INTRODUCTION
Trauma can involve the kidneys, ureters, bladder or urethra. Urinary tract trauma has been associated with automobile accidents or falls, penetrating wounds secondary to bites, gunshot wounds and penetrating foreign bodies, trauma related to the presence of obstructive or irritating calculi, and iatrogenic trauma secondary to surgical trauma, urethral catheterization or bladder expression. Additionally, traumatic injury of the urinary tract usually accompanies injury to the abdomen or pelvis. The kidneys and ureters are considered retroperitoneal and the bladder and proximal urethra are considered intraperitoneal. Because of their retroperitoneal location, the kidneys and ureters are less commonly damaged when compared to the bladder and urethra. The distinction between the retroperitoneal vs the intraperitoneal space is an important concept to understand when evaluating these patients since the site of trauma can often effect the animal’s clinical presentation and, as a result, the ability to make a prompt and accurate diagnosis. If the retroperitoneal space has been disrupted secondary to a traumatic incident, urine leakage can also enter the peritoneal cavity.

A diagnosis of urinary tract trauma is based on history, physical examination, clinical pathological findings, evaluation of peritoneal or retroperitoneal fluid (if present), abdominal radiographs, abdominal ultrasound and contrast studies. Advanced diagnostic imaging including fluoroscopy, computed tomography (CT), or magnetic resonance imaging (MRI) may also prove beneficial in some cases. Not only is it important to make a diagnosis, but the aim is also to determine the location of urinary leakage.

CLINICAL SIGNS
Clinical signs in a patient that has sustained urinary tract trauma may range from vague signs such as depression or vomiting to life threatening cardiovascular disorders. Additionally, signs may be masked by concurrent illness or trauma to other organ systems. If enough force was present to cause trauma to the urinary tract, there is a reasonable chance that other organ systems may have been affected. Along with trauma to the urinary tract, these patients may present with a life threatening bleed associated with splenic or hepatic trauma, respiratory distress associated with thoracic injury as well as neurological deficiencies. Thoracic radiographs should be performed on any trauma patient to rule out pulmonary contusions, rib fractures as well as a possible diaphragmatic hernia. Clinical signs more specifically associated with trauma to the urinary tract include pain on abdominal palpation, hematuria, dysuria, anuria, swelling, bruising or pain in the perineal or sublumbar region or bruising on the ventral abdomen.

INITIAL STABILIZATION
Any life-threatening abnormalities potentially involving other organ systems should be addressed immediately. Depending on the time delay until diagnosis, many patients will have electrolyte and acid base abnormalities which need to be corrected as much as possible prior to surgery since these changes can make them poor anesthetic candidates. Urinary leakage can result in dehydration, azotemia, hyperkalemia, hyponatremia, hypochloremia, acidosis and hypovolemic shock, however these electrolyte abnormalities are not always a consistent finding in the cat. The rate of fluid administration as well as the type of fluid therapy should be based on a patient’s specific needs. Although potassium free solutions such as 0.9% saline are recommended, a balanced electrolyte solution such as Normosol-R will correct hypovolemic shock.
and not contribute substantially to the serum potassium on an acute basis. Additionally, a balanced electrolyte solution may be preferred for its more neutral pH, as compared to the more acidic pH of 0.9% saline. Dogs are typically started at a rate of 60-90ml/kg/hr and cats are typically started at a rate of 40-60ml/kg/hr. The patient is then reassessed halfway through their initial fluid bolus and the rate and supplementation adjusted accordingly.

An ECG should be placed and if hyperkalemia is present, it should be treated accordingly. Cardiac arrhythmias are first apparent at potassium levels of 7.5-8mmol/L when the P-R interval becomes prolonged. As the hyperkalemia becomes more severe, the QRS complexes become wider, the T waves become taller and the P waves flatten and eventually disappear. In addition to the intravenous fluid therapy, treatment for hyperkalemia often includes intravenous 10% calcium gluconate (0.25-0.5ml/kg) given slowly over 5 minutes with continuous ECG evaluation, 25% dextrose solution given slowly IV over 3-5 minutes (0.7-1 g/kg), allowing for co-transportation of potassium into cells or regular insulin (0.1-0.25 U/kg) and dextrose (0.5g/kg). In patients that are severely acidotic (pH<7.1), sodium bicarbonate can be administered. The recommended dose of sodium bicarbonate administration is 0.3 X base deficit X body weight (kg). One-quarter to one-third of the calculated dose is given slowly IV over 15 to 30 minutes and then the acid base status of the patient is reassessed. Terbutaline is a beta-adrenergic receptor agonist that can induce hypokalemia, and some have recommended its use clinically in treating patients with hyperkalemia.

