor predicting UTI (OR 4.93; CI 1.91–12.93, p < 0.001). In patients with UTI, the smaller (or single) kidney tended to be shorter than that in the patients without UTI, but the difference did not reach statistical significance (p = 0.117). Neither the SFU grade (p = 0.392) nor the APDs (p = 0.301) nor parenchymal thickness (p = 0.416) differed between the worse kidney of the patients with and without UTI (Table 4).

---

**Table 1** The voiding cystourethrogram findings in patients with prenatally detected hydronephrosis and the number of patients who experienced urinary tract infection during the follow-up period

<table>
<thead>
<tr>
<th>Parameters predicting UTI</th>
<th>VUR</th>
<th>Grade 1–3 VUR</th>
<th>Grade 4–5 VUR</th>
<th>No VUR</th>
<th>VCUG not performed</th>
</tr>
</thead>
<tbody>
<tr>
<td>Renal units, n (%)</td>
<td>52 (15)</td>
<td>22 (6)</td>
<td>30 (9)</td>
<td>226 (64)</td>
<td>74 (21)</td>
</tr>
<tr>
<td>Patients, n (%)</td>
<td>34 (19)</td>
<td>11 (6)</td>
<td>23 (13)</td>
<td>108 (60)</td>
<td>38 (21)</td>
</tr>
<tr>
<td>Female, n (%)</td>
<td>7 (4)</td>
<td>4 (2)</td>
<td>3 (2)</td>
<td>27 (15)</td>
<td>10 (6)</td>
</tr>
<tr>
<td>Male, n (%)</td>
<td>27 (15)</td>
<td>7 (4)</td>
<td>20 (11)</td>
<td>81 (45)</td>
<td>28 (16)</td>
</tr>
<tr>
<td>With UTI, n (%)</td>
<td>13 (7)</td>
<td>0 (0)</td>
<td>13 (7)</td>
<td>8 (4)</td>
<td>0 (0)</td>
</tr>
<tr>
<td>Without UTI, n (%)</td>
<td>21 (12)</td>
<td>11 (6)</td>
<td>10 (6)</td>
<td>100 (56)</td>
<td>38 (21)</td>
</tr>
</tbody>
</table>

*UTI* urinary tract infection, VUR vesicoureteral reflux, VCUG voiding cystourethrogram

*a Voiding cystourethrogram performed on all patients

*b A horseshoe kidney considered as two renal units
Bilateral HN and normal kidneys in RUS

Cross-tabulation was used to study the risk of VUR and UTI in bilateral HN and the risk of VUR in kidneys with normal RUS finding. Bilateral grade 2 HN was found in 71 patients and grade 3 HN in 6 patients. Grade 4–5 VUR was not more common among patients with bilateral SFU grade 2 or 3 HN than that in other patients \( (p = 0.649 \text{ and } p = 0.250, \text{ respectively}) \).

Patients with bilateral SFU grade ≥2 HN did not have a higher risk for UTI than the other patients \( (p = 0.165) \) while patients with bilateral SFU grade ≥3 HN had more UTI than the remaining patients \( (p = 0.024) \).

Table 2  The association of postnatal renal ultrasound findings with high-grade vesicoureteral reflux

<table>
<thead>
<tr>
<th>Risk factor</th>
<th>Grade 4–5 VUR</th>
<th>Grade 0–3 VUR</th>
<th>OR (CI)</th>
<th>( p ) value*</th>
</tr>
</thead>
<tbody>
<tr>
<td>Median renal length (mm) (IQR)</td>
<td>50 (45–58)</td>
<td>55 (50–59)</td>
<td>2.71 (1.48–5.25)</td>
<td>0.002</td>
</tr>
<tr>
<td>Median pelvic APD (mm) (IQR)</td>
<td>9 (16–14)</td>
<td>6 (2–13)</td>
<td>1.02 (0.97–1.06)</td>
<td>0.420</td>
</tr>
<tr>
<td>SFU grade, number of RU</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>0–2</td>
<td>16</td>
<td>184</td>
<td>2.52 (1.15–5.45)</td>
<td>0.019</td>
</tr>
<tr>
<td>3–4</td>
<td>14</td>
<td>64</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Renal parenchymal Thickness, number of RU</td>
<td></td>
<td></td>
<td>2.05 (0.71–5.19)</td>
<td>0.152</td>
</tr>
<tr>
<td>Normal</td>
<td>24</td>
<td>221</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Reduced</td>
<td>6</td>
<td>27</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Distal ureter, number of RU</td>
<td></td>
<td></td>
<td>13.57 (5.96–32.40)</td>
<td>&lt;0.001</td>
</tr>
<tr>
<td>Not visible</td>
<td>11</td>
<td>220</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Visible</td>
<td>19</td>
<td>28</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

\( *P \) value refers to the difference between renal units with grade 4–5 VUR and with grade 0–3 VUR (univariate analysis)

\( ^a n = 29 \) RU

\( ^b n = 246 \) RU

\( ^c n = 30 \) RU

\( ^d n = 248 \) RU

\( ^e \) Non-refluxing hydroureter in six RU

Sixty-five RU appeared normal in RUS (SFU grade was 0 or 1 and the ureter was not visible) and they were compared with the RU with an abnormal appearance in RUS. VUR was detected in seven (11%) of the normal RU \( (p = 0.070) \) but it was grade 4–5 in only one case \( (p = 0.005) \).

