

Delayed diagnosis of ureteropelvic junction avulsion in a child owing to unstable hemodynamics

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Background. A 7-year-old previously healthy girl was injured in a traffic accident and presented to the emergency room with abdominal pain, microscopic hematuria, and wide skin defects and deep lacerations on the left flank, left upper abdomen, and right inguinal area. Initial CT of the abdomen was unremarkable. 3 weeks later, the patient complained of abdominal distension, left flank pain, and fever.

Investigations. Blood and urine tests, CT of the abdomen, chest X-ray, antegrade pyelography, intravenous urography, renal ultrasonography and diuretic renal scan.

Diagnosis. Complete avulsion injury of the left ureteropelvic junction

Management. The patient underwent 11 plastic reconstructive surgeries, including a skin grafting operation. A percutaneous nephrostomy was performed for temporary diversion. After complete healing of the left flank wound, open pyeloplasty was performed to create a ureteropelvic anastomosis with stent. The patient was discharged 1 week after surgery and the stent was removed 5 weeks later. 5 years after pyeloplasty, her renal function was normal and she had experienced no complications.

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The case

A 7-year-old previously healthy girl presented to the emergency room after being crushed by a heavy-duty truck. On presentation, she was tachycardic and hypotensive with tachypnea. She had wide skin defects and deep lacerations on the left flank, left upper abdomen, and right inguinal area. Laboratory tests performed on presentation revealed leukocytosis, hypokalemia, and elevated alanine aminotransferase (ALT) and aspartate aminotransferase (AST) levels (Table 1). The remaining liver function tests were within normal range. Urinalysis revealed microscopic hematuria. Hourly urine output volume was tolerable at 15 ml/h (normal range 20–40 ml/h for a 20 kg child). Initial CT of the abdomen performed on presentation was unremarkable except for a skin defect and fracture of the right ilium with a hematoma (Figure 1). Delayed CT could not be performed because of the patient's unstable hemodynamics.

An emergency surgical team performed primary repair of the wide skin defects and deep lacerations on the left flank, left upper abdomen, and right inguinal area 20 h after presentation. The patient was subsequently transferred to the intensive care unit under the care of the department of general surgery. The day after surgery the patient had aggravated dyspnea, and a chest X-ray revealed pulmonary edema and atelectasis. She required intubation and ventilator care for 7 days.

Competing interests

The authors declare no competing interests.

Blood tests performed 7 days after surgery revealed the patient was hemodynamically stable, with only mild leukocytosis (white blood cell count $13.6 \times 10^9/l$; normal range, $6-10 \times 10^9/l$). After extubation, general care was implemented, which involved monitoring of vital signs, electrocardiography and oxygen saturation, supplementation of nutrition and electrolytes, and hydration.

Wound infection occurred at the primary repair sites in the left flank and left upper abdomen 7 days after surgery. The patient was treated with wound irrigation and debridement 11 times over the next 7 weeks. A final plastic surgery was performed 2 months after injury, which included skin grafting with medium split thickness skin grafted from the left thigh.

At 3 weeks after injury, the patient complained of abdominal distension, left flank pain, and fever. CT of the abdomen revealed fluid collection around the lower pole of the left kidney, but normal renal parenchyma (Figure 2). The fluid was collected by percutaneous aspiration and the indigo carmine test identified it as clear urine. The treating physician presumed a missed ureteral injury causing urinary obstruction and urinoma. Percutaneous nephrostomy was performed for temporary diversion because the patient's general condition was poor.

An antegrade pyelogram, performed 9 months after injury owing to the severity of the abdominal skin wounds, revealed complete obstruction of the ureteropelvic junction (Figure 3). Exploration of the left kidney

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Table 1 | Laboratory tests performed on presentation

Laboratory test	Value	Normal range
White blood cell count	$25.8 \times 10^9/l$	$6-10 \times 10^9/l$
Potassium	2.7 mmol/l	3.5–5.5 mmol/l
ALT	0.75015 $\mu\text{kat/l}$ (45 U/l)	0.17–0.68 $\mu\text{kat/l}$ (10–40 U/l)
AST	1.8036 $\mu\text{kat/l}$ (108 U/l)	0.17–0.51 $\mu\text{kat/l}$ (10–30 U/l)

Abbreviations: ALT, alanine aminotransferase; AST, aspartate aminotransferase.

