Urinary contrast study techniques

Author : Anna Zlot, Natalie Webster

Categories : Companion animal, Vets

Date : October 10, 2011

Urinary contrast studies are helpful in diagnosing urinary tract disease. The goal is to contribute information towards the diagnosis of renal, ureteral and urinary bladder diseases. Contrast studies can provide an answer when signs of disease are limited or not detected on survey radiographs.

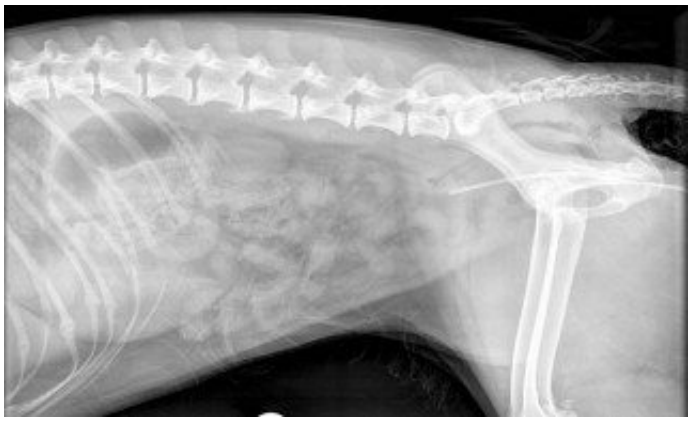

Figure 1. Control left lateral recumbent radiograph of the mid-caudal abdomen before injection of CM. Female, neutered, three-year-old springer spaniel with a history of recurrent cystitis and only one kidney visualised with ultrasound. A urinary catheter is present in the bladder but the bladder is not visualised. The left renal silhouette is visible. Image: © Animal Health Trust.

Negative contrast agents consist of room air, carbon dioxide (CO_2) and nitrous oxide (NO_2). Room air is cheap and readily available, but CO_2 and NO_2 are recommended due to their higher solubility compared to air – thus decreasing the risk of a fatal air embolus.

Positive contrast agents used in the urinary tract consist of water-soluble iodinated contrast media (CM). Barium is contraindicated in the urinary tract. Water-soluble iodinated CM can be divided into two categories: ionic and non-ionic.

Ionic iodinated CM have a higher incidence of side effects – mainly due to hypertonicity. However, the non-ionic contrast agents are traditionally more expensive.

Ionic iodinated CM are becoming less commonly used, due to potential side effects after IV administration and the reducing cost of non-ionic CM. Low osmolality non-ionic CM have similar osmolality to plasma. Non-ionic iodinated monomers, iopamidol and iohexol, are commonly used. The third generation of non-ionic CM are iodinated dimmers: iodixanol and iotrolan.

Ionic CM include meglumine diatrizoate, sodium diatrizoate, sodium amidotrizoate and meglumine amidotrizoate. Non-ionic CM (such as iopamidol and iohexol) are useful in high-risk patients for urography, angiography, arteriography, cardioangiography, CT enhancement, myelography and gastrointestinal tract studies.

Urinary tract contrast studies include the following:

- excretory urography or intravenous urography (IVU);
- positive contrast antegrade nephropyelography;
- positive, negative and double-contrast cystography; and
- positive contrast retrograde urethrography (males); or vaginourethrography (females).

