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Misleading Appearances in Pediatric Uroradiology

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Abstract. Certain misleading appearances are peculiar to pediatric uroradiology. The most frequently encountered pitfalls are related to the bladder, to vesicoureteral reflux, and to the duplicated collecting system. The bi-chambered nature of the child's bladder, and the rapid settling of contrast material to the most dependent portion causes many pitfalls in diagnosis. When the child is prone, normal ureters may seem to be ectopic, and ureteroceles may become invisible. When the child is supine, the volume of urine in the bladder may be grossly under-estimated. Reflux can mimic function at urography. The dynamic nature of reflux leads to under-estimation of its presence and degree on the IVP and static cystogram. Reflux into an already dilated system can lead to over-estimation of its degree. Aberrant micturition with rapid refilling of the bladder can simulate incomplete emptying. The diagnosis of "ectopic ureterocele" is based on indirect evidence. Any condition that affects the urinary apparatus in the same way will have a similar appearance. A huge ureterocele may have a small ureter, and massive reflux into a lower pole ureter may make the diagnosis of duplication difficult. Ureterocele "look-alikes", and effacement or intussusception of the ureterocele are cystographic pitfalls. Lower pole ureteropelvic junction obstruction and Wilms tumor in the lower portion of a kidney can have surprisingly similar appearances.

Key words: Pediatric uroradiology – Misleading appearances – Bladder – Vesicoureteral reflux – Aberrant micturition – Duplex collecting system – Ectopic ureterocele

Uroradiology in children is different in many ways from uroradiology in adults. This is not only because of the smaller size of the patient and anatomical differences but also because of differences in the frequency with which certain problems are seen. For instance, congenital anomalies are encountered much more often than malignancies.

There are certain misleading appearances that are caused by these differences and if they are not recognized, they can lead to incorrect urographic interpretation and in some cases, inappropriate treatment.

The most frequently encountered misleading appearances are related to the bladder, to vesicoureteral reflux, and to the duplicated collecting system.

This report will describe some of the most common misleading appearances or uroradiological pitfalls and will explain why they occur and how they can be avoided.

Part I: Bladder

The dome of the bladder of the infant and small child is intra-abdominal and situated anteriorly, while the base is intra-pelvic and posterior. This arrangement makes the child's bladder a bi-chambered organ (Fig. 1).

If contrast material remained homogeneously mixed with urine, this anatomic peculiarity would not be of urographic significance. However since contrast material quickly settles to the most dependent portion of any receptacle that it occupies (Fig. 2), the fact that the bladder has a superior compartment that is anterior, and an inferior compartment that is posterior, becomes significant.

"Fake" Ureteral Ectopia

If the child is prone when the radiograph is exposed, so that contrast material settles to the dome of the bladder, the base of the bladder will be filled with non-opaque urine. Ureters whose insertion into the bladder is normal, will then appear to insert infravesically. A supine radiograph will show the true ureter-bladder relationship (Fig. 3 and 4).

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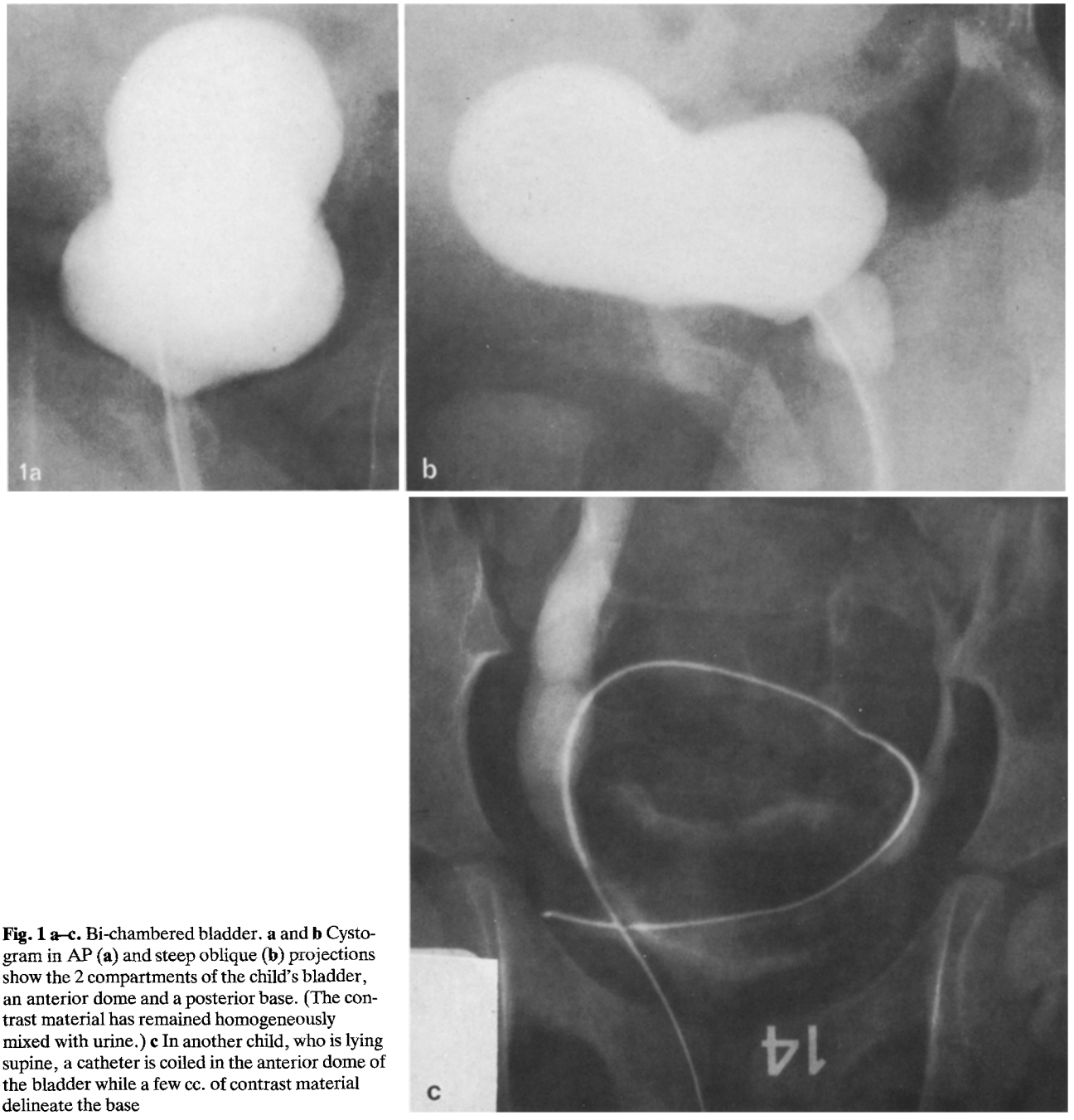


Fig. 1 a–c. Bi-chambered bladder. **a** and **b** Cystogram in AP (**a**) and steep oblique (**b**) projections show the 2 compartments of the child's bladder, an anterior dome and a posterior base. (The contrast material has remained homogeneously mixed with urine.) **c** In another child, who is lying supine, a catheter is coiled in the anterior dome of the bladder while a few cc. of contrast material delineate the base

Ectopic Ureterocele

An ectopic ureterocele is located in the base of the bladder. The radiograph exposed with the child prone, as advocated by some to better visualize the collecting system [3], will result in settling of contrast material in the dome of the bladder. Since the ureterocele is usually seen indirectly i.e. as a defect in the contrast filled bladder, if the base of the bladder contains non-opaque urine, the ureterocele will be invisible. Again a supine radiograph will solve the problem and show the ureterocele (Figs. 5 and 6).

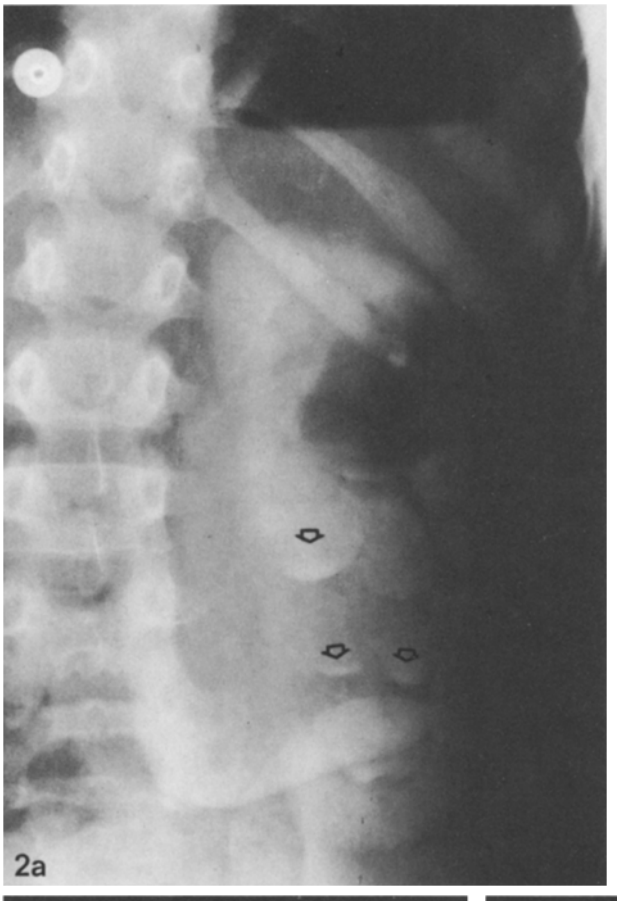
Problems with Estimation of Bladder Volume

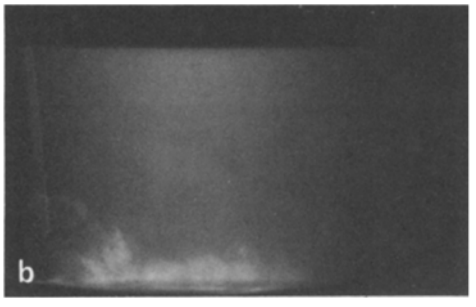
Misleading appearances caused by the settling of contrast material are not all solved by the supine position. In fact, some are caused by it.