In some patients, temporary peritoneal dialysis or urinary diversion using a urethral catheter or percutaneous locking-loop cystostomy tube to divert urine flow from the site of trauma or peritoneal cavity may be necessary. To perform peritoneal dialysis, the caudal abdomen is prepared for aseptic surgery and a local anesthetic is infused. A small stab incision is made in the caudal abdomen and the peritoneal catheter introduced. The catheter is advanced off of the stilette, sutured to the ventral abdomen and connected to a sterile closed urine collection system.

**KIDNEY**
Isolated renal trauma is often difficult to diagnose since clinical signs are often nonspecific. Historical information in conjunction with the presence of gross or microscopic hematuria and pain on palpation in the sublumbar region may be suggestive of a primary renal injury, however are not pathognomonic for the condition. Survey radiographs may reveal loss of detail as well as widening of the retroperitoneal space secondary to fluid accumulation which can be confirmed with abdominal ultrasound. Fluid evaluation is important to determine if a uroretroperitoneum or hemorrhage in the retroperitoneal space is present. Occasionally, renal injury can be confirmed by excretory urography, however often the diagnosis is made during exploratory surgery or with the use of advance imaging such as renal angiography or CT. If excretory urography is performed, it is important that a patient be hemodynamically stable ensuring adequate renal perfusion prior to the administration of contrast material. Treatment of renal trauma is dictated by the extent of injury. Patients that are azotemic secondary to renal contusions are treated with supportive care to address their renal failure. Lacerations of the kidney can be sutured, however if severe injury has occurred a partial or complete nephrectomy may be necessary. Kidney avulsion can result in severe and often fatal hemorrhage in the patient.

**URETER**
Unilateral ureteral tears secondary to trauma can be challenging to diagnose. Clinical signs in these patients are often vague and may include lethargy, dehydration, sublumbar pain, vomiting, anorexia and pyrexia. Clinicopathological findings in these patients may be normal if
urine leakage is confined to the retroperitoneal space. Similar to renal trauma, abdominal radiographs often reveal a loss of retroperitoneal detail and an increased size of the retroperitoneal space and ultrasound may identify fluid accumulation. If both ureters are disrupted, signs of acute azotemia will occur. If urine leakage enters the peritoneal cavity secondary to traumatic disruption of the retroperitoneal space, a uroperitoneum will develop. Excretory urography or antegrade pyelography is beneficial in cases of both unilateral and bilateral ureteral abnormalities. Similar to patients that have sustained renal injury, it is imperative that the patient be hemodynamically stable prior to performing the study.

Treatment options for ureteral trauma are often dictated by patient stability, function of the remaining kidney and location of the injury. Options include primary repair, ureteral reimplantation, ureteral stenting or ureteronephrectomy. Proximal to mid-ureteral injury often require primary repair. This may be performed in conjunction with ureteral stenting. Disruptions of the distal third of the ureter may be treated by excision of the compromised segment and reimplantation of the distal end of the ureter into the bladder via a ureteroneocystostomy. Damage to the mid-portion of the ureter as well as some cases of proximal injury may also be treated by reimplantation. Often a cystopectomy via a psoas hitch in conjunction with caudal translocation of the kidney by renal descensus may be necessary to prevent tension and disruption of the anastomotic site. In some cases, a percutaneous nephrostomy tube may be beneficial in diverting urine away from the surgery site.

In cases of undue tension or severe loss of ureteral length, a modified Boari flap can be created from the apex of the urinary bladder. In this technique, the ureter may be reimplanted into a full thickness bladder flap and then the bladder closed primarily. Other uncommonly used techniques include performing a subcutaneous ureteral bypass (SUB), an end-to-side anastomosis of the damaged ureter to the contralateral ureter (transureteroureterostomy) or renal autotransplantation to move the kidney and ureter more caudally.

**BLADDER**

Traumatic bladder rupture is the most common cause of a uroperitoneum. Traumatic bladder rupture can also occur secondary to aggressive palpation or poor catheterization technique. Urine leakage into the peritoneal cavity results in uremia, electrolyte abnormalities, dehydration, hypovolemia and death if untreated. Initial clinical signs are often vague and nonspecific and may include weakness, vomiting, lethargy, anorexia, dysuria, hematuria or anuria. It is important to remember that patients may urinate normally if a small leak is present and the ability to retrieve fluid on bladder catheterization does not preclude the diagnosis of a ruptured bladder. Additionally, the ability to palpate a bladder does not rule out rupture since, in one report, the bladder was palpable in 20% of cats with a bladder rupture. Finally, the inability to palpate a bladder as well as the presence of a fluid wave is supportive of a diagnosis of uroperitoneum.

