Bilateral penetrating renal trauma (BPRT) is a rare injury that threatens both the kidneys. There is a paucity of literature on this subject. We recently encountered a challenging case (case 1), which prompted us to review our experience with BPRT to identify the principles of management.

METHODS

The 3,529 cases in the San Francisco General Hospital Renal Trauma Registry between September 1977 and February 2006 were scanned for patients with BPRT. Six cases (0.17%) were identified. The medical records of three cases were reviewed and abstracted below. Three additional cases were reported previously but not in detail.

Case 1

A 14-year-old boy was admitted to the emergency room (ER) in shock with gunshot wounds (GSWs) to the left lateral abdominal wall and the right flank. On physical examination, he had decreased breath sounds in the right chest, paraplegia, and gross hematuria. After right tube thoracostomy, he was transported immediately to the operating room (OR).

At laparotomy, the following injuries were identified:

1. Splenic hilar injury treated with splenectomy,
2. Exsanguinating hemorrhage from a large gunshot wound to the right lobe of the liver, requiring five Vicryl mesh packs in the liver defect to control the hemorrhage,
3. Three large holes in the splenic flexure of the colon, causing moderate contamination, which were oversewn,
4. A stable right perinephric hematoma, which was not explored, and
5. Exsanguinating hemorrhage from a shattered transected upper pole of the left kidney.

The patient continued to make bloody urine throughout the case. An intraoperative single-shot intravenous pyelogram taken 10 minutes after injecting 150 mL of Renograffin failed to demonstrate a nephrogram on either side. After proximal control of the left renal artery and renal vein, the left kidney was mobilized, the left upper pole resected and the left lower pole repaired.

The right and left upper quadrants of the abdomen were packed, the fascia left open and the abdomen temporarily closed with a Wound Vac because of massive distension of the bowel subsequent to infusion of 11 L of crystalloid, 24 units of packed red blood cells, 14 units of fresh frozen plasma, and 500 mL of 5% albumin. The patient continued to bleed postoperatively and underwent visceral angiography 6 hours after completion of the initial operation. At angiography, active bleeding from the lower pole of the left kidney was identified and successfully treated with coil embolization. Angiography demonstrated a gunshot injury to the right kidney and revealed two segmental artery injuries in the mid-renal area with active extravasation, which were successfully treated with coil embolization. No extravasation from the hepatic artery radicals was identified. After embolization, there was no flow to the inferior pole of the left kidney. The patient returned to the OR for the completion of left nephrectomy.

The patient required postinjury mechanical ventilation for 28 days. He returned to the OR five times for serial abdominal closure ultimately achieving successful delayed primary fascial closure on postoperative day (POD) 21. His BUN/creatinine rose to 67/3.7 on POD 9 and fell to 31/1.5 at the time of discharge on POD 50. His discharge blood pressure was 110/58.

Case 2

A 15-year-old boy was admitted to the ER in shock with bilateral flank stab wounds associated with gross hematuria. After initial resuscitation, he underwent emergency laparotomy. The following injuries were identified:

1. A through-and-through injury to the right lobe of the liver,
2. A nonbleeding laceration of the left adrenal gland,
3. A 3-cm laceration of the inferior vena cava, which was repaired,
4. A large right psoas muscle laceration, which was repaired, and
5. A through-and-through right renal laceration, which was repaired and drained.

On the second postoperative day (POD 2), the patient developed recurrent gross hematuria associated with a hematocrat (Hct) of 21. His blood pressure was stable at 140/80 mm Hg. Two units of blood were transfused, and the patient was observed. On POD 8, an abdominal computed tomography (CT) scan revealed a small degree of urinary extravasation from the right kidney and an unsuspected injury to the left
kidney, associated with a segmental infarct of the posterior medial aspect of the left kidney and a large blood clot in the bladder.

On POD 9, gross hematuria recurred associated with hemodynamic instability, a fall in Hct to 21, and a rise in BUN/creatinine to 18/1.8. After fluid resuscitation, the patient underwent coil embolization of a lacerated segmental branch of the left renal artery identified at angiography, after which the clot was removed from the bladder through cystoscopy.

On POD 12, a repeat abdominal CT scan demonstrated a pseudoaneurysm of the left renal artery. Three hours later, the patient suddenly developed gross hematuria and a fall in Hct to 20. Migration of the coil was identified on repeat angiogram, and a new coil was placed resulting in immediate hemostasis.

The subsequent postoperative course was complicated by a bowel obstruction caused by a fascial suture penetrating the jejunum requiring laparotomy and small bowel resection. The patient recovered and was ultimately discharged 7 1/2 weeks after his initial operation with a BUN/creatinine of 13/0.7. The patient has since been lost to follow-up.

Case 3

A 27-year-old man was admitted to the ER hemodynamically stable with GSW of the left flank, back, right axilla, and left groin. Evaluation revealed a left hemopneumothorax requiring tube thoracostomy, hematuria, and T-10 paraplegia.

Hemodynamic deterioration led to emergency laparotomy that revealed the following:

1. Bilateral renal vein injuries requiring venorrhaphy,
2. A left posterior renal injury requiring repair,
3. A duodenal injury requiring primary repair, and
4. A gallbladder injury treated with cholecystectomy.

The postoperative course was uneventful and the patient was discharged to a rehabilitation facility 2 weeks after his injuries with a BUN/creatinine of 47/1.1. The patient has since been lost to follow-up.