Discussion

About 15–21% of the children with prenatal HN have VUR [4, 5]. Since high-grade VUR is associated with an increased risk of UTIs, it would be important to identify the patients with grade 4–5 VUR [6, 20, 21]. However, the recommendation for

Table 3  The study population categorized into three risk groups for high-grade vesicoureteral reflux

<table>
<thead>
<tr>
<th>Risk group</th>
<th>Score*</th>
<th>VUR 0–3 ( (n = 246) )</th>
<th>VUR 4–5 ( (n = 29) )</th>
</tr>
</thead>
<tbody>
<tr>
<td>Low, ( n ) (%)</td>
<td>0–1</td>
<td>201 (82)</td>
<td>6 (21)</td>
</tr>
<tr>
<td>Intermediate, ( n ) (%)</td>
<td>2–3</td>
<td>34 (14)</td>
<td>11 (38)</td>
</tr>
<tr>
<td>High, ( n ) (%)</td>
<td>4–5</td>
<td>11 (4)</td>
<td>12 (41)</td>
</tr>
<tr>
<td>Variable</td>
<td>Beta</td>
<td>Categories</td>
<td>Points</td>
</tr>
<tr>
<td>Renal length</td>
<td>0.98</td>
<td>&gt; 53 mm(^b)</td>
<td>0</td>
</tr>
<tr>
<td></td>
<td></td>
<td>46–53 mm (^b)</td>
<td>1</td>
</tr>
<tr>
<td></td>
<td></td>
<td>&lt; 46 mm (^b)</td>
<td>2</td>
</tr>
<tr>
<td>Ureteral visibility</td>
<td>2.54</td>
<td>Visible (^b)</td>
<td>0</td>
</tr>
<tr>
<td></td>
<td></td>
<td>invisible</td>
<td>3</td>
</tr>
</tbody>
</table>

VUR vesicoureteral reflux

\( ^* \) The risk score table is created by using a logistic multivariate regression model for the following parameters: (1) renal length and (2) ureteral visibility

\( ^b \) The reference category
Postnatal evaluation and follow-up of prenatally detected HN leaves open the question on which patients VCUG should be performed [11]. RUS is commonly used in the follow-up of infants with antenatally detected HN. However, it has been shown that RUS is a relatively insensitive method for screening even high-grade VUR, and a significant number of unnecessary VCUCs are performed [22, 23]. According to the present study, a visible ureter and reduced renal length are significant risk factors for gross VUR; in addition, a visible ureter appears to be associated with febrile UTIs. These

Table 4 The renal ultrasonography findings predicting urinary tract infections in patients with prenatally detected hydronephrosis

<table>
<thead>
<tr>
<th></th>
<th>UTI</th>
<th>No UTI</th>
<th>OR (CI)</th>
<th>p value $^g$</th>
</tr>
</thead>
<tbody>
<tr>
<td>Median kidney length (mm) $^a$ (IQR)</td>
<td>50 (IQR 46–54)</td>
<td>52 (IQR 49–55)</td>
<td>1.71 (0.88–3.41)</td>
<td>0.117</td>
</tr>
<tr>
<td>Median pelvic APD (mm) $^b$ (IQR)</td>
<td>10 (IQR 7–17)</td>
<td>11 (IQR 8–17)</td>
<td>0.97 (0.91–1.02)</td>
<td>0.301</td>
</tr>
<tr>
<td>SFU grade, number of RU</td>
<td></td>
<td></td>
<td>1.49 (0.60–3.85)</td>
<td>0.392</td>
</tr>
<tr>
<td>0–2</td>
<td>9</td>
<td>84</td>
<td></td>
<td></td>
</tr>
<tr>
<td>3–4</td>
<td>12</td>
<td>75</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Renal parenchymal thickness, number of RU</td>
<td></td>
<td></td>
<td>1.53 (0.51–4.08)</td>
<td>0.416</td>
</tr>
<tr>
<td>Normal</td>
<td>15</td>
<td>126</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Reduced</td>
<td>6</td>
<td>33</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Distal ureter, number of RU</td>
<td></td>
<td></td>
<td>4.93 (1.91–12.93)</td>
<td>&lt;0.001</td>
</tr>
<tr>
<td>Invisible</td>
<td>10</td>
<td>130</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Visible</td>
<td>11</td>
<td>29$^h$</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

APD anteroposterior diameter, RU renal units, SFU Society of Fetal Urology, UTI urinary tract infection

$^a$From each patient, the smaller kidney was included

$^b$From each patient, the more abnormal kidney was included

$^c$n = 21 RU

$^d$n = 157 RU

$^e$n = 22 RU

$^f$n = 157 RU

$^g$The patients with UTI against the patients without UTI (in univariate analysis)

$^h$Non-refluxing hydroureter in six RU

Fig. 1 Receiver operating characteristic (ROC) curve (a) and box plot (b) for the risk factors (reduced renal length in standard deviation scale and visibility of the ureter in the renal ultrasonography imaging) for high-grade vesicoureteral reflux in patients with antenatally detected hydronephrosis. Voiding cystourethrogram results were categorized as grade 4–5 and grade 0–3 vesicoureteral reflux. In the ROC analysis, the area under the curve for renal ultrasonography findings was 0.817 (95% CI 0.722–0.912), suggesting relatively good specificity and sensitivity.
findings suggest that RUS can be used to identify HN patients who would benefit from having a VCUG.

