“Routine” radiologic studies do not, often enough, concentrate on the part of the anatomy and physiology of importance for the diagnosis. The close cooperation between the pediatrician, urologist and the radiologist will insure more useful uro-radiographic studies on which rational clinical decisions can be based. The child’s signs and symptoms, as well as the anatomic and physiologic information needed, dictate the type and order of the radiographic studies. It is beyond the scope of this paper to go into the indications for specific uro-radiographic studies. The radiographic techniques will be presented.

Cystourethrography. There are several methods for studying the bladder, urethra and vesicoureteral reflux. The method used most often is filling the bladder via a urethral catheter in a retrograde manner, either by gravity or by injecting the contrast material. Radionuclide introduced into the bladder can be used as an adjunct to radiographic investigation of reflux.

Cystourethrography can be done at the end of the intravenous pyelogram. This method avoids a urethral catheter and would appear to be more physiologic. The child voids immediately before the intravenous injection of contrast material. The administration of as much as 5 ml per kg of 50% or 60% contrast material is recommended. There are, however, several limitations of this method—the patient must be cooperative and usually several years of age. Another disadvantage is that often parents or an aid must be kept in the Radiology Department with the patient for several hours, adding to generally crowded waiting areas. The bladder must become sufficiently distended to stimulate the urge to void.

Contrast in the lower portion of the ureter during the voiding phase presents the problem of differentiating between urine flow from the kidney and reflux into a ureter that maintains its normal caliber.

Cinecystourethrography came into wide use in the mid 1950’s. The chief contribution of cine recording was its revelation of the importance of performing the procedure under fluoroscopic control. Fluoroscopy during the voiding phase of cystourethrogram allows optimal timing of films for the permanent record. Dissatisfaction with the cine procedure is that it has poor resolution, and that it delivers a large radiation dose to the patient’s gonads. Fluoroscopy with video tape recording for the documentation of motion, and spot filming with 70, 90 or 105 mm film is diagnostic with less radiation than cinefluoroscopy. Video tape recording delivers no additional radiation to the patient beyond that required for image-intensification fluoroscopy.

Retrograde filling of the bladder by gravity permits the observation of reflux at low or high water pressure. In the absence of infection, low pressure reflux is considered a more significant observation when making a decision about reimplanting a ureter. Sufficient distention of the bladder can be obtained by gravity filling to stimulate voiding.

The normal male urethra demonstrates many variations. Sequential spot x-rays avoid confusion of normal anatomical structures (fig. 1). It is necessary to identify accurately the urethrovesical junction and prevent the error of considering the trigonal canal as part of the urethra.

Controversy exists among urologists about the existence or frequency of bladder neck obstruction and meatal stenosis in boys or girls. Posterior urethral valves, lesions probably existing only in males, appear to be the most common bladder outlet or urethral obstruction. From the Hospital for Sick Children in London, 165 children were recently
reported with lesions at or below the bladder neck which interfered with normal urine flow. From 1959 to 1970, of 130 boys and 35 girls, all were under the care of Mr. Ennis Williams. The most common lesions were posterior urethral valves and ectopic ureteroceles. Stenosis or atresia of the urethra and bladder neck obstruction were uncommon. A palpable bladder was the most common physical finding in this group of patients.

A one-day-old boy had not voided since birth and a large abdominal mass was felt (fig. 2, A). Catheterization of the bladder revealed a large volume of urine. The catheter was left in place and a cystourethrogram was done. During fluoroscopic observation reflux occurred when the bladder was partially filled (low pressure), and during the act of voiding it was noted that massive reflux occurred in dilated ureters and calyces (fig. 2, B). The posterior urethra was dilated and distal to this point, the urinary stream was narrow. The association of posterior urethral valves and reflux is common. Posterior urethral valves may be present, however, with competent ureterovesical valves and normal ureters and kidneys.

In boys, defects in the anterior urethra are less
Fig. 3-A. (left) Four-month-old male with urinary tract infection. Voiding cystourethrogram demonstrates an anterior urethral diverticulum. No reflux occurred.
Fig. 3-B. (right) Residual contrast in diverticulum persisted after the bladder emptied. After surgical removal of the diverticulum the infant remained free of infection.

common than in the posterior urethra. Most often a single “pouch” in the anterior urethra is non-obstructive and represents Cowper's ducts or glands.