With the patient supine and the contrast material settled to the base of the bladder, a large volume of

non-opaque urine may occupy the dome and be unnoticed. This may lead to gross under-estimation of the volume of urine in the bladder. A clue is that the upper edge of contrast material in the bladder is unsharp.

This 12-year-old girl had undergone bilateral ureteral reimplantation for reflux. A periodic IVP had been performed to make sure that obstruction had not occurred at the reimplant sites. The 15 minute "supine radiograph" showed mild fullness of the ureters (Fig. 7a). Because problems with ureteral emptying can be caused simply by a full bladder [4, 11], especially after reimplant, a film after voiding was obtained. Although the patient voided several hundred cc's of urine, the volume in the bladder seemed slightly greater than before, but the caliber of the ureters became normal (Fig. 7b).





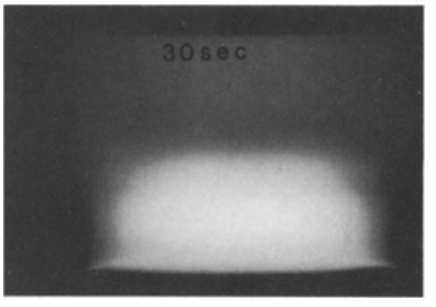


Fig. 2 a and b. Settling of contrast material. **a** In vivo: A radiograph was exposed a few moments after this child with UPJ obstruction assumed the upright position. The contrast material has settled to the most dependent portions of the pelvicalyceal system (arrows). **b** In vitro: Contrast material being instilled via catheter into cup containing normal saline (left) has settled within 30 seconds (right)

Comment. This apparent paradox is explained by the fact that there was a considerable amount of non-opaque urine in the dome of the bladder that was not readily apparent. The actual volume of the urine in the bladder was considerably less after voiding, appearances to the contrary notwithstanding. This assumes special importance when there is hydronephrosis, because a full bladder alone can cause dilatation of the ureter and pelvicalyceal system and the fact that the bladder is actually full may not be recognized.

Conclusions

1. The bi-chambered nature of the child's bladder can lead to problems in urographic interpretation when contrast material settles to the most dependent portion.

2. When contrast material occupies the dome of the bladder on the "prone radiograph" a normal ureter may appear to insert ectopically or a ureterocele may be invisible.

3. Significant under-estimation of the volume of urine in the bladder may occur when the child is supine and contrast material settles to the base.

Part II: Reflux

Vesicoureteral reflux is the abnormal passage of urine from the bladder to the ureters. It is a very dynamic phenomenon, and its presence is best recognized by a fluoroscopically monitored voiding cystourethrogram (VCUG)]16] or a radionuclide reflux study [7].

The method of showing reflux is crucial to its accurate depiction. Understanding its dynamic nature and some of its misleading images is essential for appropriate diagnosis and management.

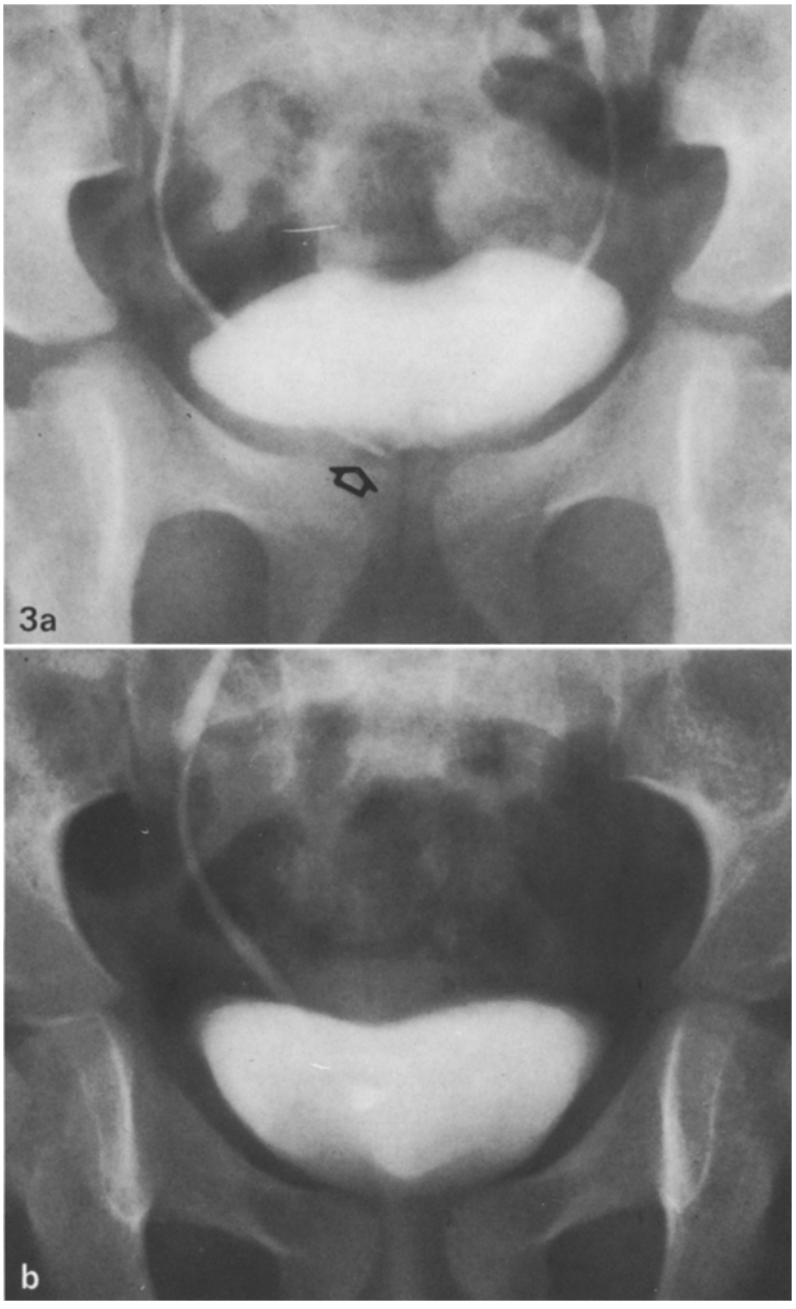


Fig. 3 a and b. „Fake" ureteral ectopia. **a** „Prone radiograph" seems to show infravesical insertion of right ureter (arrow). **b** „Supine radiograph" shows normal ureteral insertion

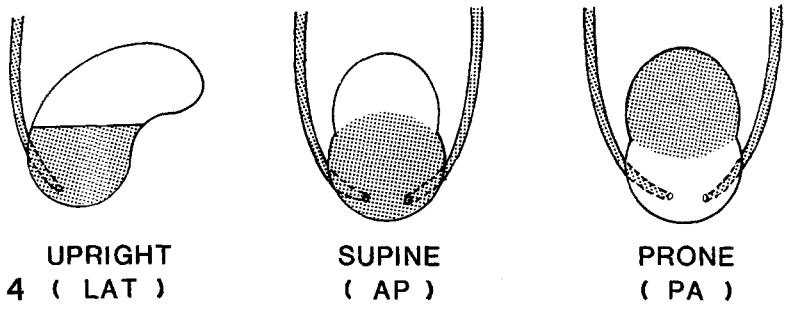


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Fig. 4. Diagrammatic representation of „fake ectopia" phenomenon

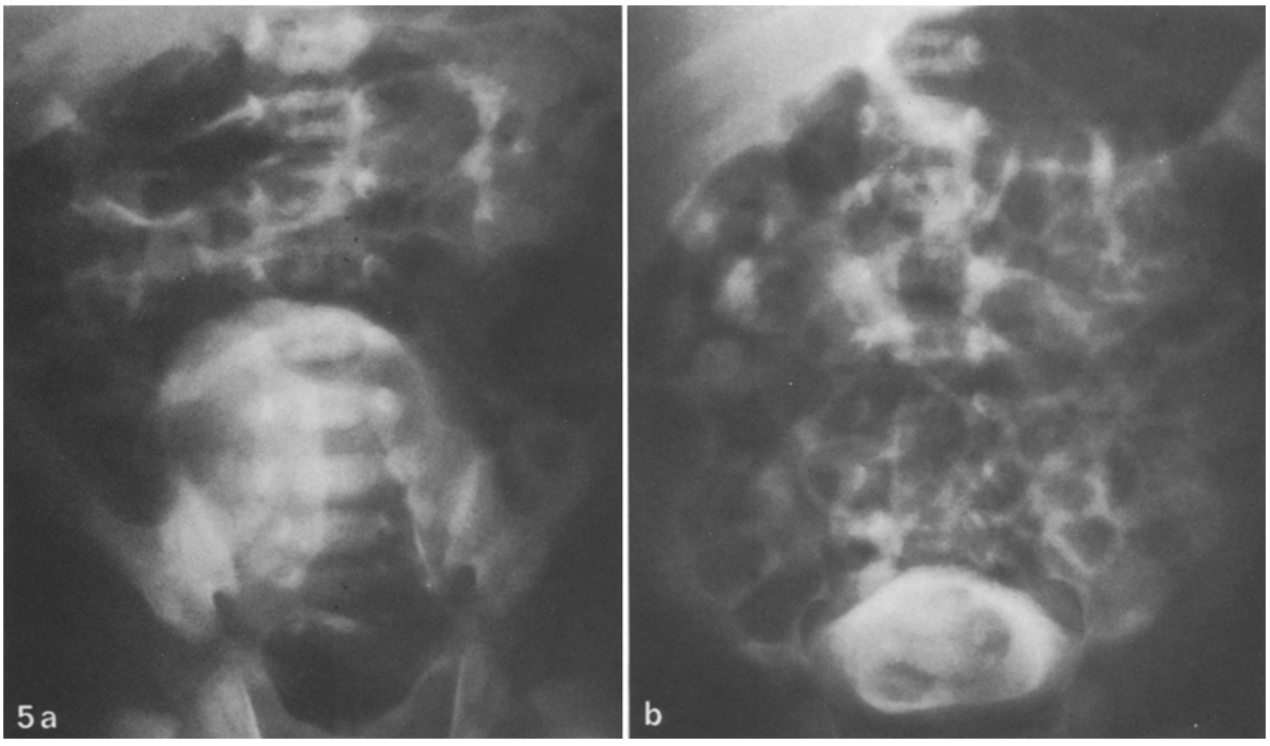


Fig. 5 a and b. Ectopic ureterocele. **a** „Prone radiograph" in a child with right duplex collecting system and ectopic ureterocele. The ureterocele is not seen. **b** „Supine radiograph" clearly shows the ureterocele as a filling defect in the base of the bladder