DISCUSSION

The management of bilateral penetrating renal injuries is an unusual but challenging problem because both the kidneys are at risk. Only 0.17% of renal injuries involve penetrating injury to both the kidneys in our registry. Preservation of at least 25% of renal parenchymal mass or 20% of total renal function is necessary to avoid dialysis. Therefore, a management strategy placing particular emphasis on preservation of renal parenchymal mass is essential.

After completion of the primary and secondary survey, penetrating abdominal trauma patients with hemodynamic instability or peritoneal signs should be immediately transported to the OR for emergency laparotomy. Hematuria is a sensitive sign of renal injury after penetrating trauma. An abdominal CT scan is appropriate in completely stable patients with penetrating abdominal trauma and hematuria to assess the tract of the penetrating injury, the anatomy of the genitourinary system, and the presence of associated injuries. None of the patients in our series, however, were stable enough to undergo a preoperative abdominal CT scan.

Both of our patients with bilateral renal injuries due to GSWs were paraplegic as a result of spinal cord injury (SCI). These patients may not demonstrate the usual tachycardia associated with significant hemorrhage because of the sympatholytic effect of SCI. GSWs causing paraplegia should alert the clinician to a high probability of significant intraperitoneal hemorrhage even in the absence of initial hemodynamic instability.

At laparotomy, initial attention must be directed to control of hemorrhage and closure of holes in the gastrointestinal tract. Hemorrhage from penetrating renal injuries can present in four ways: (1) free hemorrhage into the peritoneal cavity because of disruption of Gerota’s fascia and the retroperitoneum; (2) an expanding perirenal hematoma; (3) exsanguination into the renal collecting system presenting as gross hematuria with clots in the bladder; and (4) a stable retroperitoneal hematoma.

Renal exploration is mandatory in unstable patients in situations 1 to 3 to control hemorrhage. Proximal control of the ipsilateral renal artery and renal vein before mobilization of the kidney permits rapid control of hemorrhage and increases the chance of kidney salvage. An intraoperative single-shot intravenous pyelogram should be performed 10 minutes after injecting 1 mL/lb of Renograffin to confirm the presence of a functioning contralateral kidney. Only one of our three patients (case 3) required bilateral renal exploration.

In the rare event of devastating bilateral injury requiring bilateral nephrectomy for hemostasis, back-table renorrhaphy with immediate kidney reimplantation can be considered if the patient stabilizes. Options for management of the renal injuries include repair of injuries of the renal artery and vein, ligation and/or repair of segmental arterial or venous injuries, closure of defects in the collecting system and/or renal parenchyma, partial nephrectomy, and nephrectomy.

Nonoperative management of grade I-IV blunt renal injuries without significant injury to the collecting system is now standard treatment. Patients with CT evidence of active hemorrhage or renal arterial pseudoaneurysms can usually be effectively treated with selective coil embolization of the offending vessel. There is an increasing body of literature supporting nonoperative management of selected patients with penetrating renal injury who do not require laparotomy to treat associated injuries. These patients should have no evidence of urine extravasation. Hemodynamically stable patients with CT evidence of vascular injury can usually be managed by renal angiography.

All penetrating injuries to the kidney require planned renal exploration unless radiographic staging (i.e., CT scan) demonstrates the absence of exsanguinating hemorrhage and massive renal destruction. If bleeding can be controlled by angioembolization, this technique can be used. However, renal angioembolization should not delay laparotomy, which is required to control hemorrhage and enteric spillage from other associated injuries. Nonoperative management can be
undertaken in penetrating renal injuries that are well staged by imaging studies.

Sixty-one percent of patients who undergo renal exploration require nephrectomy.\textsuperscript{15}

This high-percentage is most likely because of the severity of injury of the kidneys explored as well as the release of the tamponade effect of Gerota’s fascia and the retroperitoneum, especially in the absence of prior proximal control of the renal vessels.

The technical details of operative management of renal injuries have recently been reviewed.\textsuperscript{16} The principles of management include (1) wide exposure of the kidney, (2) exposure of the renal vessels before opening Gerota’s fascia to facilitate proximal vascular control in the event that manual renal compression does not achieve hemostasis, (3) debridement of nonviable renal parenchyma, (4) meticulous hemostasis, (5) water-tight closure of the collecting system, (6) reapproximation of renal parenchymal edges, (7) omental interposition between the renorrhaphy and surrounding structures such as the pancreas and duodenum, and (8) wide drainage of the kidney.

Given the low incidence of bilateral penetrating renal injury, we recommend a multiinstitutional review of these injuries to develop guidelines for management. Until that
study is completed, we do not advise exploration of nonexpanding perinephric hematomas at initial emergency laparotomy, when bilateral renal injury is suspected particularly if exploration of the contralateral kidney is required. Instead, a damage control laparotomy\textsuperscript{17} should be completed, and the kidneys studied by abdominal CT scan and/or renal angiography after completion of resuscitation in the intensive care unit. If necessary, the patient can return to the OR for definitive operative management of the renal injury after radiologic assessment and control of hemorrhage through selective coil renal artery embolization. Our current approach to the management of BPRT is summarized in Figure 1.

**CONCLUSION**

BPRT is a rare injury comprising only 0.17\% of the cases in our renal trauma registry. BPRT due to GSWs is associated with SCI. Hemostasis and closure of hollow viscus injuries are the primary goals of emergency laparotomy after penetrating trauma. We recommend initial conservative management of nonexpanding perinephric hematomas discovered at laparotomy after penetrating trauma, particularly if the contralateral kidney has required exploration to control exsanguinating hemorrhage. Definitive repair of these renal injuries, if required, can be accomplished after patient stabilization and radiographic imaging.

**REFERENCES**