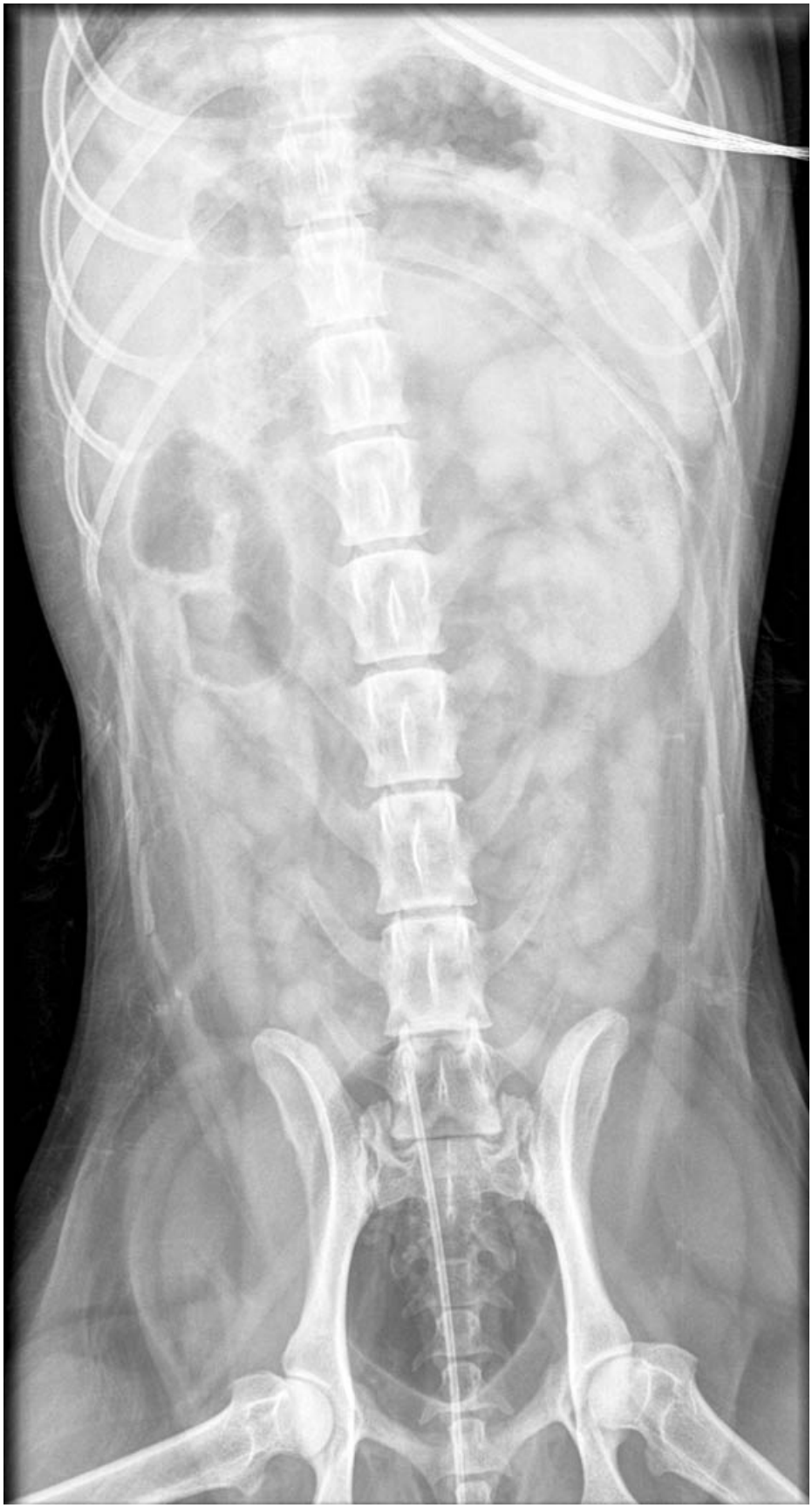

Figure 2. Intravenous urogram (IVU) zero-minute ventrodorsal radiograph of the abdomen of the dog in Figure 1. Nephrogram phase. A negative contrast cystogram has been performed before IV injection of CM. Figure shows the opacification of the left kidney parenchyma, the right kidney is not visible. The bladder is filled with air and a urinary catheter is present. Image: © Animal Health Trust.

