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Congenital and Acquired Disorders of Ureteral Course

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A wide variety of entities can alter the course of the ureter in the abdomen and pelvis. These include conditions both intrinsic and extrinsic to the ureter leading to a number of different ureteral abnormalities including thickening, displacement, dilatation, etc. An understanding of ureteral pathology, as with any organ, first requires understanding of the normal anatomic appearance. The ureter can be evaluated in a number of ways, including radiographs, such as intravenous pyelogram and retrograde pyelogram, as well as computed tomography or magnetic resonance urography. The unopacified ureter can also be evaluated on examinations tailored for evaluation of other pathologic entities. Although the full spectrum of ureteral pathology is rather broad, this article serves as a review of the normal embryology and anatomy of the ureter, methods of evaluating the ureter at imaging, and entities that can alter the course of the ureter. These potential disorders of ureteral course include embryologic causes; surgical procedures; and displacement by inflammatory, neoplastic, and anatomic abnormalities.

Introduction

Congenital abnormalities, intraabdominal and pelvic pathology, and postsurgical changes can all affect the course of the ureter. The full spectrum of ureteral pathology is beyond the scope of this single article. The purpose of this article is to review the normal course, embryology, and anatomy of the ureter as well as to discuss the different imaging modalities used for evaluation of the ureter, and provide examples of embryological and pathological entities affecting the course of the ureter. This article will highlight the normal appearance, potential complications, and imaging pitfalls of ureteral variations.

Normal Embryologic Development of the Ureter

Embryologically, formation of mesonephros (primitive kidneys) requires direct contact with mesonephric (Wolffian) duct. The ureteric bud arises from the mesonephric duct and, via direct contact, induces the formation of the metanephros (definitive kidney) from the metanephric blastema. The ureteric bud becomes the renal collecting tubules, minor and major calyces, the renal pelvis, and the ureters.[1]

Normal Ureteral Anatomy

The ureter serves as a conduit for urine to travel from the renal collecting system into the urinary bladder. The abdominal ureter begins posterior to the renal artery and veins. It runs along the medial aspect of the psoas muscle anteromedially to the tips of L2-L5 transverse processes. The pelvic ureter lies medial to sacroiliac joint where it enters the pelvis and crosses over the common iliac artery as it bifurcates to its internal and external branches. The ureter then curves laterally toward the ischial spine before it returns medially to the base of the bladder[1] (Fig 1).

Evaluation of the Ureter

In most cases contrast injected intravenously or directly into the collecting system is necessary to evaluate the ureter and collecting system. Historically, this was accomplished via intravenous pyelogram, in which multiple radiographs are taken of the kidneys, ureters, and bladder at various times during excretion following intravenous contrast injection. This technique would allow for good delineation of the renal pelvis and ureters, with a faint outline of the renal cortex (Fig 2A).

A more invasive radiographic technique termed a retrograde pyelogram involves catheterization of the ureteral orifices from within the bladder, and injection of contrast in a retrograde fashion into the ureter (Fig 2B). This method is often used to guide interventional urologic procedures. Occasionally, the collecting system would be accessed and opacified percutaneously, such as during the placement of a percutaneous nephrostomy tube.

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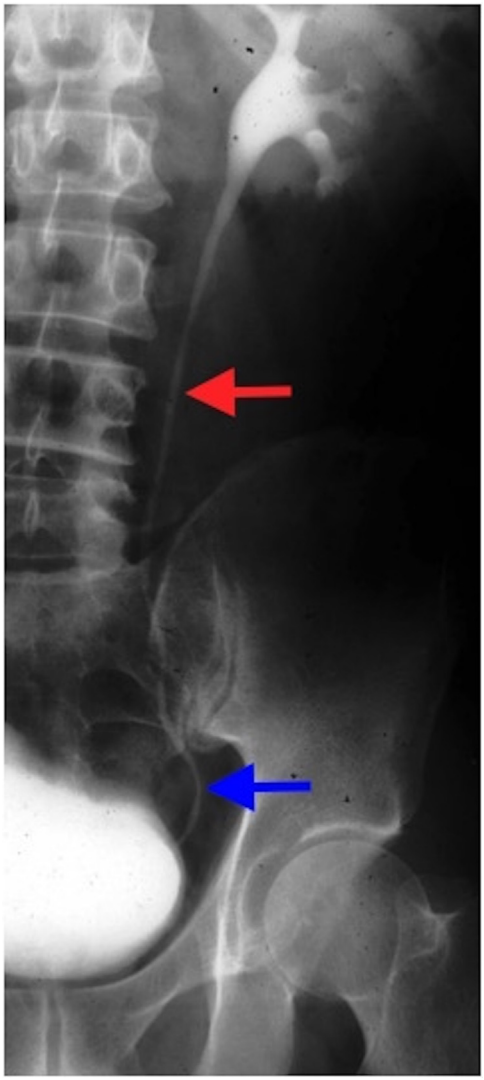

