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Indirect radionuclide cystography: a sensitive technique for the detection of vesico-ureteral reflux

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Abstract. The detection or exclusion of vesico-ureteral reflux (VUR) has classically been by micturating cysto-urethrography (MCUG). Radionuclide cystography will detect VUR but fails to provide the same detailed anatomical informations as MCUG. This study allowed a comparison of indirect radionuclide cystography (IRC) and MCUG in 65 children. Renal reflux was detected by IRC in 32% of renal units, while VUR was seen in 36% by MCUG. When a comparison was made with MCUG, IRC had a sensitivity of 74.1% and a specificity of 90.5%. The markedly reduced radiation dose, avoidance of a bladder catheter plus the ability to monitor the urinary tract constantly during the entire procedure should ensure that IRC is the examination of choice in follow-up studies for VUR in all toilet-trained children.

Key words: Indirect radionuclide cystography – Vesico-ureteral reflux – Micturating cysto-urethrography

Introduction

Vesico-ureteral reflux (VUR) is considered a major enemy of the paediatric renal tract, being closely related to urinary tract infection (UTI) and pyelonephritic scarring. Controversy exists as to the appropriate imaging for children with a proven UTI with new algorithms appearing annually.

The detection and grading of VUR was established by micturating cysto-urethrography (MCUG), a procedure which requires bladder catheterization and gives a significant radiation dose. Direct radionuclide cystography (DRC) was introduced by Winter in 1959 [1], and allows a significant decrease in the radiation dose which the child receives [2]. Indirect radionuclide cystography (IRC) not only gives an even lower radiation dose [3] but also avoids bladder catheterization. This study was carried out to assess the sensitivity and specificity of IRC at this institution.

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Materials and methods

Two hundred and four children underwent IRC on 236 occasions at this institution between 1987 and 1988. On 14 occasions IRC was judged to be technically inadequate and these were excluded from further analysis. There were 93 boys and 111 girls between 2 and 21 years of age (median age 6.4 years). Sixty-five children underwent IRC on 78 occasions and also had MCUG within 4 months of IRC; this group is the study group. The age distribution was the same for this study group. This gave 149 renal units for analysis.

IRC consisted of i.v. ^{99m}Tc diaminotetraethylpentauretic acid (DTPA) in a dose scaled for body surface area. Shortly after injection, (1–2 h) during which time the child was encouraged to drink freely, a dynamic series of images with a 5-s frame rate were acquired on a dedicated mini computer (Sofa, Paris, France) connected to a large field of view gamma camera (Scintronix, Livingstone, Scotland), starting at least 30 s before micturition and ending 30 s after completion of micturition. Analogue images were obtained throughout the procedure. The computer images were summated to allow creation of three regions of interest, one around each kidney and one around the bladder, from which time-activity curves were generated. Renal reflux was diagnosed if both the renal images and the time-activity curves over the kidneys showed a simultaneous increase in activity [4]. Frequently there was a subsequent secondary increase in bladder activity after the reflux episode as the refluxed radioactive urine drained back into the bladder. No attempt was made to diagnose reflux only into the ureter.

MCUG was carried out in the same institution. The child was catheterized in the radiology department using a 6 Fr feeding tube, the bladder emptied and contrast (18% iodine) run into the bladder under gravity. When the bladder was full spontaneous micturition occurred. Intermittent fluoroscopy was carried out during the examination and 100-mm spot films were obtained.

Results

Renal reflux was detected by IRC in 32% of renal units, while VUR (grades 1–4) was seen in 36% of renal units by MCUG (Table 1). When compared with MCUG, IRC had a sensitivity of 74.1% and a specificity of 90.5%.

Table 1. Comparison of indirect radionuclide cystography (IRC) and micturating cysto-urethrography (MCUG) for the detection of vesico-ureteral reflux (VUR)

IRC		+[a]	−[b]	Total
M				
C	+[a]	40	14	54
U	−[b]	9	86	95
G				
Total		49	100	149

[a] Reflux seen; [b] No reflux

Table 2. Summary of previously published IRC results using either MCUG or direct radionuclide cystography as the gold standard

Study	Year	No. of renal units	Sensitivity	Specificity
Merrick et al. [4]	1977	114	66.6%	79.5%
Nielsen et al.[8]	1985	68	82.4%	44.1%
Bower et al. [9]	1985	54	68.4%	85.7%
Carlsen et al. [10]	1986	193	41.7%	88.5%
Chapman et al. [11]	1988	85	65.2%	56.4%
Present study		149	74.1%	90.5%

Discussion

DRC has been shown to be more sensitive in the detection of renal reflux than MCUG [5, 6], with a reduction in radiation dose by a factor of between 10 and 20 [2]. If this decreased radiation exposure could be coupled with avoidance of bladder catheterization then clinicians would have a minimally invasive method for the detection of renal reflux.

