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MODERN APPROACHES TO THE CLINICAL COURSE, DIAGNOSIS, AND TREATMENT OF DUPLEX KIDNEY

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Abstract. Duplex kidney is one of the most common congenital anomalies of the kidney and urinary tract. Although many patients remain asymptomatic, the condition may be associated with recurrent urinary tract infection, hydronephrosis, vesicoureteral reflux, ureterocele, ectopic ureter, urinary incontinence, and progressive functional loss of the affected moiety. This article presents a structured narrative review of the current literature on the clinical course, diagnosis, and treatment of duplex kidney. Contemporary evidence shows that ultrasonography remains the initial imaging method, while voiding cystourethrography, renal scintigraphy, and magnetic resonance urography are essential in selected patients for clarifying reflux, obstruction, and differential renal function. Current management is increasingly individualized. Conservative follow-up is appropriate in uncomplicated asymptomatic patients, whereas intervention is indicated in the presence of obstruction, ectopic ureter, ureterocele, significant reflux, recurrent febrile infection, incontinence, or functional deterioration. Organ-preserving reconstructive procedures now play a central role in patients with viable renal tissue, while heminephrectomy remains justified for nonfunctioning symptomatic moieties. The modern approach therefore combines precise anatomical and functional assessment with selection of the least traumatic treatment capable of preserving long-term renal function and quality of life.

Keywords: duplex kidney, duplicated collecting system, ureterocele, ectopic ureter, vesicoureteral reflux, magnetic resonance urography, ureteroureterostomy, heminephrectomy

INTRODUCTION

Duplex kidney, also referred to as a duplicated collecting system, is a congenital anomaly in which one renal unit contains two pyelocaliceal systems with partial or complete ureteral duplication. It is among the most common forms of congenital anomalies of the kidney and urinary tract and is often detected during prenatal ultrasonography or later in the workup of urinary symptoms [1, 2].

From an embryological point of view, the anomaly develops when the ureteric bud divides prematurely or when two ureteric buds arise from the mesonephric duct. These developmental variants explain the continuum from incomplete duplication to two fully separate ureters. The classical Weigert-Meyer principle remains clinically useful because the upper-pole ureter usually inserts more inferomedially and therefore tends to be associated with obstruction, ureterocele, or

ectopic drainage, whereas the lower-pole ureter is more often related to vesicoureteral reflux [2, 11, 12].

The practical importance of duplex kidney lies not only in the anatomical anomaly itself but also in the complications that may accompany it. Recurrent urinary tract infection, hydronephrosis, vesicoureteral reflux, ureterocele, ectopic ureter, flank pain, hematuria, urinary incontinence, and progressive segmental loss of renal function may all occur in different combinations [1, 3, 12]. In some patients the anomaly remains an incidental imaging finding, whereas in others it becomes a source of repeated hospitalization and long-term functional impairment.

The aim of this article is to summarize contemporary evidence on the clinical course, diagnosis, and treatment of duplex kidney and to present the principles of individualized management focused on renal preservation whenever feasible.

MATERIALS AND METHODS

This article was prepared as a structured narrative review in accordance with the IMRAD framework. The analysis was based on current publications in pediatric urology, radiology, and congenital nephrourology, with particular attention to review articles, guideline documents, retrospective cohort studies, and reports devoted to imaging strategy, surgical indications, and long-term outcomes [3, 12, 13].

The reviewed material was analyzed in four interrelated domains that are essential for clinical decision making. The first domain concerned embryological and anatomical features that influence symptom formation. The second domain addressed the clinical course and the most frequent complications observed in pediatric and adult patients. The third domain focused on diagnostic strategy, especially the role of ultrasonography, voiding cystourethrography, renal scintigraphy, and magnetic resonance urography. The fourth domain examined the indications, advantages, and limitations of conservative management, reconstructive surgery, and ablative procedures.

RESULTS

The literature consistently shows that the clinical course of duplex kidney is heterogeneous. A substantial proportion of patients remain asymptomatic, particularly when the anomaly is isolated and not accompanied by obstruction or reflux. Prenatal studies indicate that a duplicated collecting system detected in the fetus is often a stable anatomical finding, but follow-up is still necessary because hydronephrosis, ureterocele, and associated lower urinary tract pathology may become more apparent later in gestation or after birth [4].

Among symptomatic patients, urinary tract infection is the dominant presentation. In the retrospective series by Yener and colleagues, urinary tract infection represented the most frequent complaint, and associated abnormalities such as antenatal hydronephrosis, vesicoureteral reflux, ureterocele, and postnatal hydronephrosis were common [1]. These observations confirm that the clinical burden of duplex kidney depends mainly on the presence of associated pathology rather than on duplication alone.

Clinical manifestations vary with age. Infants are more likely to present with antenatal urinary tract dilation, fever, pyelonephritis, or urinary sepsis. Older children may present with abdominal pain, dysuria, hematuria, recurrent cystitis, or persistent wetting. Continuous

dribbling in a girl with otherwise normal voiding should always raise suspicion of an ectopic ureter draining an upper-pole moiety. In adolescents and adults, duplex kidney may remain silent for years and then become evident because of recurrent infection, pain, incontinence, or incidental radiological discovery [1, 3, 11].

