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SURGERY OF THE URINARY SYSTEM
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UROABDOMEN
Bladder rupture is the most common cause of uroabdomen in dogs and cats. It may occur spontaneously (associated with tumor, severe cystitis, or urethral obstruction), be due to blunt or penetrating abdominal trauma, or be iatrogenic following cystocentesis or bladder catheterization or manual expression of the bladder. Urinary tract leakage may also be a complication of surgery. Any animal presenting after vehicular trauma should be assessed for possible urinary tract trauma. The impact of the collision may cause the bladder, urethra, or ureter to rupture or necrose. The sharp ends of pelvic fractures may sever or lacerate the urethra. Diagnosis is usually delayed because clinical signs are rarely present at initial examination (see below).

Immediate surgery is contraindicated in animals with uroabdomen that are hyperkalemic or uremic. They should first be treated medically to normalize electrolytes and acid base, as well as decrease circulating nitrogenous waste products. Intravenous fluids should be given and abdominal drainage performed. Penrose drains or a peritoneal dialysis catheter (preferred because it can be made into a closed system) can be placed in the ventral abdomen under local anesthesia (sedate if necessary) to allow drainage for 6 to 12 hours. This will stabilize most animals with previously normal renal function. When urine leaks into the abdominal cavity, some nitrogenous waste products and electrolytes are reabsorbed across the peritoneal membrane and reenter the circulation. Whether molecules are reabsorbed depends on their size. Urea rapidly equilibrates across the peritoneal surface while some larger molecules (e.g., creatinine) cannot pass back into the bloodstream and remain concentrated in the abdominal fluid. Abdominal fluid creatinine concentrations must substantially exceed serum concentrations to diagnose uroabdomen. Because urea rapidly equilibrates across the peritoneum, BUN may be approximately the same in both abdominal fluid and serum, regardless of the cause of the abdominal effusion. Potassium may also help diagnose uroabdomen. A potassium abdominal fluid to blood ratio of greater than 1.4 to 1 is definitive for uroabdomen.

DIAGNOSIS
Clinical Presentation
Signalment. Urinary bladder rupture has been suggested as being more frequent in male versus female dogs because their long, narrow urethras cannot dilate rapidly; however, ruptured bladders are common in females that have sustained vehicular trauma. Traumatic urethral rupture in female dogs is uncommon. Male dogs and cats with obstruction due to calculi or sterile cystitis (FUS) have a high risk of bladder rupture if the obstruction is not alleviated promptly.

History. Clinical signs of urinary tract trauma are often vague and may be masked by other signs of trauma. In one study of dogs with pelvic trauma and concurrent urinary tract trauma, urinary trauma went clinically undetected in one third of the dogs. The animal may present for azotemia (i.e., vomiting, anorexia, depression, lethargy), or hematuria, dysuria, abdominal pain, and/or abdominal swelling or herniation may be noted. Abdominal and perineal bruising are common with vehicular trauma, particularly if there are pelvic fractures. Bruising in this region, however, may also indicate subcutaneous urine leakage. Further evaluation of the urinary tract is therefore warranted in such patients. In female dogs, there may be a history of previous catheterization using a rigid catheter. Rupture of the urethra is most frequently associated with pelvic fractures in male dogs. Urinary tract rupture is often overlooked in the initial workup of traumatized patients, and the diagnosis is not made until the animal shows signs of azotemia. It is important to remember that animals with ruptured bladders or unilateral ureteral trauma may urinate normal volumes, without evidence of hematuria. If the rupture is located dorsally or is small, leakage may only occur when the bladder becomes...
distended. Similarly the ability to retrieve fluid while performing bladder catheterization does not preclude a diagnosis of ruptured bladder.