Other lesions in the anterior urethra appear to represent congenital diverticulae or anterior urethral valves which may cause obstruction or be a cause of infection because of stasis in the diverticulum (figs. 3, A, B).

Fig. 4-A. (left) Normal female urethra during voiding.
Fig. 4-B. (right) With the stopping of micturition the "spinning top" deformity develops and is a normal variation.

Fig. 5-A. (left) Cystogram with water soluble contrast material demonstrates massive reflux into both ureters and kidneys.
Fig. 5-B. (right) Cystogram with technetium 99 M pertechnetate, followed by scanning over the kidneys detects reflux into the kidneys.
Fig. 6—Intervesical ureterocele causing a lucent defect in the bladder. Ureterocele developed from the ureter draining the upper pole of a double right renal collecting system. Obstruction caused hydronephrosis and nonfunction of the upper pole with downward displacement of the lower pole collecting system. Double collection system is present in the left kidney.

Fig. 7—Nephrotomography demonstrated the rim of functioning renal tissue in the right upper pole suggesting a duplicate renal system. Ectopic ureter was obstructed in the posterior urethra.

Fig. 8—A. Prolapsed ureterocele dilates the posterior urethra. Density of the contrast material around the ureterocele obscures the lucency normally seen. Reflux into dilated ureter also is noted.

Fig. 8—B. Retrograde urethrogram demonstrates the lucency in the bladder caused by the ureterocele.
In the early 1960's, the "spinning top deformity" of the female was considered a sign of urethritis or of meatal stenosis. It is now regarded as a normal variation in most instances. A single roentgenogram during voiding may be exposed when the patient is beginning or stopping micturition, and it is during this phase of voiding that the "spinning top" configuration is most common (figs. 4, A, B). Video tape recording and multiple spot x-rays usually show the normal anatomy and demonstrate physiologic function. At any rate, bladder neck obstruction and meatal stenosis are not radiographic diagnoses.

There is a high correlation of urinary tract infection in children with vesicoureteral reflux. In some patients, an obvious anatomic abnormality in the urinary tract is present; in many children, however, no discernible defect is found. Vesicoureteral reflux while a child has a urinary tract infection
Fig. 12—A. (left) Right ureteral reflux during voiding cystourethrogram. B. (right) Right kidney demonstrates caliectasis and decreased amount of cortex.

Fig. 13—A. (left) Poor delineation of the left kidney due to overlying gas and feces. B. (right) Paddle with an inflated balloon displaces the bowel contents and delineated the calyceal system.

Fig. 14—Carbonated beverage or carbon dioxide capsules contrast the calyces and renal outlines.
may be due to inflammation of the vesicoureteral orifice; therefore, it is preferable to do a cystourethrograph when the patient has been free of infection for more than two weeks.

The main use of cystourethrography is the detection of ureterovesical reflux. Instillation into the bladder of a short-lived pure gamma-emitting radiopharmaceutical, such as technetium 99m pertechnetate, followed by scanning over the kidneys (fig. 5), can be an adjunct to the radiographic investigation of reflux. This procedure does not give the detail of standard radiographic methods, nor does it detect transient ureteral reflux. The markedly lower gonadal dose of radiation may make this method useful as a means of following patients for gross reflux into the kidneys.

Ectopic ureters, with or without a ureterocele, are most frequently present with renal duplication. The upper renal pole drains into a ureter whose orifice is medial and inferior to the normal orifice. Approximately three-quarters of the patients with ectopic ureters in association with renal duplication are female. Bilateral renal duplication is present in approximately one-quarter of the patients with an ectopic ureter.

The intervesical ectopic ureter balloons out as a cyst-like mass within the bladder lumen causing a lucent defect (fig. 6). The poorly functioning hydronephrotic upper pole is outlined by thinned renal parenchymal. Generally there is function in the lower pole of the involved kidney. The lower pole calyces may be displaced downward and laterally by the dilated medially positioned ureter.