The need for postnatally performed VCUG in neonates with antenatally detected HN has been under debate in recent years. VCUG has been shown to be unnecessary in patients with prenatal HN if the postnatal RUS examination is normal [24, 25]. In case HN persists postnatally, the degree of HN does not seem to correlate with the incidence of VUR [8]. Since the grade of HN in RUS seems to be a poor predictor for VUR, further investigation has been made to find better predictors. According to Gordon et al., uroepithelial thickening (appearing as hypoechoic rim within the renal pelvic wall), hydroureter, and duplication are significant independent risk factors for high-grade VUR [26]. In a multidisciplinary consensus statement by Nguyen et al., five parameters were counted: central calyceal dilation, parenchymal thickness, appearance, ureteral dilation, and bladder appearance. Patients were classified into three categories and VCUG was only recommended for high-risk patients, who had peripheral calyceal dilation, abnormal thickness and appearance of renal parenchyma, and abnormal ureter and bladder. According to the statements, in the low-risk groups, the decision on VCUG imaging depends on clinical judgment [11]. In the present study, the RUS images were re-analyzed by an experienced pediatric radiologist; only 3% of 30 RU with grade 4–5 VUR met the high-risk criteria defined by Nguyen et al. (renal pelvic APD > 15 mm, peripheral calyceal dilation, abnormal renal parenchyma, and dilated ureter).

The study by Muensterer showed that patients with increasing degree of VUR tended to have abnormal kidney length more often than other patients [27]. Our results support this finding, showing that short renal length was associated with grade 4–5 VUR. Based on this observation, we created a scoring system that takes into account renal length and ureteral visibility in RUS. The patients were categorized according to the grade 4–5 VUR into low-, medium-, and high-risk categories. Our aim was to reach acceptable sensitivity and specificity to exclude the patients with low risk of grade 4–5 VUR from further VCUG examinations. According to ROC analysis, 79% sensitivity and 82% specificity for grade 4–5 VUR was achieved. Moreover, grade 3 VUR was found in 15 RU, and 6 (40%) of them settled into the high- or moderate-risk group in our scoring system.

According to our previous study, prenatally detected HN with grade 0–3 VUR or non-refluxing hydroureter did not increase the risk of UTI. On the contrary, grade 4–5 VUR was found to be a significant risk factor for UTIs [14]. The current RUS findings were analyzed using UTI as a separate variable in order to find out whether RUS findings differ between patients with UTI and VUR. Only a visible ureter in RUS predicted an increased risk for UTI, whereas renal length or SFU grade did not. This finding differs from the results of Sencan et al., which suggested that SFU grade 4–5 HN increases the risk of UTI [28]. It is also of note that by itself, VCUG causes UTI in about 2% of the examined patients [14]. These findings strengthen the idea that VCUGs should only be targeted at patients at high risk for grade 4–5 VUR.

The main caveat of the study is the relatively small size of the study population; thus, we were not able to perform a sub-analysis between the patients with febrile and afebrile UTI. All infections were, however, well documented. Eighteen (86%) of the 21 patients with UTI had fever ≥ 38.3 °C and additional two afebrile patients were ≤ 35 days of age and may have had pyelonephritis [18]. Secondly, some patients had too short follow-up time to draw any definite conclusion about the UTI risk. In addition, most of the patients received prophylactic antibiotics which may also have influenced the number of UTIs. Only patients with grade 4–5 VUR had breakthrough UTIs suggesting lower risk for infections in subject with grade 0–3 VUR or other causes of HN. Thirdly, due to the retrospective nature of the study and variable fullness of the bladders in the images, neither the bladder wall, renal cortical, nor uroepithelial thickness could be measured reliably. The strength of the study was carefully evaluated patient material and centralized follow-up in the same unit. In addition, the patient records concerning the clinical and radiological follow-up were well documented.

Conclusions

A visible ureter and reduced renal length in RUS are significant risk factors for high-grade VUR. We conclude that a vast majority of the patients with grade 4–5 VUR can be identified in RUS examinations and a significant proportion of unnecessary VCUGs can be avoided.

Acknowledgments We would like to thank Mitja Lääperi, M.Sc., for the biostatistical expertise in our study.

Compliance with ethical standards

The study protocol was approved by the ethics committee at Helsinki University Hospital.

Conflict of interest The authors declare that they have no conflict of interest.

References