**Diagnostic Imaging**
Survey radiographs may show reduced size or absence of the urinary bladder, decreased visceral detail and increased size of the retroperitoneal space. If a ruptured bladder is suspected, a positive contrast cystogram should be performed; however, leakage of contrast medium into the peritoneal space during cystography does not necessarily mean that the animal needs exploratory surgery. If there is no clinical evidence of uroabdomen, conservative management of the patient may be appropriate. To perform cystography a balloon-tipped catheter is placed into the urinary bladder or to perform a cystourethrogram in a male dog, the catheter is placed into the distal urethra (just past the os penis), and the balloon is inflated. While palpating the bladder for distention, approximately 2.2 ml/kg of diluted (1 part contrast medium to 2 parts sterile saline) aqueous organic iodide contrast medium is injected into the catheter. A radiograph is obtained while the last few milliliters of contrast are being injected. Fluoroscopy is advantageous to determine when the bladder is distended. It is critical to adequately distend the urinary bladder before determining that the study is normal as small lesions may not leak when the bladder wall is flaccid. Also, care should be taken not to completely occlude the neck of the urinary bladder with the bulb of the catheter as this may prevent leakage from a rupture in this area. Obtaining a radiograph while the contrast agent is being injected may show a “jet” lesion of contrast agent from the bladder. Free contrast agent in the abdominal cavity will coat and highlight abdominal organs. If a lesion is not identified in the bladder after adequate distension or urethra and the animal is well-hydrated, an excretory urogram can be performed. Contrast leakage into the retroperitoneal space (for proximal lesions) or abdomen (for distal lesions) occurs with ureteral rupture or laceration. If periureteral fibrosis has occurred, obstruction rather than leakage may be noted. Leakage of contrast from the renal capsule may be noted with renal parenchymal trauma. Parenchymal trauma of the right kidney should be suspected in dogs with uroabdomen and fractures of the thirteenth right rib.

**Laboratory Findings**
A CBC and serum biochemical profile with electrolytes should be performed. Hyperkalemia and azotemia may be noted. Analysis of abdominal fluid should be performed if urinary tract rupture is suspected. With uroabdomen, creatinine levels of the abdominal fluid will be greater than those in the blood (see above). Renal failure may be present if obstruction preceded the rupture. Bladder rupture secondary to urinary tract infection causes septic peritonitis.

**MEDICAL MANAGEMENT**
If the animal is not hyperkalemic or azotemic (e.g., uroabdomen is diagnosed within 12 to 18 hours after rupture), it should be rehydrated with 0.9% saline and immediate surgical repair should be considered. Occasionally, concurrent trauma (e.g., traumatic myocarditis, pulmonary contusions) will delay surgery. In such patients, abdominal drainage and/or urinary diversion (i.e., urethral catheter and/or tube cystostomy) may be necessary until the animal is stable. With delayed diagnosis, correction of electrolytes, hydration, and acid-base balance should be performed before surgery. Antibiotics may be administered based on culture results or upon bacterial morphology if a urinary tract infection is present, or prophylactically if abdominal drains are placed.

**SURGICAL TREATMENT**
Urethral trauma may be repaired by primary anastomosis (immediate or delayed) or the urethra may be allowed to heal over a urinary catheter if it is not completely transected. Ureteral rupture may be repaired by anastomosis or reimplantation into the bladder, depending on location of the damage. Bladder rupture generally occurs near the apex. Although small ruptures may heal if the bladder is kept decompressed, surgical exploration and repair are indicated in most patients. The entire
abdomen should be explored to determine the reason for rupture and/or identify concurrent trauma. If bladder rupture is secondary to severe cystitis, tumor, or obstruction, the bladder may be extremely friable or large areas may be necrotic, making excision and primary closure of the rent difficult. In such cases, prolonged urinary diversion may be beneficial. If cystitis or tumor is present, a biopsy of the bladder mucosa should be submitted for culture and histologic examination. In animals with rupture due to obstruction from calculi, the urethra should be carefully checked for calculi and its patency verified before repairing the bladder defect.