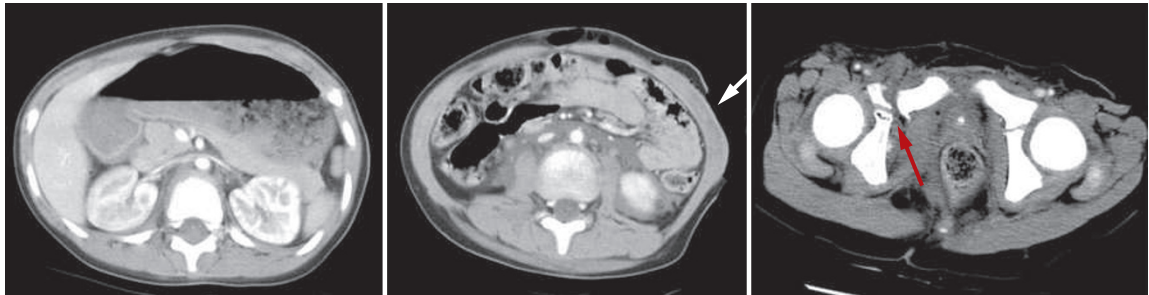


Figure 1 | Initial CT of the abdomen. The scan was unremarkable except for a skin defect (white arrow) and a fracture of the right ilium (red arrow) with hematoma formation.

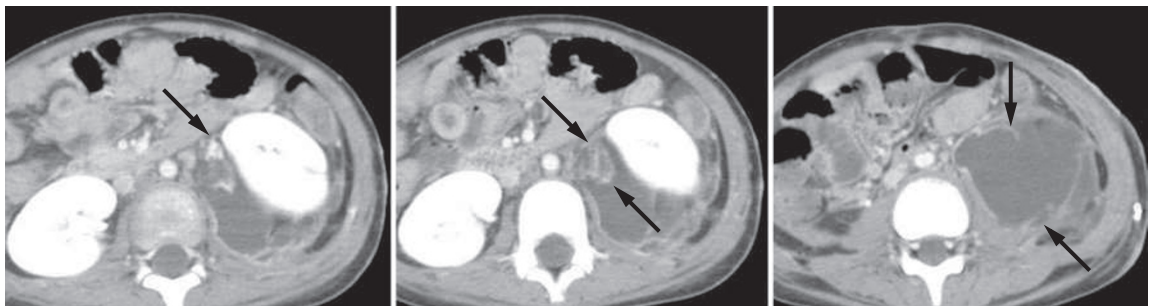


Figure 2 | CT of the abdomen at 3 weeks after injury. The left kidney was displaced upwards with a collection of fluid at its lower pole (arrows). No parenchymal injury was noted.

through a flank incision revealed extensive, severe adhesions, upward displacement, and fixation. The scarred upper ureter and fully contracted renal pelvis were identified, mobilized and removed with much difficulty owing to the severe adhesion, necrotic tissues and scar formation. A ureteropelvic anastomosis, protected with a ureteral stent, was created. This proved difficult because of the short remnant ureter and contracted pelvis. The percutaneous nephrostomy was removed during the pyeloplasty. The patient was discharged 1 week later. Intravenous urography, performed 2 weeks after pyeloplasty, confirmed a healed ureteropelvic junction with satisfactory drainage. The ureteral stent was removed 6 weeks after surgery. Follow-up renal ultrasonography and diuretic renal scan performed 6 months later showed no evidence of ureteropelvic junction obstruction. The patient was advised to have annual follow-up investigations but did not attend until 5 years after injury, when repeat renal ultrasonography and diuretic renal scan revealed no evidence of ureteropelvic junction obstruction (Figure 4).

Diagnosis

Complete avulsion of the ureteropelvic junction following blunt trauma is a rare injury that is most common in the pediatric age group. Motor vehicle accidents are the most common source of blunt trauma associated with ureteral avulsion,^{1,2} followed by crushing injuries and falls from a height.^{3,4} Avulsion of the ureter following blunt trauma can be unilateral or bilateral, with 70–80% of reported unilateral cases being right-sided.^{1,3} Avulsion usually occurs at the level of the ureteropelvic junction, but can occur more distally, up to 4 cm below that level.¹ Avulsion is most often complete, but can sometimes be partial, as indicated by a lack of immediate anuria in bilateral cases.^{5,6} Here, we present a case of left-sided complete avulsion at the level of the ureteropelvic junction in a 7-year-old girl following a traffic accident.