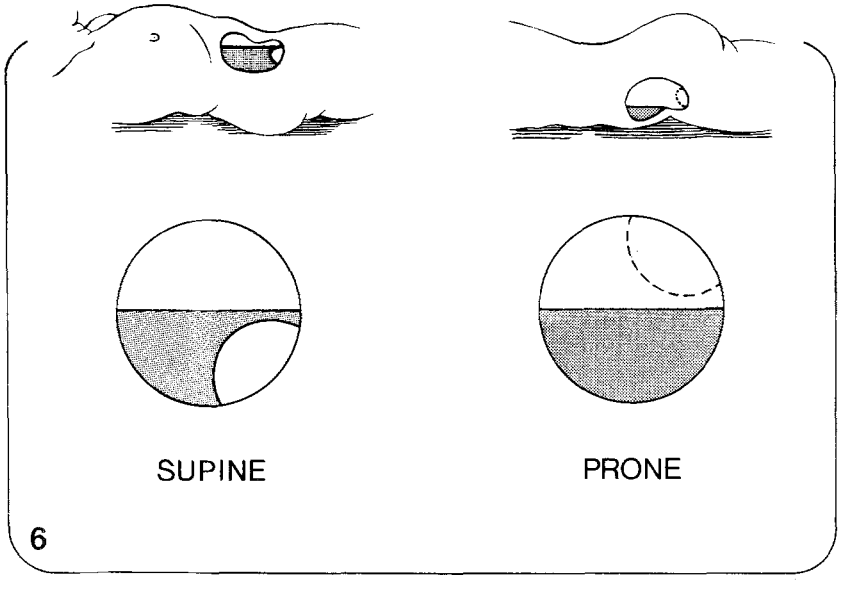


Fig. 6. Diagrammatic explanation of the failure to show the ureterocele when the child is prone, drawn as if the radiographs were taken with a horizontal beam

IVP: Problems of Recognition of Reflux

Reflux Obvious but not Recognized

If an IVP is viewed out of context and without a corresponding VCUG, reflux can be misinterpreted as function [20].

This 1-year-old boy was seen in another hospital. His IVP showed a left duplex collecting system with non-visualization of the upper pole and a typical ectopic ureterocele in the bladder. The ureterocele was incised at cystoscopy. Repeat IVP showed the upper pole collecting system to good advantage, filled with concentrated contrast material (Fig. 8a).

This was misinterpreted as return of function after relief of obstruction. The boy was then referred to Children's Hospital Medical Center (CHMC) for further evaluation.

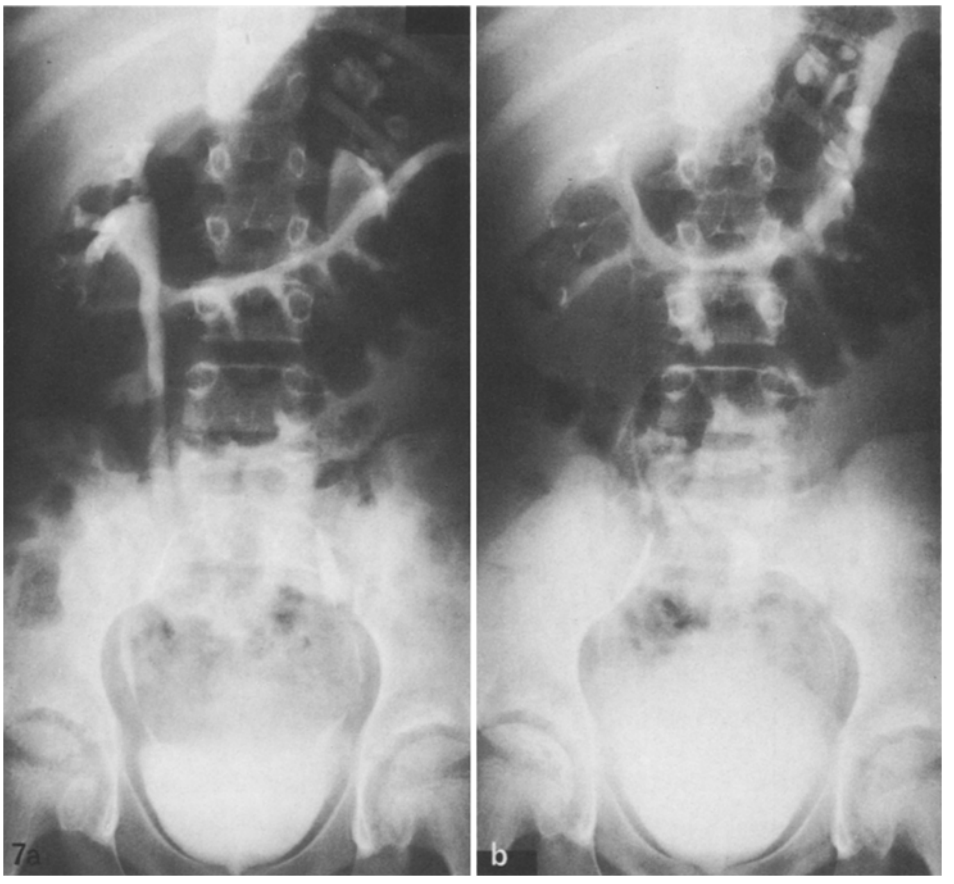


Fig. 7 a and b. Under-estimation of bladder volume (,,supine radiographs"). **a** IVP after ureteral reimplants reveal slight fullness of ureters and right pelvicalyceal system, raising the possibility of mild UV obstruction. The bladder does not appear to be very full. Note that the upper margin of contrast material in the bladder is unsharp. **b** After several hundred cc's were voided, the collecting systems and ureters have drained, suggesting that the hold-up at the UV junction was due to the full bladder [4, 11]. However the bladder appears to be fuller! This is because there was a large volume of non-opaque urine in the dome of the bladder which was not readily apparent on film **a**

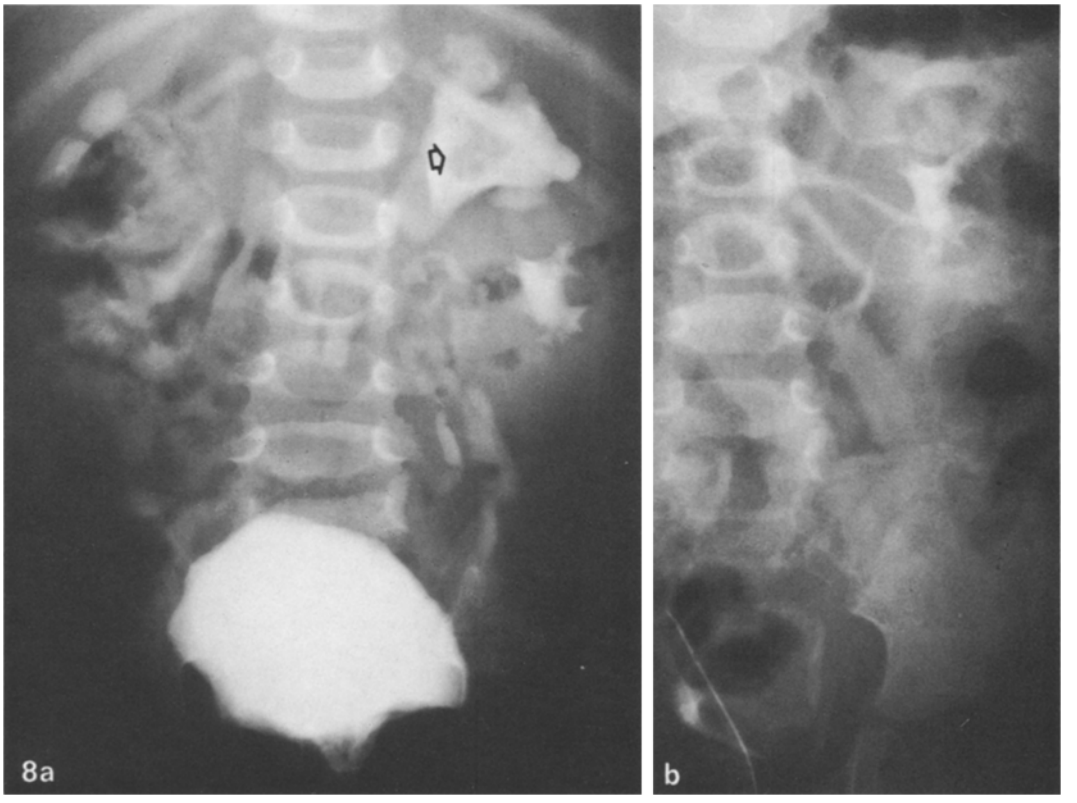


Fig. 8 a and b. Reflux mimics function. **a** IVP (not shown) before incision of left ectopic ureterocele showed non-visualization of the left upper pole collecting system. The film shown here from a post-operative IVP shows the upper collecting system exceedingly well. It should have been realized that this was reflux mimicking function, especially since there are air bubbles (arrow) from a recent catheterization. **b** Repeat IVP at CHMC with reflux prevented by a catheter draining the bladder. There is no excretion by the left upper moiety

A repeat IVP, with a catheter draining the bladder to prevent reflux, showed non-function of the upper pole (Figure 8B). This was confirmed by nuclear medicine studies and so the upper pole was removed.