To diagnose a uroperitoneum, the concentration of the creatinine and potassium in the fluid retrieved on abdominocentesis should be compared with that of the peripheral blood. Comparing the BUN in the abdominal fluid to the peripheral blood is often not helpful since the urea molecule is small and rapidly equilibrates across the peritoneal membrane. The creatinine and potassium are less permeable and as a result, in a patient with a uroperitoneum, the creatinine and potassium level in the abdominal fluid are higher than that of the serum. In cats diagnosed with a uroperitoneum, the mean serum to abdominal fluid creatinine and potassium ratios were 1:2 and 1:1.9 respectively in one study, however it is important to note that the creatinine and potassium ratios may also be very small (1:1.1 and 1:1.2 respectively). In dogs, serum to abdominal fluid creatinine and potassium ratios of 1:2 and 1:1.4 are highly suggestive
of a uroperitoneum. Cytological evaluation should also be performed on the abdominal fluid to evaluate for signs of inflammation, sepsis or evidence of damage to other intraabdominal organs. Abdominal radiographs in these patients may reveal a loss of abdominal detail as well as the absence of the urinary bladder. Positive contrast retrograde urethrocystography, with leakage of contrast material out of the bladder, provides a diagnosis of a ruptured bladder as the cause of the uroperitoneum. If the urethra is obstructed or ruptured, a normograde cystourethrogram may be performed using fluoroscopic guidance by percutaneously catheterizing the bladder or with the placement of a temporary locking-loop tube cystostomy.

Treatment of a patient with a bladder rupture includes stabilization of the cardiovascular system, treatment of any life threatening metabolic abnormalities and then definitive surgical repair of the bladder. An exploratory laparotomy is performed and the damaged area of the bladder is debrided and sutured in a single interrupted or continuous appositional pattern. Because of the chemical peritonitis that can occur with urine leakage, copious lavage of the abdominal cavity is recommended prior to closure. Additionally, if a urinary tract infection is present, the patient may need to be treated for a septic peritonitis. Although uncommon, very small tears in the urinary bladder may be managed with an indwelling catheter for 3-5 days.

Bladder herniation may be associated with a perineal or inguinal hernia or through an abdominal wall defect secondary to trauma. Depending on the degree of herniation and vascular compromise, ischemic necrosis and rupture of the bladder may occur. If the bladder cannot be reduced, a cystocentesis may be performed to reduce the size of the bladder and aid in manual reduction. Placement of a urethral catheter is also recommended until a more definitive treatment can be performed. A ventral midline laparotomy is necessary to investigate the extent of bladder damage. When full thickness ischemic damage has occurred, a partial cystectomy may be necessary. Definitive repair of the hernia may proceed at the time of exploratory laparotomy, or in cases of perineal herniation, definitive herniorrhaphy may be delayed a few days to allow for some resolution of perineal inflammation.

**URETHRA**

Both partial and complete urethral tears can also occur secondary to trauma. Urethral lacerations and ruptures are associated with pubic fractures, penetrating wounds, gunshot wounds and iatrogenic injury secondary to urethral catheterization and surgery on or adjacent to the urethra. Clinical signs will vary depending upon the location of the rupture. A proximal urethral rupture can result in a uroperitoneum and clinical signs similar to a patient with a ruptured bladder. A distal urethral tear will result in urine leakage into the surrounding soft tissues. This is manifested as swelling, pain and cellulites in those areas. A diagnosis of urethral rupture is confirmed by retrograde urethrocystography or antegrade cystography. To accurately determine the site of rupture, positive contrast material is injected slowly using these techniques in conjunction with fluoroscopy. If a retrograde urethrocystogram is being performed in a patient with a complete urethral rupture, extravasation of contrast material generally does not pass proximal to the complete tear.

Surgery for urethral trauma often includes primary repair and urinary diversion. Urinary diversion can be accomplished by a cystostomy tube or by a urethral catheter. In some cases that have sustained minor urethral injuries, urinary diversion may be performed without primary repair. If a urethral catheter is placed, the catheter should remain in place for approximately 7 days to allow for adequate healing of the urethral mucosa. Primary suture repair is the best treatment for complete urethral rupture or avulsion of the urethra from the bladder. In some cases of severe injury, a permanent urethrostomy is necessary.
Fractures of the os penis can also result in urethral injury. Most fractures can be stabilized concurrently with treatment for the urethral injury by placing an indwelling urethral catheter. If a catheter cannot be passed or in cases of gross displacement of fracture fragments, the fracture may need to be reduced and repaired by a direct surgical approach. If the damage to the urethra or os penis is too extensive, a permanent urethrostomy may be necessary.

CONCLUSION
Although trauma can involve all parts of the urinary tract in the dog and cat, the bladder and urethra are most commonly affected. The site of trauma can often effect the animal’s clinical presentation and, as a result, the ability to make a prompt and accurate diagnosis. A successful outcome with these cases is often dependent on an early and accurate diagnosis as well as the presence of concurrent injuries.