MCUG detects both renal and ureteral reflux whilst IRC confidently detects only renal reflux. The sensitivity (74.1%) of IRC in this study is in keeping with other published data which compare IRC with either DRC or MCUG (Table 2). The first study in 1973 by Handmaker et al. [3] showed that in eight kidneys with VUR by MCUG, there was renal reflux in seven by IRC. Pollet et al. [7] showed 32 children with positive results ba MCUG and negative results by IRC, and 53 children with negative MCUG and positive IRC. Nielsen et al. [8] had 25 children with positive MCUG and negative IRC and 55 with negative MCUG and positive IRC. Bower et al. [9] using a strict definition of reflux (i.e. a scarred kidney together with loss of more than 20% of function plus previous evidence of reflux), recorded, from 54 renal units, 6 which were positive by DRC and negative by IRC and 5 which were negative by DRC and positive by IRC. Carlsen et al. [10] showed that of 193 renal units 21 had a positive MCUG and a negative IRC whilst 18 had a negative MCUG and a positive IRC, giving a predictive negative result for IRC of 87% and for MCUG of 89%, and a predictive positive for IRC of 45% and for MCUG of 42%. Chapman et al. [11] who studied 85 renal units, demonstrated a positive MCUG in 19% with a negative IRC, and a negative MCUG in 20% with a positive IRC. When they looked at only those with severe reflux, however, there were 11% with a negative MCUG and a positive IRC and 1% with a negative IRC and a positive MCUG.

The impression gained from these studies is that the pathophysiological events detected by MCUG and DRC are different. MCUG is the examination upon which the definition of VUR was established, yet the nature of the phenomena as well as the above results suggest that it is an inappropriate examination to use when investigating other techniques. This is especially true if bladder filling artificially provokes VUR. However, we had no other examination to use for comparison purposes. One might conclude from this study that MCUG is more sensitive than IRC but less specific. We propose, however, comparing each examination to the other thus giving equal weight to both examinations. The results would then suggest that IRC has a specificity of 100% while MCUG has a sensitivity of 100%. This would mean that IRC has a sensitivity of 74% and MCUG a specificity of 86%.

There are other studies showing similar results, but relatively few studies which show a low sensitivity for the detection of renal reflux using IRC [12]. An explanation for the discrepancies between MCUG and IRC is that the filling phase of MCUG (or DRC) is not possible with IRC. Willi and Treves [5] showed VUR only during the filling phase of DRC in 3% of all kidneys with reflux. Conway and Kruglik [13] however, found VUR only during the filling phase of DRC in 21% of all cases of reflux. The significance of VUR seen during filling only is uncertain, this makes comparison with MCUG or DRC difficult to interpret. VUR seen prior to but not during micturition has been recorded by IRC [14], and may be the physiological equivalent of VUR seen only during the filling phase of MCUG or DRC. VUR is an intermittent phenomenon, such that, even using the same examination on different occasions, the incidence of VUR varies [15].

This study recorded a failure rate of 7% of the entire population studied; 5 of these 14 children were unable to micturate on demand even though they were toilet trained and 3 children voided as soon as they were placed in front of the gamma camera thus preventing adequate data acquisition prior to micturition. A further 6 studies failed due to technical (equipment) faults. IRC can only be attempted in a child over approximately 3 years of age. In this study there were a few children below this age but they are the exception. As IRC is used more frequently in this hospital, the technician spends time with the child giving a full explanation of the entire procedure and ensuring a good fluid intake by the child. This procedure coupled with technical advances in the equipment has resulted in a lower failure rate in the past year.

The disadvantages of IRC include: an i.v. injection, applicability only to the toilet-trained child, no information about the bladder filling phase or the urethra in the male, poor anatomical resolution, reflux only confidently diagnosed in the upper ureter and kidney, and a failure rate of

7%. This must be weighed against the advantages of IRC which include: information about the function of the kidneys, a reduced radiation dose (by a factor of up to 20 compared with MCUG), a quantifiable physiological study with spontaneous micturition, and avoidance of a bladder catheter. Evaluating any technique for the detection of VUR will remain difficult since there is no absolute accurate method. These results show that IRC has a high sensitivity and specificity; this combined with the low radiation burden and avoidance of bladder catheterization, makes IRC a valuable technique for the detection of renal reflux in the toilet-trained child.

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