Comment. Reflux through the incised ureterocele was mimicking function. (Reflux during the IVP can also lead to under-estimation of function [20].)

Reflux not Obvious and Difficult to Recognize

If it is important to the management of the patient to know if reflux is present, and if so, on which side and what degree, then a normal IVP cannot be used as a reason for not performing the VCUG. Reflux is a very dynamic phenomenon and the IVP is notorious for under-estimating its presence and degree [14]. The IVP is a series of static images, each picturing the urinary tract for just a fraction of a second, and timed relative to the injection of contrast material. If the wave of reflux is not occurring at the instant the film is exposed, and if the tone of the collecting system is good and kidney damage has not occurred yet, then reflux, even severe in degree, may not be suspected (Fig. 9).

VCUG: Problems with Method

The severity of the abnormality at the ureterovesical junction that permits reflux is directly proportional to the maximum degree of reflux seen during a properly performed VCUG [14, 16]. Like the IVP, a static VCUG under-estimates the presence and degree of reflux [5, 14]. Therefore a negative static cystogram in no way excludes the presence of even severe reflux (Fig. 10).

VCUG was performed 6 months after bilateral anti-reflux surgery in this 5-year-old boy. Static cystogram showed only left grade 1 reflux and so it was presumed that the surgery had been successful. However, *voiding* cystography showed massive bilateral reflux, revealing that the surgery had failed.

VCUG: Interpretation Problems

Reflux of contrast material into the vagina during VCUG is seen commonly [1, 15]. Also, in young girls, the pelvic organs are closely approximated. If these features are not appreciated when interpreting VCUG images, it may appear that the ureter has an ectopic insertion into the vagina. This can be especially confusing if the patient has a duplex collecting system (Fig. 11).

This 5-year-old girl underwent urography because of urinary tract infection and wetting. The VCUG showed reflux into the distal portion of a left ureter and filling of the vagina. This was misinterpreted as reflux into an ectopic upper pole ureter inserting into her vagina. In reality the reflux occurred into a normally inserted ureter from the lower pole of a duplex collecting system.

VCUG: Grading Reflux

Grading reflux is extremely important because the degree of reflux is inversely proportional to the likelihood of spontaneous resolution, regardless of whether the reflux is congenital or acquired [9]. The grading system is based on the degree of dilatation and tortuosity of the ureter and the degree of dilatation of the collecting system. It assumes that reflux caused the dilatation [6].

If reflux occurs after an operation into an already dilated system, the degree of reflux may be over-estimated (Fig. 12).

This 10-year-old boy underwent ureteral reimplant for primary obstructed megaureter. The routine post-op VCUG 6 months later showed reflux. Superficially, this appeared to be grade 3 reflux, that would not be expected to disappear spontaneously. However, in reality, this was only a small amount of reflux into a previously dilated system and it subsided spontaneously by the time the next VCUG was performed 6 months later.

Comment. Failure to recognize this misleading feature might have lead to unnecessary re-operation.

VCUG: Aberrant Micturition

In 1966, Hutch introduced the term "aberrant micturition" to describe partial emptying of the bladder through incompetent ureteral orifices or into diverticula, with subsequent rapid refilling of the bladder [13] (Fig. 13). Appreciation of the frequent occurrence of this phenomenon has paralleled the use of fluoroscopic monitoring for the VCUG. Failure to recognize aberrant micturition can lead to the false idea that both the reflux (or the diverticulum) and the residual urine in the bladder (a fake residual) are secondary to distal obstruction (Fig. 14) [20].

Conclusions

1. The recognition of reflux is essential to the management of patients with urinary tract infection and the dynamic VCUG is necessary for its detection, even if the IVP is normal.

2. The grade of reflux is also important to management, but the degree may be over-estimated if it is into an already dilated system.

3. Reflux can mimic function on an IVP. This pitfall can be avoided if a catheter drains the bladder during the study.

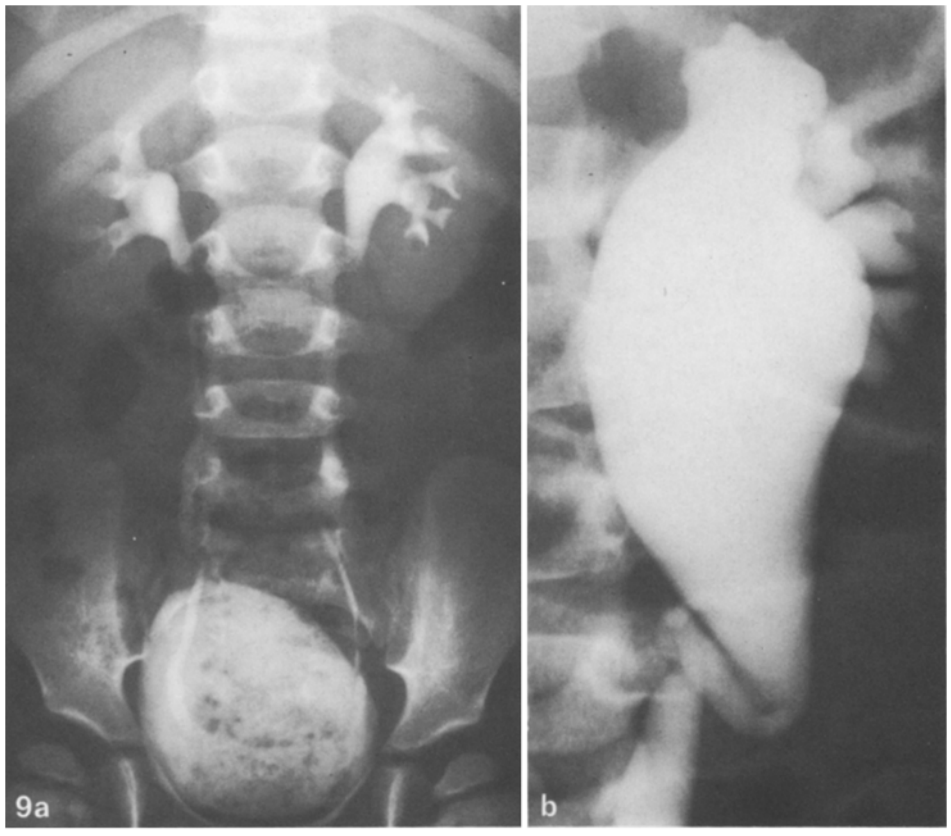


Fig. 9 a and b. IVP under-estimates reflux. **a** Normal IVP. **b** VCUG 1 day later shows massive left reflux

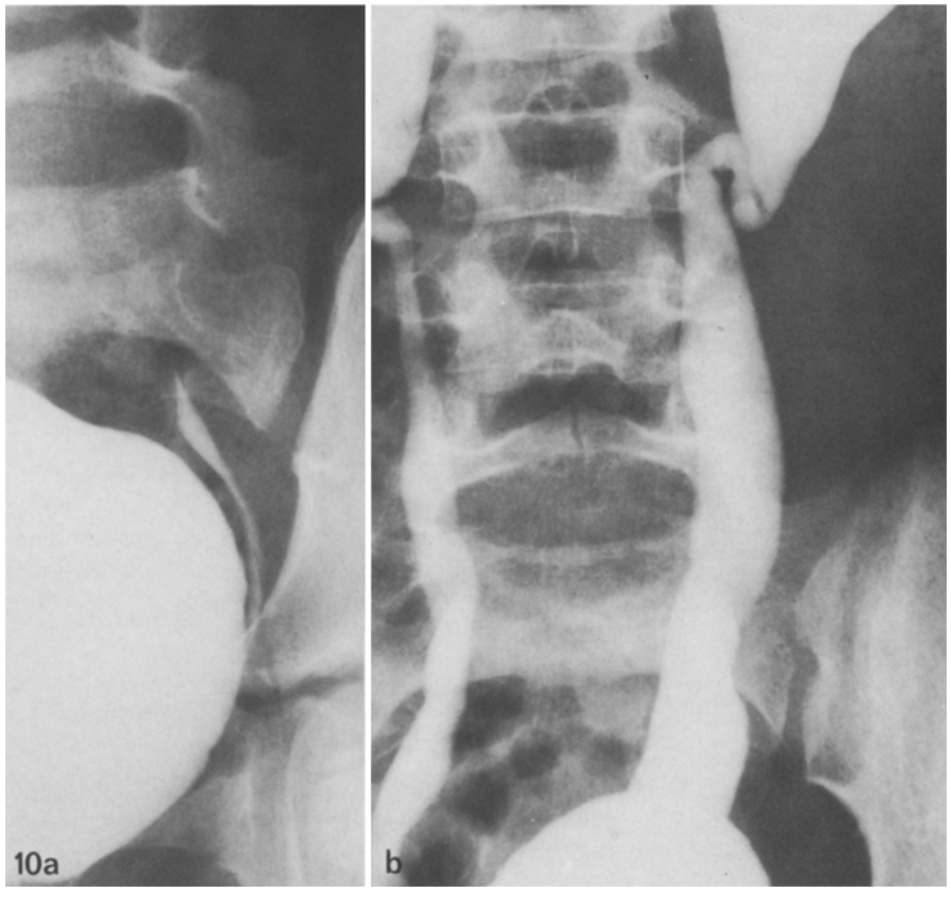


Fig. 10 a and b. Static cystogram under-estimates reflux. **a** *Static* cystogram shows minimal left reflux. **b** *Voiding* cystogram, including serial brief observations by fluoroscopy, allows one to see the maximum degree of reflux which in this case is bilateral and severe