Modern diagnosis begins with ultrasonography. Ultrasound is the preferred first-line method because it is noninvasive, widely available, repeatable, and usually sufficient to detect hydronephrosis, duplication, ureteral dilatation, cortical thinning, or a ureterocele in the bladder. However, ultrasonography alone is often insufficient for complete treatment planning. When reflux is suspected, voiding cystourethrography remains important. When the contribution of an affected moiety must be measured, radionuclide imaging retains its value. When anatomy is complex or equivocal, magnetic resonance urography can provide both detailed structural information and clinically useful functional assessment [3, 12, 13].

The role of magnetic resonance urography has expanded in recent years. In complex duplex systems it can delineate the ureteral course, the relationship between upper and lower moieties, the presence of ectopic insertion, and the degree of parenchymal preservation in one integrated study. This is particularly helpful when the clinician must decide whether a poorly draining segment should be reconstructed or removed [3, 13].

Treatment strategy is currently based on symptoms, infection burden, obstruction, reflux status, continence, and residual function of the involved moiety. Observation is appropriate for asymptomatic patients who have no severe dilatation, no recurrent febrile infection, and no clinically significant reflux. By contrast, surgical treatment is justified when there is ectopic ureter, ureterocele with obstruction, persistent febrile urinary tract infection, progressive hydroureteronephrosis, marked reflux, urinary incontinence, or documented functional deterioration [3, 11, 14].

One of the most important changes in modern management is the expansion of renal-preserving reconstructive surgery. Ureteroureterostomy has become a key option in children with a functioning upper or lower moiety when the anatomy is favorable. Recent comparative studies demonstrated that laparoscopic ureteroureterostomy is associated with less tissue trauma, faster recovery, and good postoperative anatomical improvement when compared with open surgery. Other reports have shown that laparoscopic ureteroureterostomy is a safe and effective alternative to common sheath ureteral reimplantation in selected patients with duplex kidney anomalies [5, 6, 7].

Heminephrectomy remains an important option in carefully selected cases. When the upper-pole moiety is nonfunctioning or severely dysplastic and is associated with recurrent infection, significant obstruction, ectopic drainage, or severe symptoms, upper-pole heminephrectomy or heminephroureterectomy can provide definitive treatment. Long-term outcome studies indicate that most patients maintain satisfactory function of the remaining moiety, although postoperative adverse events are more likely in anatomically complex cases, especially when ureterocele, upper-pole obstruction, or accessory vessels are present [3, 8, 9, 10].

DISCUSSION

The reviewed literature shows that the central change in the management of duplex kidney is a shift from anomaly-based treatment to function-based treatment. Earlier practice often relied

on ablative surgery once the duplicated system became symptomatic. Current management is more nuanced and begins with two practical questions. First, is the symptomatic moiety salvageable. Second, will preservation of that renal tissue improve long-term outcome without exposing the patient to recurrent infection or repeated intervention. This functional logic explains why observation, endoscopic decompression, ureteroureterostomy, ureteral reimplantation, or heminephrectomy may each be the correct option in different patients [3, 14].

Another major development is the growing use of multimodal imaging. Ultrasound remains indispensable, but it is not always sufficient when ureteral insertion is unclear, when the residual function of a moiety must be quantified, or when the distinction between dysplastic tissue and salvageable parenchyma influences the choice of surgery. In such settings, the combined use of voiding cystourethrography, scintigraphy, and magnetic resonance urography allows the clinician to move beyond a purely descriptive diagnosis and toward a true anatomical and functional map of the abnormal kidney [3, 12, 13].

The debate between renal preservation and ablative surgery remains clinically relevant. Older data showed that function of the remaining moiety could decline after heminephrectomy in a minority of patients [8]. However, more recent pediatric series demonstrated stable long-term results in most children after carefully performed minimally invasive upper-pole heminephrectomy [9]. At the same time, contemporary studies on ureteroureterostomy have strengthened the position of reconstructive surgery in patients whose affected moiety retains useful function [5, 6, 7]. The current evidence therefore does not support a uniform surgical approach. Instead, it favors individualized selection based on symptoms, anatomy, and expected functional benefit.

Prenatal detection has also changed clinical practice. Recognition of duplex systems before birth does not automatically mean that early surgery is required, but it does create an opportunity for planned surveillance, timely identification of reflux or obstruction, and prevention of renal damage caused by delayed diagnosis [4]. In this sense, the modern approach is defined not only by new operative techniques but also by better timing, better imaging, and more rational selection of patients for intervention.

CONCLUSION

Duplex kidney is a common congenital urinary anomaly with a broad clinical spectrum ranging from an incidental anatomical variant to a condition complicated by infection, reflux, obstruction, ureterocele, ectopic ureter, incontinence, and progressive loss of renal function. The contemporary approach relies on precise anatomical and functional characterization rather than routine use of a single surgical strategy. Ultrasonography remains the gateway investigation, while voiding cystourethrography, renal scintigraphy, and magnetic resonance urography refine risk assessment and treatment planning in complex cases. Conservative surveillance is appropriate for uncomplicated patients, renal-preserving reconstruction has become increasingly important for functional moieties, and heminephrectomy remains justified for nonfunctioning symptomatic segments. The best results are achieved when management is individualized, minimally traumatic, and directed toward long-term preservation of renal function and quality of life [3].

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