Case Report
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A bifid ureter originating from separate major calyx and renal pelvis with dual calyceal systems: a case report

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Abstract: Present case report describes a case of bifid ureter arising directly from separate calyces and renal pelvis of the kidney. Incomplete ureter duplication on the left side in a 78-year-old male cadaver was found during an anatomy class. These ureters converged in a Y-shaped pattern just above the level of the anterior superior iliac spine. In the coronal section of the kidney, the anterior ureter arose from a renal pelvis that was divided into two major calyces in the lower two-thirds of the kidney. On the other hand, the posterior ureter was directly connected to a major calyx in the upper third of the kidney, without the formation of a renal pelvis. This anatomical variation has implications for diagnostic approaches, especially in the use of imaging techniques by urologists for the insertion of stents in the treatment of phyelonephritis.

Key words: Bifid ureter, Kidney, Major calyx, Renal pelvis

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Introduction

Duplication of the ureter is one of the most common congenital anomalies of the urinary tract, and it can be classified into complete and incomplete duplex ureters. Incomplete duplication of ureter, known as bifid ureter, involves two separate ureters at the proximal aspect, and they join at any point below the uretero-pelvic junction but before entering the bladder. This happens due to the bifurcation of the ureteric bud prior to its invasion into the metanephric blastema. On the other hand, a ureteral bud that arises twice separately results in a complete duplication of the ureter, or double ureter, which is continuous and leads to two openings into the bladder [1, 2].

A double (duplex) ureter occurs in 1 of 125 individuals, and bilateral double ureters occur in approximately 1 of 800 cases [2]. The incidence of double or bifid ureters of autopsy study was 0.5% [3]. Privett et al. (1976) [4] found that duplication was found unilateral in 79 and bilateral in 16 patients of ninety-five patients. The authors also state that duplicated ureter was equally common on each side and twice as common in females as in males. Dorko et al. (2016) [5] described that duplicated ureter is more common in girls than in boys with a ratio of 2:1. Research on the occurrence of the bifid ureter or ureteral duplication among Koreans has not been studied extensively. Therefore, the exact prevalence among the Korean population may be limited.

A duplicated ureter and urinary collecting system can be an asymptomatic normal variant or, when abnormal, can be associated with vesicoureteral reflux, incontinence, ureterocele or obstructive uropathy as well as renal parenchymal scarring, dysplasia, and decreased renal function [1]. Bhamani and Srivastava (2013) [6] reported a case of hydro-

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nephrosis resulting from obstruction of the urinary system, where bifid ureters were incidentally found in a hydronephrotic kidney during an emergency nephrostomy, which had been missed on a previous computed tomography scan, resulting in a unique therapeutic dilemma.

Present case report describes a case of a bifid ureter arising directly from separate major calyx and renal pelvis of the kidney, exhibiting both intrarenal and extrarenal morphological patterns. This finding may enhance anatomical knowledge of ureteral variations, thereby improving of diagnostic precision and the planning of surgical interventions in cases involving atypical ureteral anatomy.

Case Report

During our anatomy class at medical school, we found a case of incomplete ureter duplication on the left side in a 78-year-old male cadaver. The two ureters originated from the left kidney and followed separate paths. At the renal hilum, one ureter coursed anterior to the renal vessels, while the other ureter coursed posterior to these vessels. The anterior ureter had a slightly larger diameter than the posterior ureter. These ureters converged in a Y-shaped pattern just above the level of the anterior superior iliac spine, anterior to the psoas major muscle (Fig. 1). Subsequently, the conjoined ureter entered the urinary bladder through a single opening.

In the coronal section of the kidney, the anterior ureter arose from the renal pelvis that was divided into two major calyces in the lower two-thirds of the kidney. This renal pelvis was located within the renal sinus. On the other hand, the posterior ureter was directly connected to a major calyx in the upper third of the kidney, without the formation of a renal pelvis. Confluence of the major calyx draining the superior zone was separate from the confluence of the other major calyces responsible for draining the middle and inferior zones (Fig. 2).

There were no abnormalities in the right kidney. The ureter on this side coursed posterior to the renal vessels at the renal hilum, exhibiting a normal shape and position. In the horizontally sectioned images of the normal kidney of 88-year-old female cadaver, the renal papillae drained into minor calyces. These minor calyces then appeared to unite with adjacent ones to form the major calyces (Fig. 3).