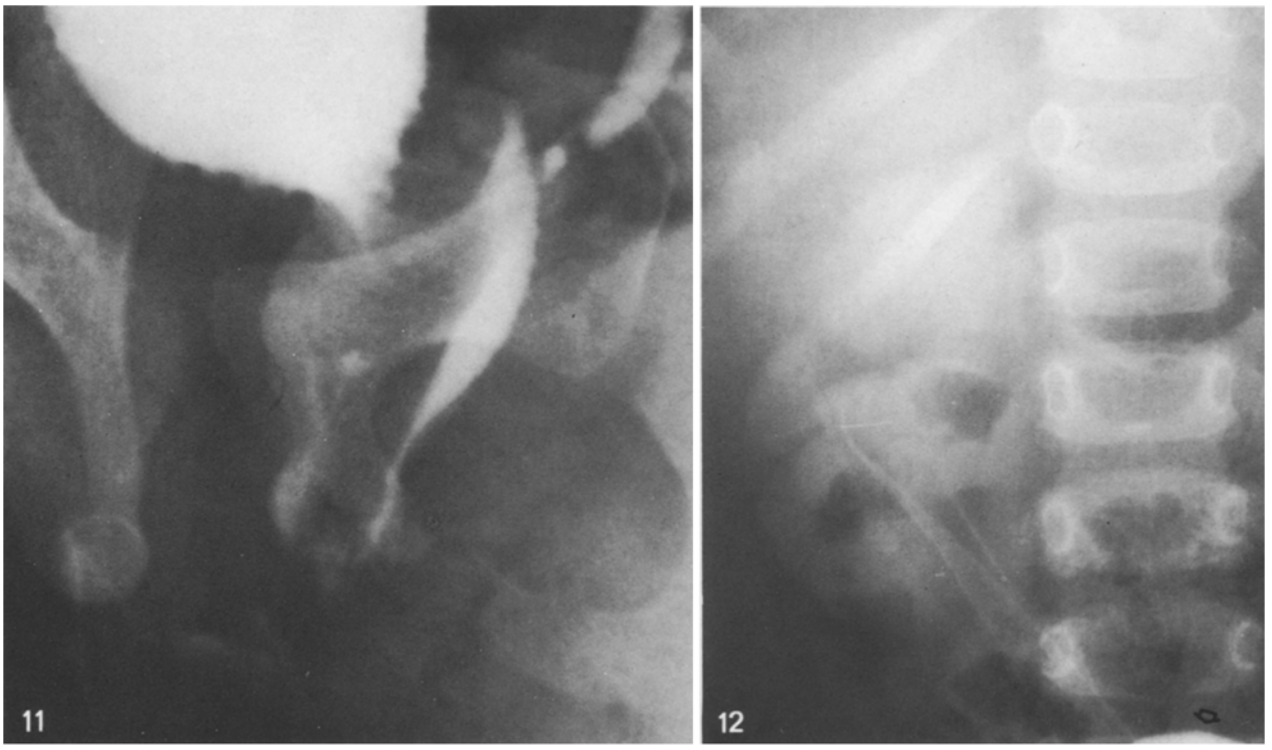


Fig. 11. „Fake" ureteral ectopy: The VCUG in this girl with a left duplex collecting system shows minimal reflux into the left lower pole ureter *plus* reflux into the vagina. This was misinterpreted as reflux into a vaginal ectopic ureter that served the left upper moiety

Fig. 12. Over-estimation of degree of reflux: This boy had reimplant of a right primary (obstructed) megaureter. Post-operative VCUG shows faint opacification by reflux of the still dilated right pelvicalyceal system. This could be misinterpreted as severe reflux. In actuality, it is minimal reflux into a still dilated system. Note the dilution of refluxed contrast material compared to that in the bladder (arrow). The next VCUG some months later (not shown) showed that the reflux had disappeared spontaneously

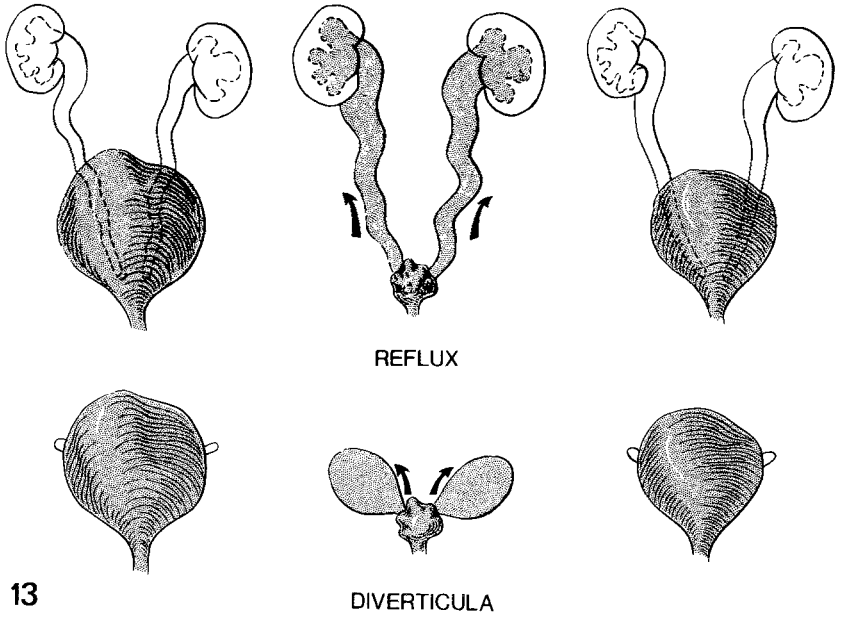


Fig. 13. Aberrant micturition: Diagrammatic representation

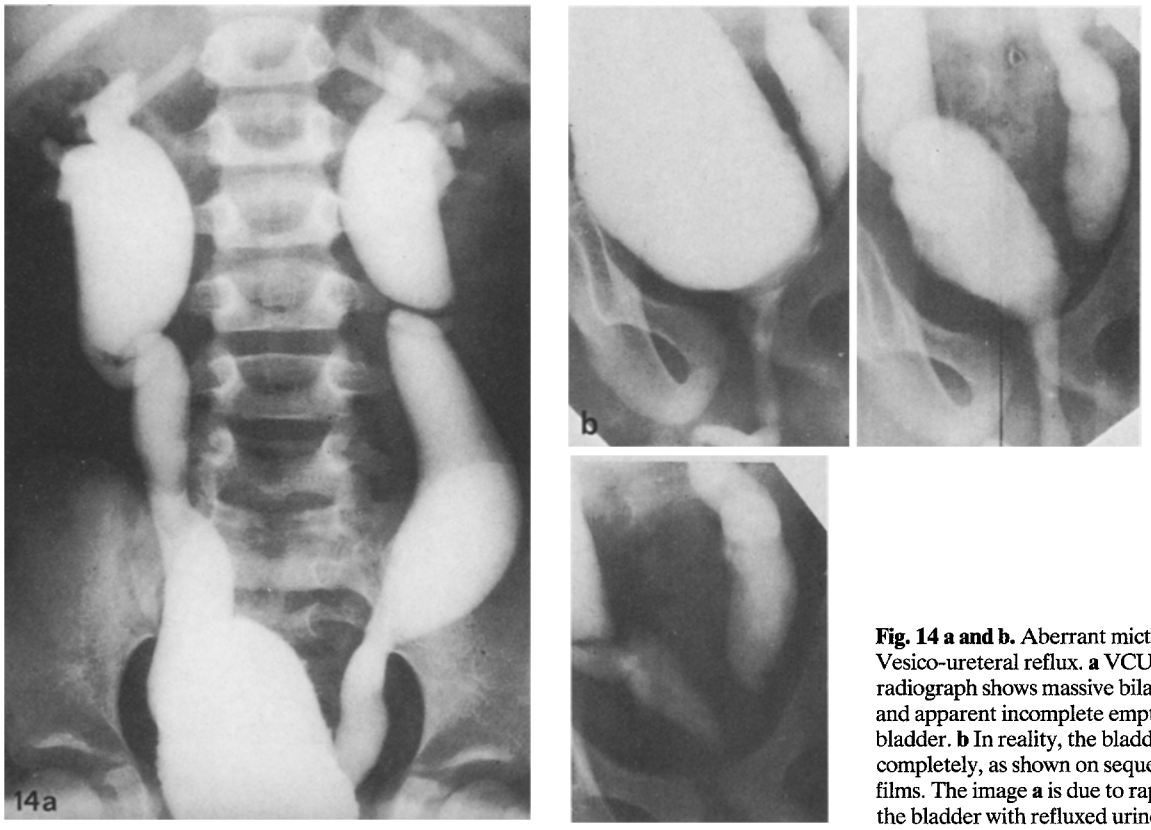


Fig. 14 a and b. Aberrant micturition: Vesico-ureteral reflux. **a** VCUG: Post-void radiograph shows massive bilateral reflux and apparent incomplete emptying of the bladder. **b** In reality, the bladder empties completely, as shown on sequential spot films. The image **a** is due to rapid refilling of the bladder with refluxed urine

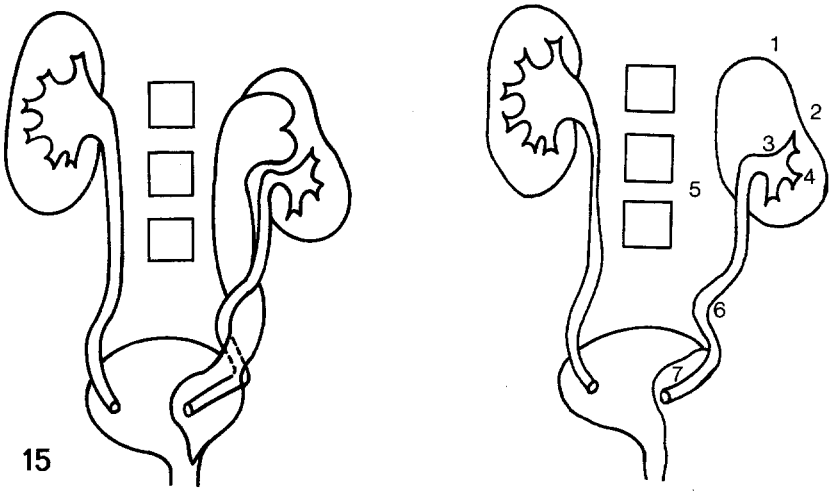


Fig. 15. Diagrammatic representation of anatomic and urographic appearances of „ectopic ureterocele". The latter depend on the effects that the non-visualized dilated upper unit has on its lower pole mate. These are: 1) increased distance from top of nephrogram to top of collecting system, 2) abnormal axis of collecting system, 3) concave upper border of renal pelvis, 4) diminished number of calyces compared to opposite side, 5) lateral displacement of kidney and ureter, 6) spiral course of ureter and 7) filling defect in the bladder

4. Aberrant micturition with rapid refilling of the bladder by the refluxed urine can lead to the false impression that the bladder has not emptied completely. The fluoroscopically monitored VCUG can prevent this error.