The distal end of the ectopic ureter may be stenotic and terminate in the bladder neck, ("posterior") urethra, or in the vagina, with dilation of the proximal portion of the ureter. Nephrotomography may be necessary to visualize the rim of functioning renal tissue (fig. 7).

Ureteroceles may prolapse into the urethra causing dilatation of the posterior urethra on a cystourethrogram, which mimics posterior urethra
Fig. 16—Nephrotomography in infant with poor renal function demonstrates a hypoplastic right kidney and small normal left kidney. Visualization was not successful on intravenous pyelography.

valves (fig. 8, A). Slow filling of the bladder via retrograde urethrography demonstrates a large lucent defect due to a ureterocele (fig. 8, B).

An ectopic ureter from a solitary ureter occurs in 20–30% of all ectopic ureters. Its site of insertion is similar to ectopic ureters associated with renal duplication. Ureterovesical reflux may occur when the ectopic ureter inserts in the bladder or urethra (fig. 9).

A newborn infant was noted to have a left flank mass. Nonfunction of the left kidney could have been due to hydronephrosis or a multicystic kidney (fig. 10). The lucency in the bladder suggested the correct diagnosis. This latter observation was important so that the ureterocele could be surgically removed in order to prevent the opposite ureterovesical junction from becoming obstructed.

Various simple techniques may help make a

Fig. 17—A. (left) Incomplete filling of calyceal system on intravenous pyelogram.

Fig. 17—B. (right) Compression band on lower abdomen and inflatable balloon causes partial stenosis of ureter and filling out of normal ureter and pelvocalyceal system.

Fig. 18—A. On intravenous pyelogram no visualization is seen in the left kidney. The right kidney demonstrates moderate ureteropelvic obstruction. Large left flank mass was palpated.
Fig. 18—B. Ultrasound shows a large echo free area in left flank indicating a cystic mass. At surgery, a hydrenephrotic kidney was found.

correct radiographic interpretation. The “bodygram” is the result of high dose (4 ml per kg) intravenous urography. Thirty seconds to one minute after the injection of urographic contrast material, there is opacification of well vascularized abdominal organs. Lesions with little or no blood supply produce lucent defects within the opacified structures, as was noted in a newborn that had a multicystic kidney (fig. 11).

Because of decreased concentrating ability of the kidneys of newborns for many days after birth, poor visualization on intravenous pyelography will not be improved by an immediate repeat dose. If possible, wait five or more days before repeating the intravenous pyelogram. Satisfactory visualization is usually obtained on the delayed study.

Prolonged nephrograms, lasting many hours-to-days, may be seen in newborns or infants who were dehydrated or oliguric prior to excretory urography. It is postulated that a mucoprotein (Tamm-Horsfall), normally produced by renal tubular cells, forms a precipitate that blocks the lumen of the renal tubules. Since diagnostic visualization can be obtained without iatrogenic dehydration, no fluid restriction is necessary prior to excretory urography.

Ureterovesical reflux causes damage to the kidneys because of the frequently associated infection and to a lesser degree the effect of the “back pressure” on the kidneys. Therefore, it is essential to be able to evaluate the renal outline, cortex and calyceal system. Often this can be done on the pyelogram (fig. 12, A, B).

The radiologist has various devices to obtain maximal information from excretory urography, often obviating the necessity for retrograde urography. A paddle with an inflatable balloon can be used to displace confusing bowel gas from the renal areas (fig. 13, A, B). Carbon dioxide in the stomach may contrast the renal outline and delineate the calyceal structures (fig. 14). Usually, nephrotomography will outline the kidney contour (fig. 15), and has been useful when kidneys fail to visualize well because of poor renal function (fig. 16). If visualization of the pelvocalyceal system is not adequate, compression bands may be placed on the lower abdomen, causing partial ureteral stasis with better filling of the structures in question (fig. 17, A, B).

The question of whether a flank mass that does not visualize on intravenous pyelography is cystic or solid can now be answered by ultrasonography. This procedure is noninvasive and emits no radiation. Low energy waves from a probe passed over the structure in question reflects echoes (sound reflection occurs at tissue interfaces) which are recorded as densities if the mass is solid in nature; if the mass is cystic, the recording will be echo “free” (fig. 18, A, B).