Fig. 1. Intravenous pyelogram demonstrating the normal course of the ureter. The abdominal ureter courses anteromedial to the L2-L5 transverse processes (red arrow) and the pelvic ureter lies medial to the sacroiliac joint before curving laterally toward the ischial spines (blue arrow), before finally turning medially to the base of the bladder. (Color version of figure is available online.)

Computed tomography urograms involve a multiphase computed tomography acquisition at various phases of renal enhancement, the final phase of which is generally an excretory phase during which the renal pelvis and ureters are opacified (Fig 2C). Magnetic resonance urograms generally rely on the inherent T2 signal within the urine to image collecting system (Fig 2D).

Ultrasound evaluation of the ureter is usually limited to the ureterovesical junction and ureteropelvic junction given the deep retroperitoneal nature of the ureter.

Disorders of Embryologic Development

Many causes of ureteral displacement or aberrant course are because of abnormalities of embryologic development. The most common of these entities are discussed below.

Spectrum of Ureteral Duplication

If multiple ureteric buds develop independently from the mesonephric duct, or if there is early bifurcation of the ureteric bud, a variety of findings can result along the spectrum of collecting system and ureteral duplication. This represents failure of the ureteral bud to appropriately induce the metanephric blastema.[2]

Rarely 1 moiety of the duplicated ureter terminates abruptly. This is known as a blind ending ureter or ureteral diverticulum (Fig 3).[1]

Additional potential anomalies include a bifid renal pelvis with a duplicated proximal ureter uniting to form a single ureter outside the kidney; partial ureteral duplication in which the renal pelvis and proximal ureters are duplicated and join more distally to form a single distal ureter; complete duplication where the entire collecting system and ureters are separate and duplicated, with separate ureteral orifices opening into the urinary bladder (Fig 4).[1]

In this latter scenario, the duplicated collecting systems are subject to the Weigert-Meyer rule. This rule states that the upper pole moiety generally inserts inferiorly and medially on the urinary bladder, often resulting in a distal ureterocele. The upper pole is often subject to obstruction. Conversely, the inferior pole moiety generally inserts more superiorly and laterally on the urinary bladder and is more subject to vesicoureteral reflux. For severe cases of duplication with ectopic ureteroceles, the upper pole obstructs and displaces the lower pole moiety inferiorly which is prone to reflux. This is known as the drooping lily sign (Fig 5).[3]

Of note, when 1 genitourinary anomaly is present, one must look for other anomalies within the contralateral kidney and reproductive tract.

Ectopic Ureteral Insertions

Ectopic ureters refer to termination of the ureters outside of the bladder trigone. Often times, this can include insertions outside of the urinary bladder altogether, onto sites such as the urethra. As previously mentioned, many of these ectopias are associated with ureteral duplications and are subject to the Weigert-Meyer rule. In men, the most common sites are the bladder neck and prostatic urethra.[4] Less common sites include the prostatic utricle, seminal vesicle, ejaculatory duct, and the vas deferens. Ectopic insertions are much more common in women, and insertion distal to urogenital diaphragm is associated with incontinence (Fig 6). These sites include the urethra, vestibule, vagina, cervix or uterus, and Gartner duct.[4]

Crossed Fused Ectopias

The fetal kidneys form within the pelvis and eventually ascend to their final position within the abdomen. Fusion of the metanephroi before their ascent can lead to crossed fused ectopia.[5] In this condition, one of the paired kidneys would be ectopically located contralaterally with its superior pole fused to the inferior pole of the opposing kidney. The ectopic kidney is generally malrotated with its ureter inserting in its normal location on the contralateral bladder trigone. Crossed fused ectopia is more common on the left than the right, and is associated with reflux, infection, and nephrolithiasis.