Part III: Duplex Collecting System

Duplication of the collecting system is the most common anomaly seen on the urogram of the child [12]. The degree of duplication varies from a bifid pelvis to

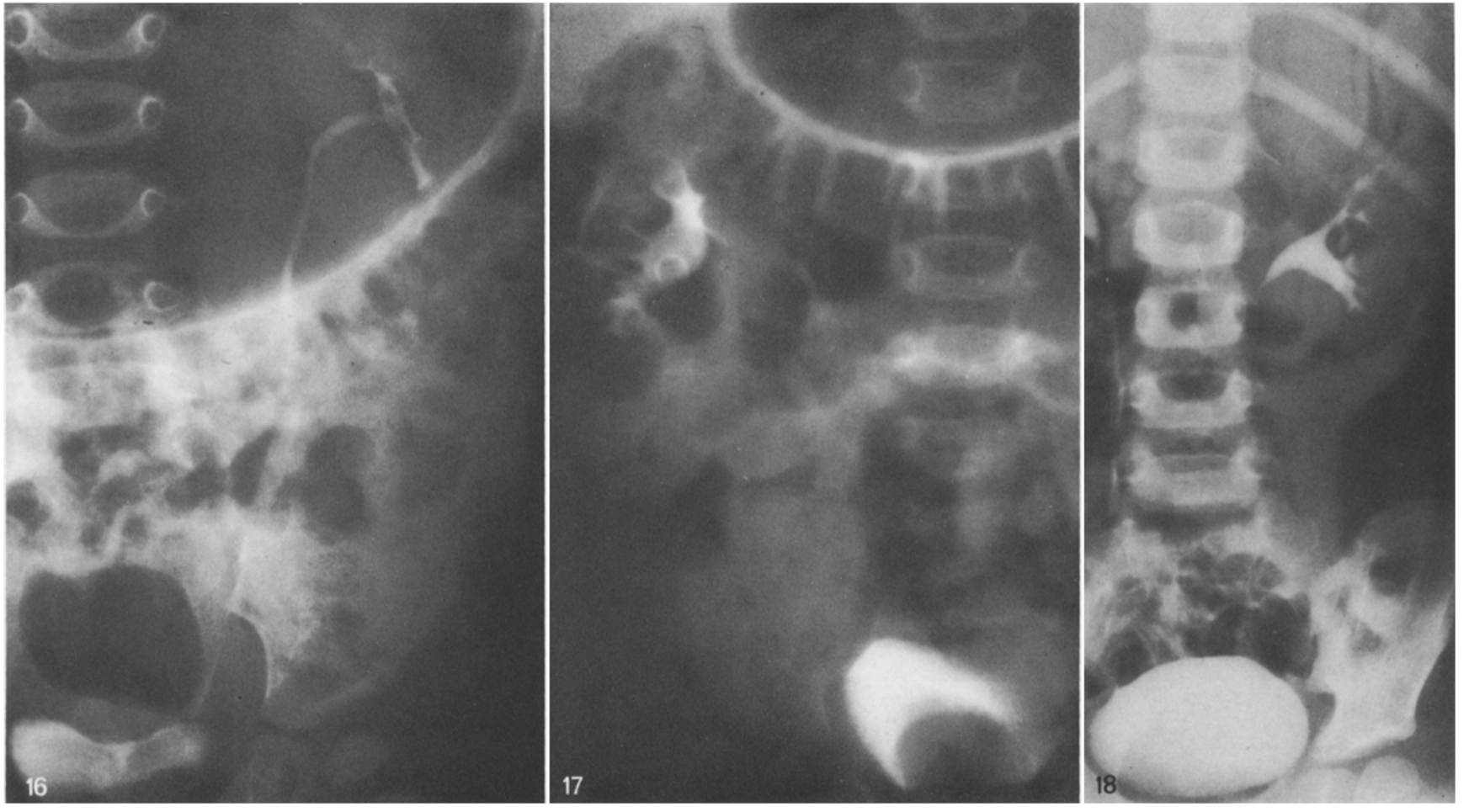


Fig. 16. Retroperitoneal and pelvic cystic hygroma (lymphangioma) was mistaken for duplex system with hydronephrotic upper unit. Although there is lateral displacement of the kidney and ureter and a ,,defect" in the bladder, the renal axis is normal and the ureter is straight

Fig. 17. Neurofibromatosis of retroperitoneum and bladder was mistaken for ectopic ureterocele as in Figure 2. Note, however, that the axis of the kidney is normal and that there is a normal complement of calyces. (The child also had cafe-au-lait spots and a positive family history!) (Courtesy of Doctors R. Suberman and J. Scatliff.)

Fig. 18. Renal carbuncle involving upper portion of left kidney. Child was referred with diagnosis of duplex system with non-visualization of upper unit. Although there is increased distance from top of the nephrogram to the top of the collecting system and the axis of the collecting system is abnormal, none of the other signs is present

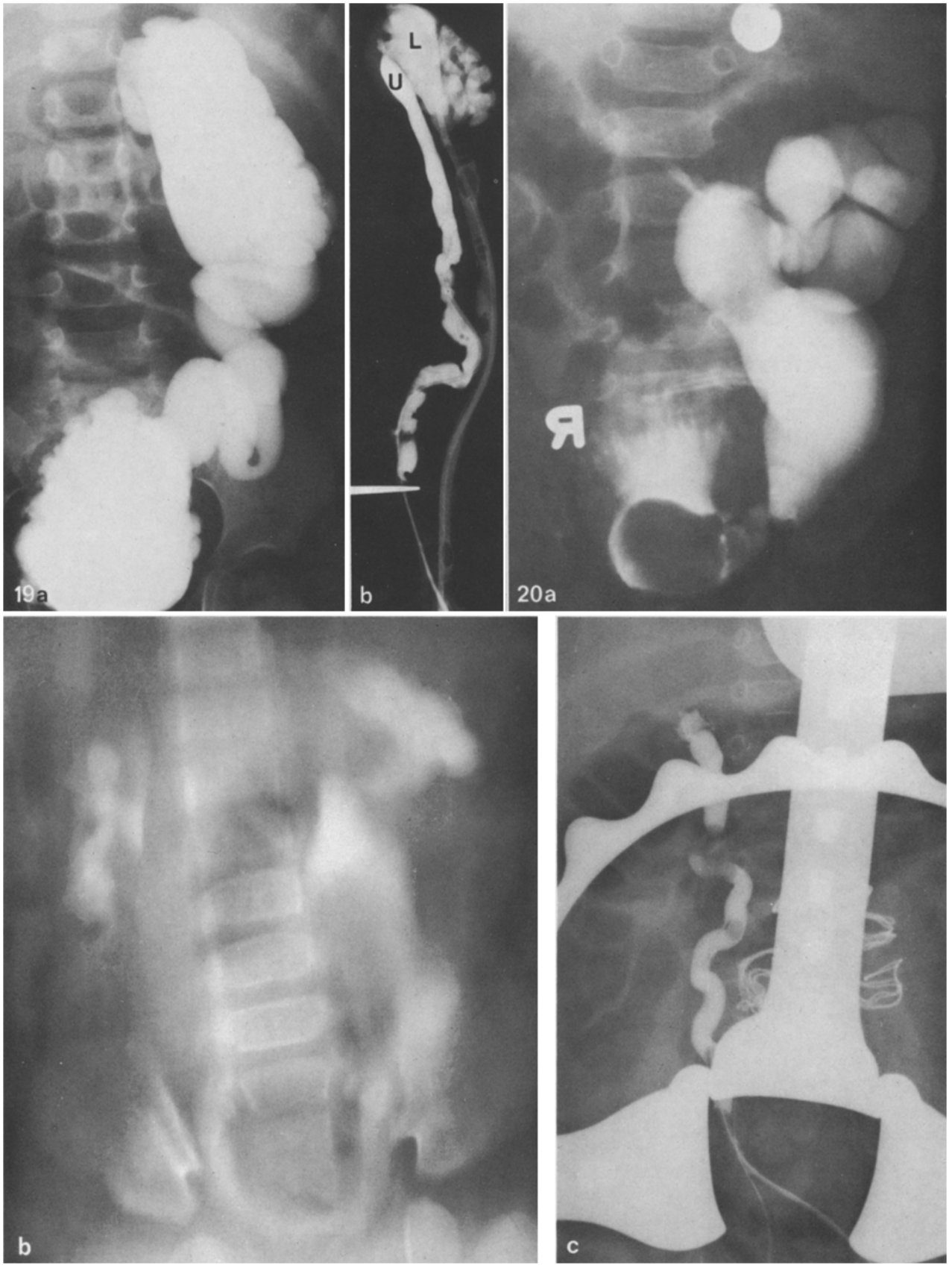
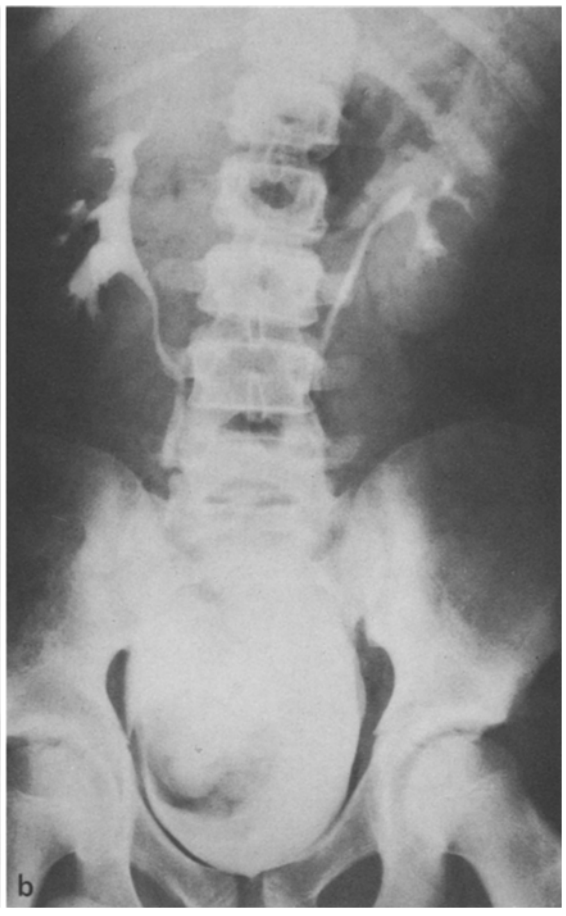