The mechanism of ureteral avulsion following blunt trauma is not yet fully understood. Bartley *et al.*⁷ have suggested that blunt trauma to the anterior aspect of the abdomen displaces the kidney upward, while the ureter remains relatively fixed, causing tearing at the

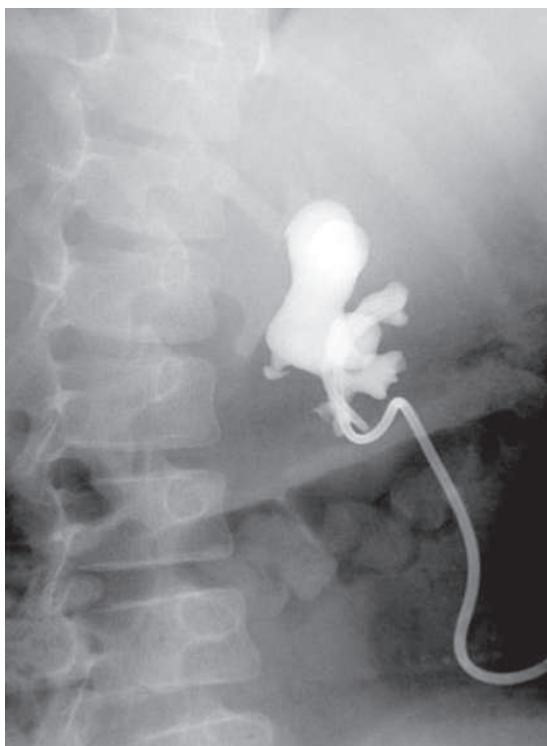


Figure 3 | Antegrade pyelography at 9 months after injury. Discontinuity of contrast media can be seen just below the ureteropelvic junction in the drained area.

ureteropelvic junction. Reznichek *et al.*¹ have proposed that avulsion is caused by two separate events occurring in rapid succession: first, the ureter becomes tense by hyperextension or lateral flexion; second, it snaps or lashes against the vertebral column. We suggest that the avulsion in this case involved two separate events. First, we believe tensing of the ureter may have occurred as a result of blunt trauma, causing a partial ureteral rupture and formation of a urinoma around the ureteropelvic junction. Then, we propose the urinoma displaced the kidney upward, causing ureteral avulsion at the level of the junction.

The classic findings of ureteral injury include gross hematuria, associated blunt abdominal trauma, transverse process fractures of the lumbar vertebra, and associated deceleration injuries.⁸ Seldom are all these findings noted in a single patient, so their absence does not rule out injury. In the present case, the patient had blunt abdominal trauma and microscopic hematuria. Gross hematuria is reported to occur in 46% of patients with ureteral injury, and microscopic hematuria in 38%.⁹ The absence of hematuria can be explained by an adynamic, partially transected ureter or complete ureteral transection.⁹ The patient presented here had a tolerable hourly urine output, and initial CT of the abdomen did not reveal ureteral injury. Delayed CT was not performed owing to the patient's unstable hemodynamics. 3 weeks later the patient complained of abdominal distension, left flank pain, and fever.

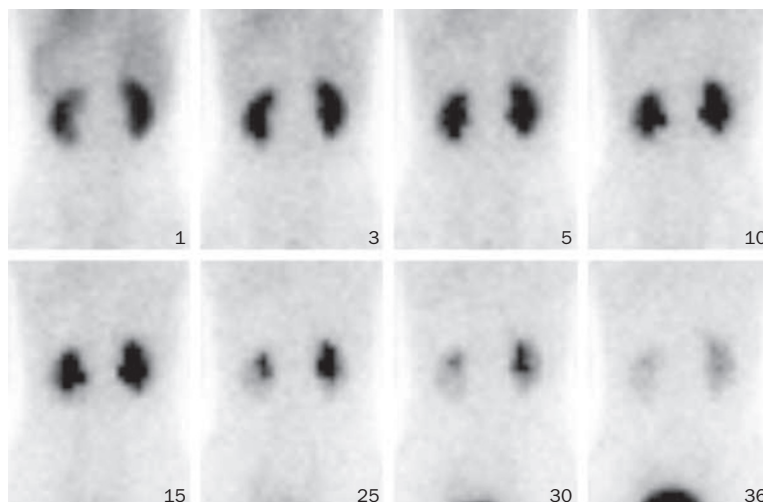


Figure 4 | Diuretic renal scan at 5 years after pyeloplasty. Radioactive tracer was injected and images taken from the posterior aspect of the abdomen. Numbers represent the time after injection in minutes for each image. The dye is seen to drain from kidney to ureter and bladder, demonstrating there is no obstruction of the ureteropelvic junction.