**SURGERY OF THE KIDNEY AND URETER**

Renal disease or ureteral trauma or obstruction may cause signs of acute or chronic renal failure. The minimum database for urinary dysfunction includes BUN, creatinine, urinalysis, hematocrit, total protein, albumin, electrolytes (especially potassium), total CO₂, and an ECG, if electrolytes are not readily available. These animals may have significant metabolic derangements, besides azotemia. Acute renal disease usually causes moderate or severe dehydration. Although most oliguric animals have acute renal failure, many animals with nonobstructive acute renal failure are not oliguric. Preoperative intravenous fluid therapy is needed to restore circulating blood volume and urine production; however, fluids must be administered judiciously to avoid overloading these patients. Diuretics may also be helpful to enhance urine production in animals that are adequately hydrated. Urine production of hydrated animals on maintenance fluids that do not have abnormal extrarenal losses should be at least 50 ml/kg/day or greater than 2 ml/kg/hr. Various electrolyte and acid-base abnormalities may occur, depending on the severity and duration of the renal or ureteral disease. Hyperkalemia is often present in acute obstructive renal disorders and some acute renal parenchymal disorders. Hypokalemia may occur with acute or chronic renal disease.
and diuretic therapy. Both conditions predispose to cardiac arrhythmias and should be corrected before surgery. Clinically important hypocalcemia is occasionally associated with chronic renal disease. Metabolic acidosis may also be present in animals with acute or chronic renal disease. Animals with chronic renal failure may be anemic because of decreased levels of erythropoietin. Erythropoietin is produced by the kidneys and acts to stimulate red cell production in the bone marrow. Elevated plasma levels of parathyroid hormone may have a negative effect on erythropoietin concentrations. Gastric ulceration, bleeding, or increased red cell fragility may occur in uremic patients. Coagulation profiles may be warranted in animals with chronic renal disorders. Normally hydrated animals with a PCV of less than 20% or hemoglobin of less than 5 g/dl may benefit from preoperative blood transfusions.

**SURGICAL TECHNIQUES**

Nephrectomy is indicated for renal neoplasia, severe trauma resulting in uncontrollable hemorrhage or urine leakage, pyelonephritis that is resistant to medical therapy, hydronephrosis, and ureteral abnormalities (i.e., avulsion, stricture, rupture, or calculi) that defy surgical repair. Before nephrectomy, renal function in the opposite kidney should be assessed by determining its glomerular filtration rate (GFR), if possible. Excretory urograms are not innocuous and can produce anuric/oliguric renal failure in animals with previously mild or moderate renal disease. If excretory urograms are done, avoid large doses of contrast material and maintain good renal perfusion. Bilateral renal dysfunction may warrant a guarded prognosis. If renal neoplasia is suspected, radiography (thoracic and abdominal) and ultrasonography should be performed to help rule out metastasis (including to the opposite kidney). To avoid unintentional transection, the opposite ureter should always be identified; this is particularly critical when removing large neoplasms.

*Grasp the peritoneum over the kidney and incise it. Free the kidney from its sublumbar attachments, using a combination of blunt and sharp dissection. Elevate the kidney and retract it medially to locate the renal artery and vein on the dorsal surface of the renal hilus. Identify any branches of the renal artery. Double ligate the renal artery with absorbable (e.g., polydioxanone, polyglyconate, or poliglecaprone 25) or nonabsorbable (e.g., cardiovascular silk) suture close to the abdominal aorta, to ensure that all branches have been ligated. Identify the renal vein and ligate it similarly. The left ovarian and testicular veins drain into the renal vein and should not be ligated in intact dogs. Avoid ligating the renal artery and vein together to prevent an arteriovenous fistula from forming. Ligate the ureter near the bladder. Remove the kidney and ureter, and after procuring appropriate culture specimens, submit them for histologic examination.*

**Pyelolithotomy**

Pyelolithotomy may be performed to remove renal calculi if the proximal ureter and renal pelvis are sufficiently dilated. This procedure avoids renal parenchymal trauma associated with nephrotomy. Pyelolithotomy is extremely difficult if the ureter is not dilated.

Dissect the kidney from its sublumbar attachments, and expose the dorsal surface. Identify the ureter and renal vessels. Make an incision over the dilated pelvis and proximal ureter, and remove the calculi. Flush the renal pelvis and diverticula with warm saline to remove small debris. Next flush the ureter to ensure its patency. Close the incision with a continuous suture of 4-0 or 5-0 absorbable suture material.