Fig. 19 a and b. Massive reflux into lower system and non-function of the non-dilated upper system led to the mistaken impression that this boy had only a single collecting system on the left. **a** VCUG showing massive left lower pole reflux. **b** Injected pathological specimen after left nephroureterectomy, showing relatively normal caliber upper system (U) and decompressed lower system (L)

Fig. 20 a–c. Size of ureterocele *not* proportional to size of ureter and collecting system. **a** VCUG: Massive left lower pole reflux and huge ureterocele. **b** IVP (tomographic section): Excellent function of left upper pole and simultaneous persistence of filling defect in the bladder ruled out the initial presumption that the ureterocele was associated with the left upper pole. The right kidney was thought to have a single collecting system and so the origin of the ureterocele was unclear. **c** Retrograde: Injection of contrast material into ureterocele at time of cystotomy showed that it was associated with a non-dilated non-functioning *right* upper unit



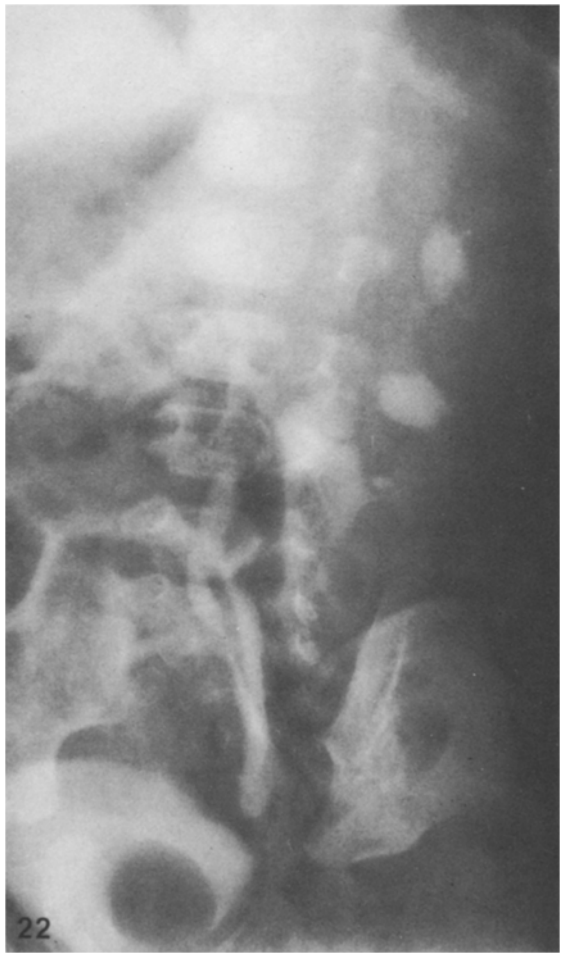
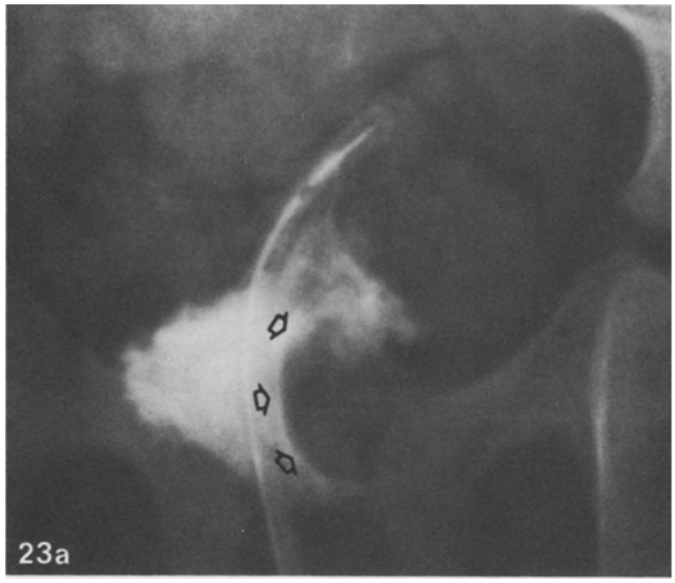
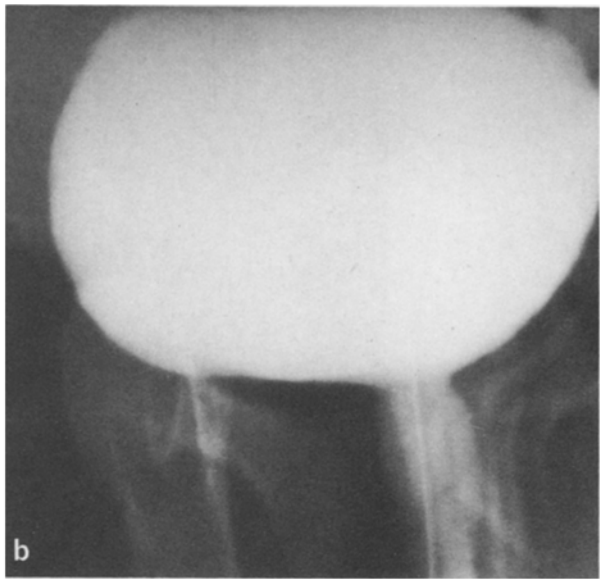


Fig. 21 a and b. Ureterocele „look-alikes". **a** Air bubble from prior catheterization (arrow) mistaken for ureterocele. **b** blood clot in bladder mistaken for ureterocele. Displacement of right kidney thought to be confirmatory. IVP done for trauma. (Note blood clots in left renal pelvis.)

Fig. 22. Ureterocele „look-alike". Almost perfectly spherical ureterocele (from single, non-duplex collecting system of non-functioning right kidney) mistaken for balloon of Foley catheter





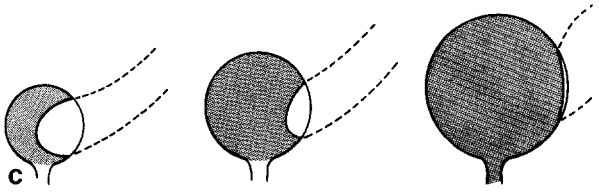
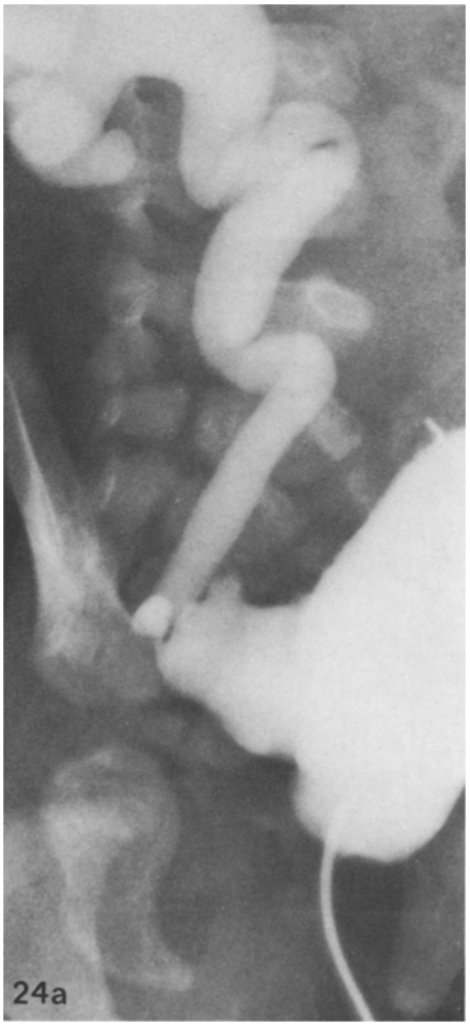


Fig. 23 a–c. Effacement of ureterocele. **a** VCUG: Ureterocele in partially filled bladder. **b** VCUG: Ureterocele effaced and invisible when bladder full and patient voiding. **c** Diagrammatic representation