Discussion

Most cases of ureteral duplication are incomplete, with the ureters joining above their entry into the bladder [7-10]. In the current study, the bifid ureter was traced to the calices of the kidney, revealing both intrarenal and extrarenal morphological patterns that differ from those reported in previ-

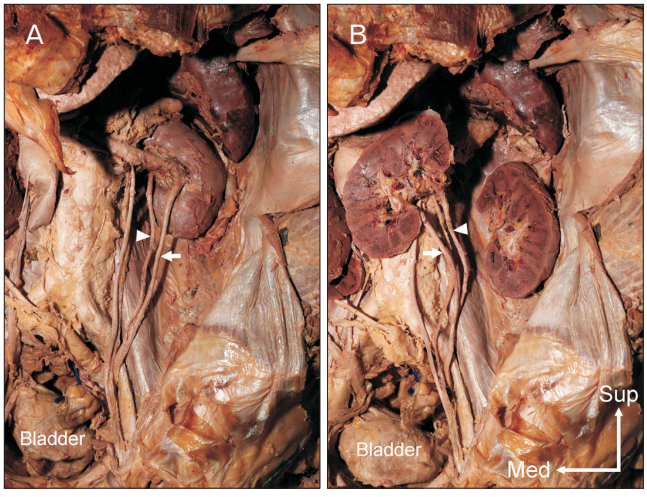

Fig. 1. A bifid ureter of the left kidney in the cadaver. (A) The two ureters converged near the level of the anterior superior iliac supine. These two ureters (arrowhead and arrow) formed a Y-shaped pattern. One (arrow) of bifid ureter traversed anterior to the renal vessels, and another ureter (arrowhead) traversed posterior to the renal vessels. (B) A bifid ureter was observed in the coronal section of the kidney. The anterior ureter (arrow) originated from the inferior pole of the kidney, while the posterior ureter (arrowhead) arose from the superior pole. Med, medial; Sup, superior.

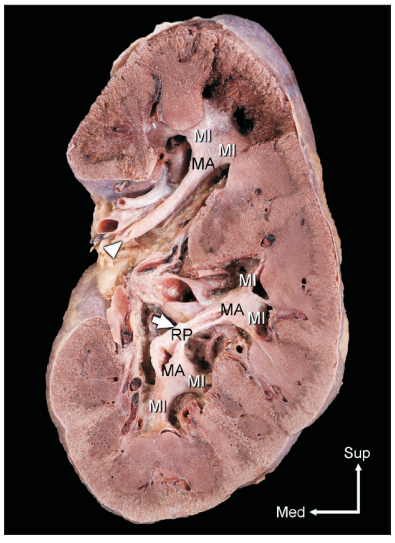

Fig. 2. A dual calyceal system that had a bifid ureter originating from separate major calyx (MA) and renal pelvis (RP) in coronal section of the left kidney. The anterior ureter (arrowhead) arose from a RP that was divided into two MAs in the lower two-thirds of the kidney. This RP was located within the renal sinus. The posterior ureter (arrow) was directly connected to a MA in the upper third of the kidney, without the formation of a RP. MI, minor calyx; Med, medial; Sup, superior.

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ous studies. This case can also serve as another reference for a variation of the bifid ureter.

This study described and compared our findings with those of previous studies, providing a comprehensive analysis of the similarities and differences observed (Table 1). Moinuddin and Dhanda (2015) [11] observed that in patients with complete ureteric duplication, the lower pole ureter drains most of the parenchyma and opens more cranially and laterally into the bladder. In the present study, the anterior ureter arose from a renal pelvis divided into two major calyces in the lower two-thirds of the kidney, whereas the posterior ureter was directly connected to a major calyx without formation of a renal pelvis in the upper third of the kidney. Consequently, we speculate that the anterior anomalous ureter might have had a more significant functional role than the posterior ureter.

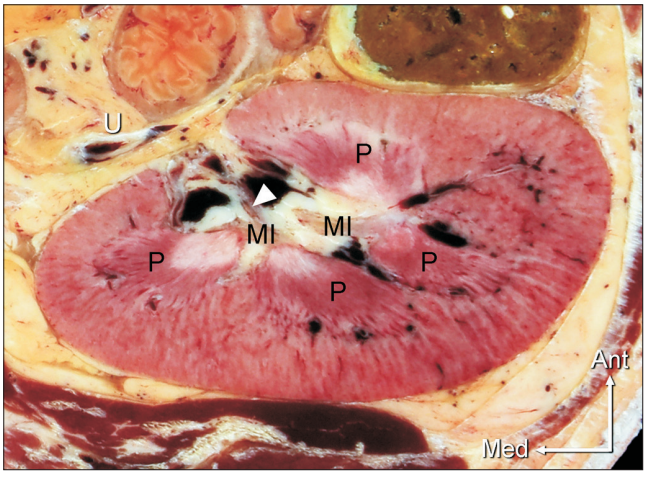

Fig. 3. A normal ureter (U) in a horizontally sectioned image of the right kidney. The renal papillae drained into minor calyces (Mis), and the Mis appeared to unite with their neighbors to form the major calyx (arrowhead). MI, minor calyx; P, renal pyramid; Ant, anterior; Med, medial.

Anjana et al. (2017) [12] reported that the renal pelvis was intrarenal in 79% of their specimens and the most common pelvicalyceal pattern was a bicalyceal with two major calyces in 35% of specimens. Additionally, they observed a rare variation in 1% of the specimens, where extrarenal calyces were present without a renal pelvis, and the ureter arose directly from the union of major calyces. In the present study, the left kidney with a bifid ureter had three major calyces: two forming the renal pelvis and the third directly connecting to the ureter. This configuration represents a unique combination of a bicalyceal pattern with an intrarenal renal pelvis and a long major calyx without a renal pelvis within a single kidney.