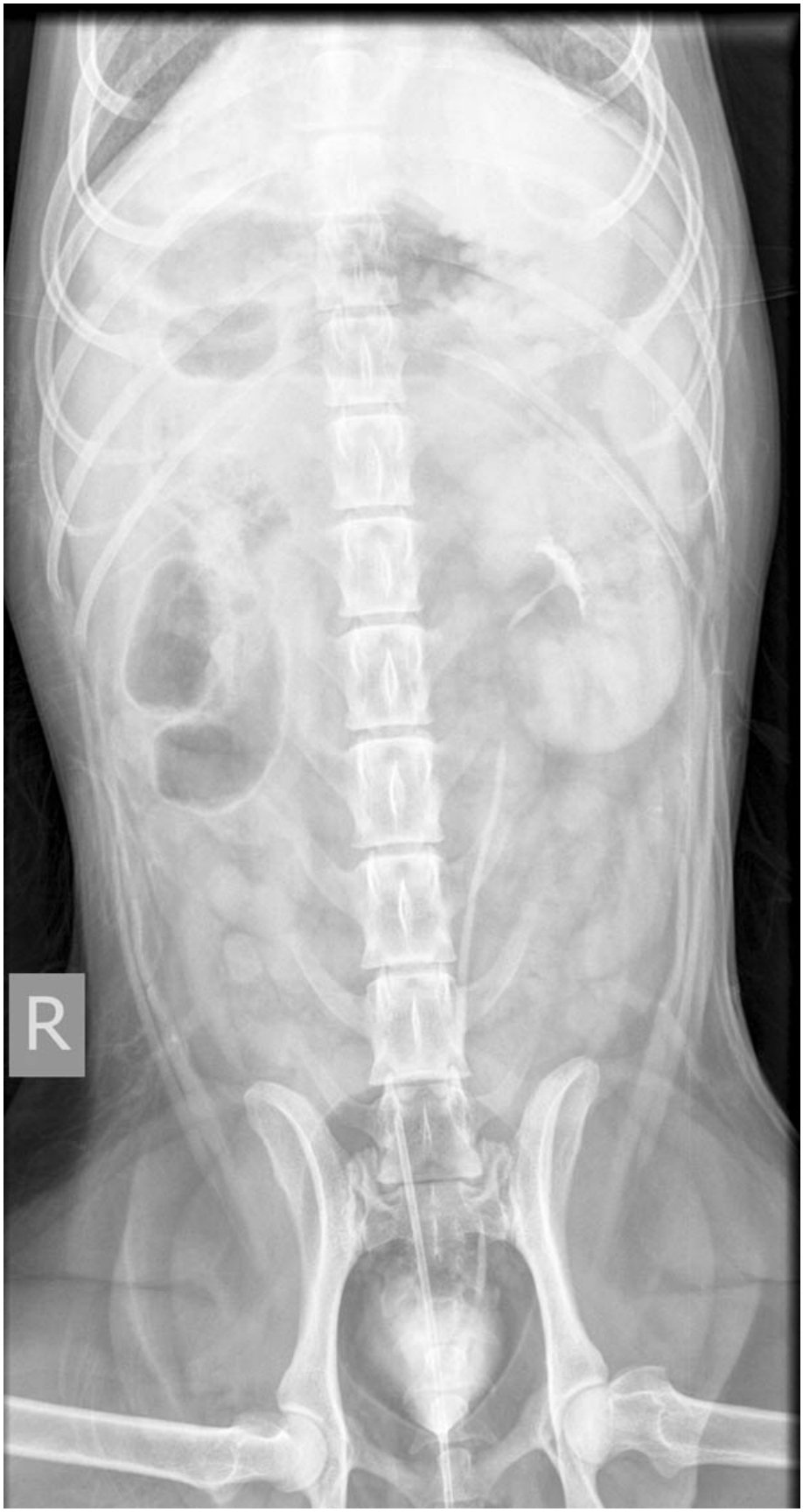
R

Figure 3. IVU five-minute ventrodorsal radiograph of the patient in Figure 1. Pyelogram phase. Contrast media is present in the left renal pelvis, ureter and bladder. The left renal parenchyma has contrast enhancement. The catheter is still present inside the bladder. The right kidney and ureter are not visible. Image: © Animal Health Trust.