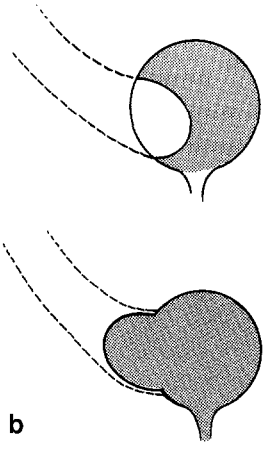
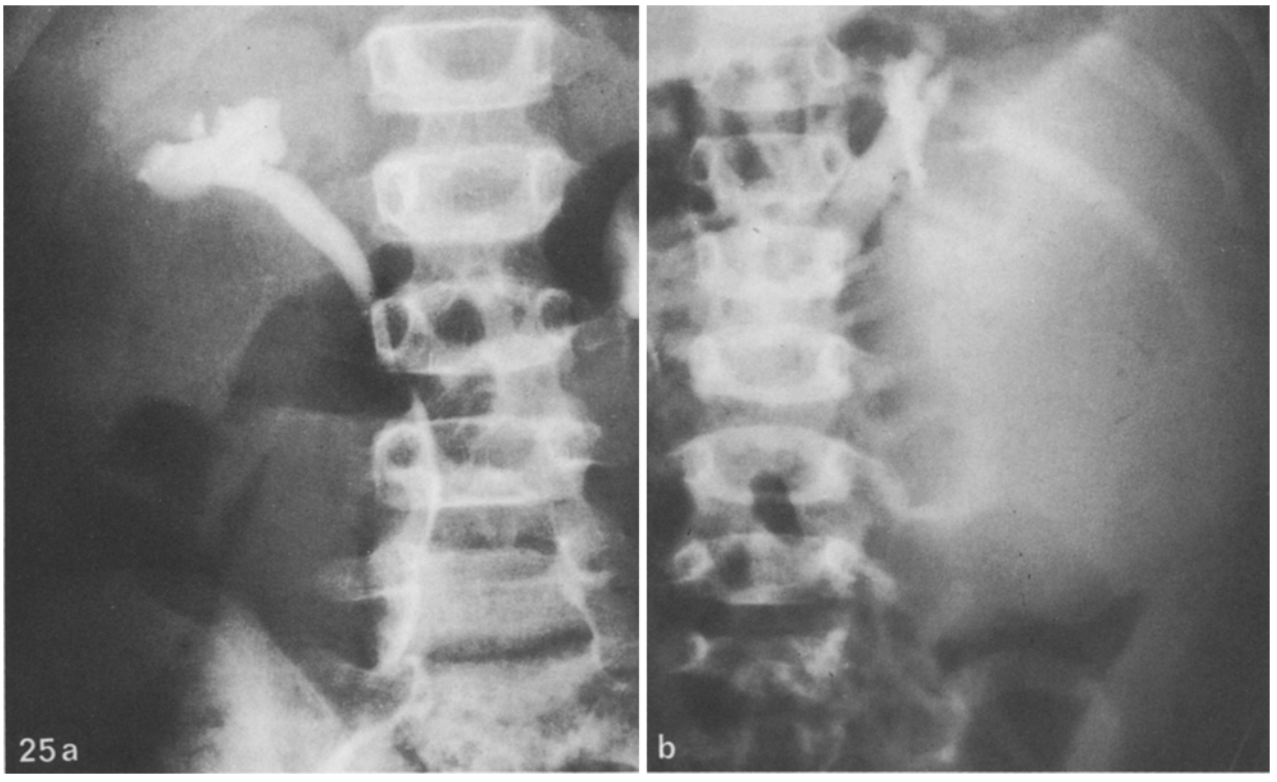


Fig. 24 a and b. Intussusception of ureterocele. **a** VCUG: Partially filled bladder showed typical right ureterocele (not shown). With bladder full, ureterocele intussuscepts into its own ureter and resembles a bladder diverticulum. Reflux into lower pole ureter makes this image especially misleading. It is easily confused with reflux into a single collecting system caused by a para-ureteral diverticulum. **b** Diagrammatic representation



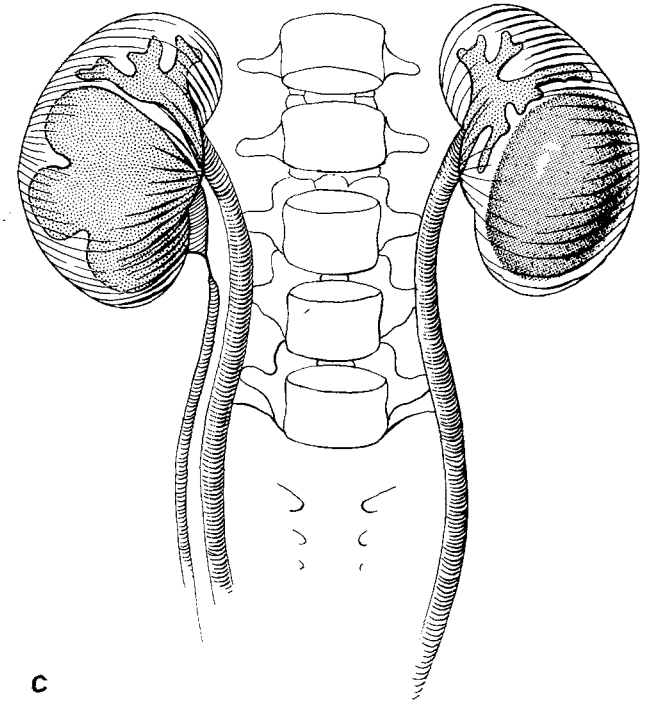


Fig. 25 a–c. Lower pole ,,look-alikes". **a** and **b** UP junction obstruction of lower pole of duplex system **a** bears striking resemblence to Wilms' tumor in lower pole of kidney with single collecting system **b**. **c** Diagrammatic representation

two completely separate units. Most duplex collecting systems are normal but if there is an abnormality, it is usually either obstruction of the upper moiety and/or reflux into the lower. Several urographic pitfalls are associated with each of these entities.

The Obstructed Upper Pole on the IVP

In most children the hydronephrotic upper pole collecting system is not actually seen at urography, but its presence is inferred because its effects on its lower

pole mate and on the bladder are recognized (Fig. 15). Usually, therefore, the urographic diagnosis of an obstructed upper moiety is indirect [10] and although the findings are strongly suggestive, any condition which affects the kidney, ureter or bladder in the same way will have a similar appearance. When any of the 7 urographic findings of upper pole obstruction (Fig. 15) are seen, great care must be taken to search for the others, and the more that are present, the more certain is the diagnosis. Failure to follow this approach has led to the incorrect diagnosis of upper pole obstruction in patients with: retroperitoneal cystic hygroma (Fig. 16), neurofibromatosis (Fig. 17), renal abscess (Fig. 18), ganglioneuroma, neuroblastoma and paraspinal abscess.

Another diagnostic pitfall occurs if the upper pole collecting system is not very dilated and there is massive reflux into the lower pole. In this situation, not only is the upper pole invisible, but it has no effect on the lower. In addition, the lower pole anatomy is so distorted that it is often mistaken for a single collecting system (Fig. 19) [17].

It is also important to remember that the size of the ureterocele is not necessarily proportional to the size of the ureter and the collecting system from which it arises (Fig. 20) [2].

The Cystogram and the Ureterocele

Since the ectopic ureterocele itself is usually seen as a defect in the contrast filled bladder, its diagnosis too is based on indirect evidence. Anything that causes a "defect" in the bladder may be mistaken for a ureterocele (Fig. 21). Conversely, a ureterocele can be so spherical that it can be mistaken for the balloon of a Foley catheter (Fig. 22). Again, the other urographic findings of upper pole obstruction (Fig. 15) must be searched for before a defect in the bladder can be called a ureterocele with certainty.

In two instances, transiently, the ureterocele does not have its characteristic appearance on the cystogram. First, when the bladder is too full, the ureterocele can be effaced and becomes virtually invisible (Fig. 23). (This occurs not only at cystography but also at cystoscopy) [21]. Second, when the pressure in the bladder exceeds the pressure in the ureterocele, the ureterocele may be everted or intussuscepted into its own ureter and be mistaken for a bladder diverticulum. This becomes especially misleading if there is also reflux into the lower pole ureter (Fig. 24) [8, 19].

Obstruction of the Lower Pole

Obstruction of the lower pole of the duplex system is rare but when it occurs, the obstruction is usually at the ureteropelvic (UP) junction [18]. We have found that UP obstruction of the lower pole of the duplex system and Wilms' tumor involving the lower half of the kidney can have virtually identical urographic appearances (Fig. 25). Therefore, every effort must be made to distinguish between the cystic nature of the former and the solid nature of the latter. Depending on the circumstances, this can be accomplished by either total body opacification or ultrasound.

Conclusions

1. Since the urographic diagnosis of complete duplication of the collecting system, with upper pole hydronephrosis, rests mainly on indirect evidence, any condition that affects the urinary apparatus in the same way will have a similar appearance. The more of the seven urographic signs of "ectopic ureterocele" that are present, the more certain is the diagnosis.

2. The less dilated the non-visualized upper moiety, and the more dilated the refluxing lower unit, the more difficult is the diagnosis of duplication.

3. The size of the ureterocele is not necessarily proportional to the size of its ureter and collecting system.

4. Any defect in the contrast filled bladder can mimic a ureterocele and conversely, a ureterocele can be mistaken for a balloon from a Foley catheter.

5. The ureterocele can be effaced, and become virtually invisible, if the bladder is too full either at cystography or cystoscopy. It can also become everted or intussuscepted and resemble a bladder diverticulum.

6. Lower pole hydronephrosis, caused by obstruction at the UP junction, and Wilms tumor in the lower part of the kidney, are "look-alikes".

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