In cases of complete ureteric duplication, commonly referred to as double ureter, there are two continuous ureters leading to separate openings in the bladder [2]. According to the Weigert–Meyer rule, the ureter draining from the lower pole of the kidney, analogous to the single system ureter, is termed orthotopic. In contrast, the ureter from the upper pole is known as ectopic, typically inserting inferiorly and

Table 1. Comparative summary on ureteric and pelvicalyceal anomalies in previous and present studies

Previous studies and present study (yr)	Findings
Privett et al. (1976) [4]	Children with a duplex kidney are at higher risk of reflux, which can cause ureteric and pelvicalyceal dilation and chronic pyelonephritis when urinary tract infections occur.
Ravindra Swamy et al. (2014) [7]	The superior ureter lay posterior to the renal vessels, while the inferior ureter originated at the lower end of the renal hilum.
Moinuddin and Dhanda (2015) [11]	The most common abnormality is complete ureteric duplication, and in patients with complete ureteric duplication, the lower pole ureter drains most of the parenchyma and opens more cranially and laterally into the bladder.
Ojha and Prakash (2016) [9]	Both ureters of bifid ureter traversed superficially to the renal artery and then ran parallel to each other.
Anjana et al. (2017) [12]	The renal pelvis was intrarenal in 79% of the specimens. The most common pattern of the pelvicalyceal system was a bicalyceal configuration, with two major calyces, observed in 35% of the specimens. A rare variation was noted in 1% of the specimens, where extrarenal calyces were present without a renal pelvis, and the ureter originated directly from the union of major calyces. The minor calyces drained directly into the renal pelvis in 8% of the specimens.
Shakthi Kumaran and Chitra (2019) [10]	Unilateral incomplete duplication of ureters, draining from two separate pelvicalyceal systems, crossed twice before converging just prior to entering the bladder.
Protoshchak et al. (2020) [14]	A bifid ureter, as an uncommon variant, is characterized by a low fusion occurring within the intramural part of the urinary bladder.
The present study (2024)	The bifid ureter originated from separate major calyx and renal pelvis with dual calyceal systems. One of bifid ureter, originating from the lower two-thirds of the kidney, traversed anterior to the renal vessels, and another, from the upper third of the kidney, traversed posterior to the renal vessels.

medially to the orthotopic ureteral orifice [1, 13]. In the current study, the anterior ureter of the bifid ureters resembled the lower pole ureter, draining the lower two-thirds of the kidney, whereas the posterior ureter mirrored the upper pole ureter, draining the upper third of the kidney.

Shakthi Kumaran and Chitra (2019) [10] reported that incomplete duplication ureters crossed two times and had two separate pelvicalyceal systems, joining before entering the bladder. As an unusual variation, Protoshchak et al. (2020) [14] found a bifid ureter with fusion occurring in the intramural part. However, in the current study, the course of the bifid ureter appeared to follow a common pattern, dividing into a bifid structure at the level of the pelvic rim and exhibiting a separate bicalyceal pattern with an intrarenal renal pelvis.

At the renal hilum, the positional relationship of the bifid ureter with the renal vessels was diverse. Ravindra Swamy et al. (2014) [7] found that the superior ureter lay posterior to the renal vessels, while the inferior ureter originated at the lower end of the renal hilum. Ojha and Prakash (2016) [9] reported that both ureters of bifid ureter traversed superficially to the renal artery and then ran parallel to each other. In the present study, one of bifid ureter, originating from the lower two-thirds of the kidney, traversed anterior to the renal vessels, and another, from the upper third of the kidney, traversed posterior to the renal vessels.

While most cases are asymptomatic, some variations may have clinical significance, particularly in relation to urologic procedures. Anjana et al. (2017) [12] observed that the minor calyces drained directly into the renal pelvis in 8% of their specimens. Anomalies of the major and minor calyces, such as ureters formed directly from the minor or major calyces without the formation of a renal pelvis—as found in the study of Anjana et al. (2017) [12] and in the present study—may impact procedures including nephrolithotomy, endoscopic resection, and laparoscopic surgery for removing kidney stones, small tumors, and foreign bodies. Furthermore, Privett et al. (1976) [4] noted that the duplex kidney in children is more susceptible to reflux than the non-duplex kidney, and this leads to both ureteric and pelvicalyceal dilation, and to chronic pyelonephritis in the duplex side in those children who develop urinary tract infections.

Incomplete bifid ureter occurs when the ureteric bud, which is supposed to form a single ureter for each kidney, splits partially early in development. This split results in a ureter that starts as two ureters but merges into one before it enters the bladder [15].

This anatomical variation has implications for diagnostic approaches, especially in the use of imaging techniques by urologists and radiologists, to identify potential complications related to ureteral duplication.

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Conflicts of Interest

No potential conflict of interest relevant to this article was reported.

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