Ureteropelvic obstruction is often missed in pediatric patients; delay in the diagnosis has been reported to reach up to 6 weeks,^{1,10,11} can cause significant morbidity, and increases the nephrectomy rate to 40%.¹⁰ Most delays are due to hemodynamic instability and underlying injuries, both of which are common when the trauma mechanism is severe enough to result in blunt ureteral injury.⁴ Emergency exploratory laparotomy in patients who present with nonresponsive hypovolemic shock usually fails to establish the diagnosis of ureteropelvic junction avulsion because of the absence of associated retroperitoneal hematoma.¹² These patients usually present with flank mass and abdominal pain, with nausea, vomiting and fever if secondary infection occurs. Progressive anuria can be the presenting symptom in cases of bilateral incomplete avulsion. Radiological imaging at the time of presentation typically reveals a large urinoma related to the lower pole of an intact kidney that is usually displaced upwards and is mildly hydronephrotic.¹²

Retrograde pyelography is the reference standard for diagnostic imaging of ureteral obstruction, but it is often time-consuming and impractical in unstable patients, especially children. Thus, if ureteral injury is suspected, spiral CT should be performed, including delayed images taken during the excretory phase.¹³ If the patient is unstable and requires a laparotomy, 'one-shot' intravenous urography can be performed 10 min after intravenous injection of contrast while the patient is on the operating table or trauma gurney, in order to assess the upper urinary tract and functioning renal moieties.¹⁴

In the present case, ureteropelvic injury was not identified on initial CT, so intravenous urography was not performed. Delayed CT could not be performed because of the unstable hemodynamics of the patient. Ureteral injury was diagnosed 3 weeks after the trauma

had occurred, and a percutaneous drainage tube was inserted into the urinoma to establish a nephrostomy. We emphasize that either delayed CT and post-CT KUB (radiography of kidneys, ureters and bladder) or delayed 'one-shot' intravenous urography is essential for the accurate and timely diagnosis of ureteral injuries in patients who have experienced blunt trauma to the pelvis.

Treatment and management

Creation of a ureteropelvic anastomosis with stenting and temporary proximal diversion is the preferred treatment of ureteropelvic avulsion,⁴ and can be performed successfully in the majority of cases. If the gap between renal pelvis and ureter is too great to allow a tension-free anastomosis, combined retrograde ureterography and antegrade pyelography can provide an accurate estimate of the defect length and enable proper surgical planning.¹² Ureterocalycostomy or ileal ureter operation (ureteral replacement using ileum segment) can be performed if the gap between the pelvis and the ureter is too great to allow a tension-free anastomosis.

Successful ureteral repair should include complete debridement of nonviable tissue and creation of a tension-free, spatulated anastomosis with precise mucosal approximation and coverage of the repair with fat or omentum.¹⁵ Primary closure without debridement can often be performed in partial transections resulting

from stab wounds. Diversion can also be performed using internal ureteral stents. This method has been used for unilateral transections^{14,16} and was used in the current case. The purpose of the stent in this case was for protection of the anastomosis and temporary diversion, as the nephrostomy was removed during pyeloplasty. The treating surgeon successfully created a tension-free anastomosis with complete debridement of nonviable tissue. Follow-up renal ultrasonography and diuretic renal scan performed 5 years later revealed no evidence of ureteropelvic junction obstruction.

Conclusions

Ureteropelvic junction injuries are often missed in pediatric patients, and partial tears can progress to complete avulsions, as in this case. Delayed CT and post-CT KUB or delayed 'one-shot' intravenous urography are essential for the accurate diagnosis of ureteral injuries in blunt trauma patients. Ureteropelvic anastomosis with stenting and temporary proximal diversion can usually be performed successfully in the majority of cases. In patients with delayed diagnosis, the gap between the pelvis and the ureter is often too great to allow a tension-free anastomosis, and the nephrectomy rate is increased to 40%. In the current patient, however, the delay in diagnosis led to surgical difficulty in creation of anastomosis, but did not affect patient outcome.

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