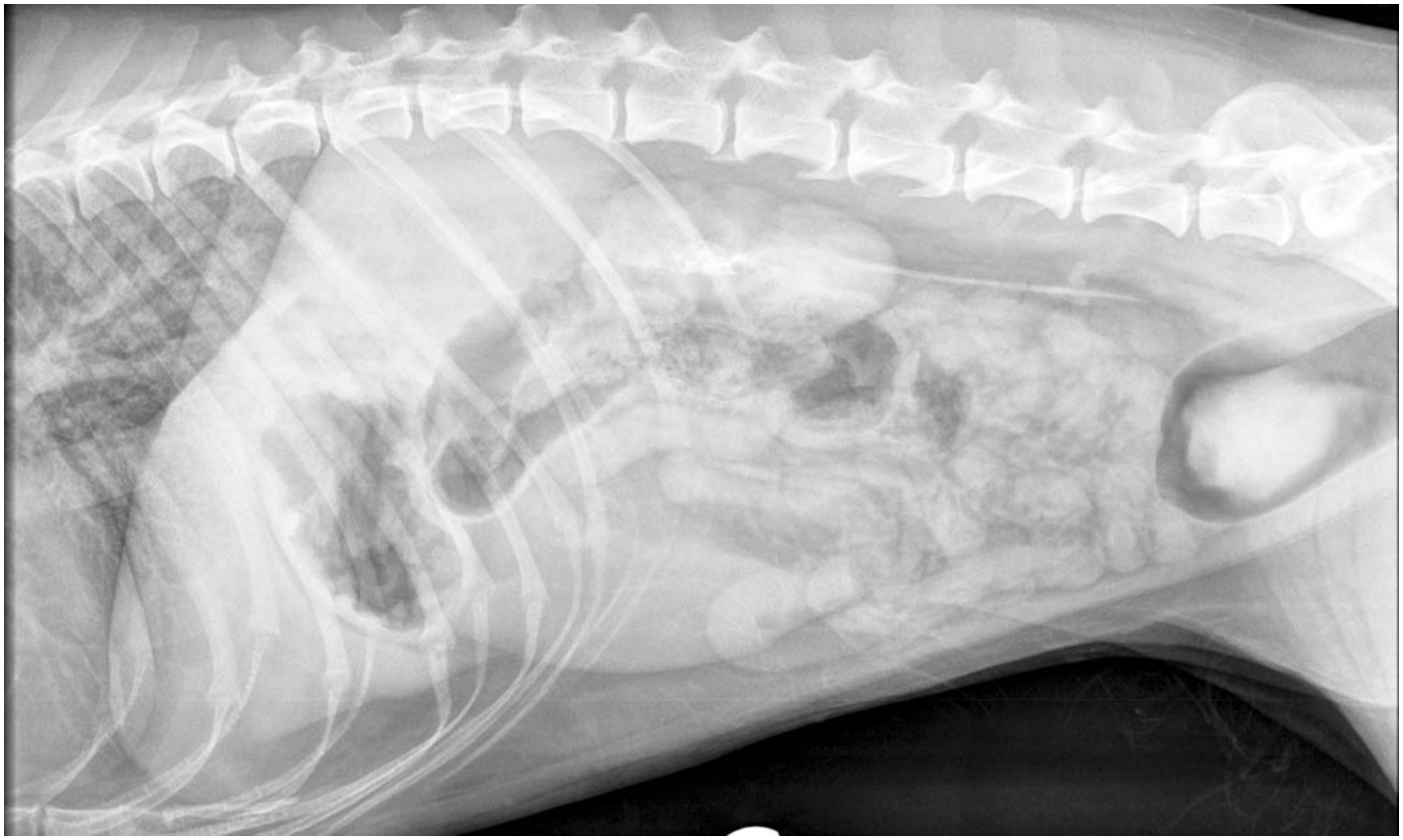

Figure 4. IVU five-minute left lateral recumbent radiograph of the patient in Figure 1. Pyelogram phase. The right kidney is not visible. Final diagnosis: absence of right kidney, left kidney enlargement secondary to hypertrophy, intrapelvic bladder. image: © Animal Health Trust.

Excretory urogram and intravenous urography

IVU is useful to evaluate the upper urinary tract. Water-soluble iodinated contrast material is administered intravenously and excreted by glomerular filtration. IVU demonstrates the size, shape and position of the kidneys, renal pelves, ureters and bladder. The IVU is divided into an

angiogram, nephrogram and pyelogram phase.

Angiogram phase

The angiogram phase is the arterial phase with contrast within the renal arterial system. Blood flow to the kidneys can be demonstrated, but usually the phase is difficult to observe. It is usually visible from zero to 15 seconds after injection of the CM.

Nephrogram phase

Contrast is within the renal parenchyma and renal tubules in this phase. Opacity depends on blood flow, glomerular filtration and tubular reabsorption of water. Opacification is proportional to the dose of CM. This phase can be observed from10 to 20 seconds after its injection (**Figure 2**).

Pyelogram phase

Contrast is within the collecting system – renal diverticuli, pelvis and ureters in this phase. Opacity is dependent upon filtration and excretion of the CM. The phase should be visualised one to three minutes following IV injection of CM and is best visible after one hour (Figure 3). Renal opacification decreases in one to three hours.

Indications of IVU include:

- abnormal renal size, shape or position;
- evaluation of abdominal masses in the kidney region;
- persistent haematuria or dysuria;
- ectopic ureters; • ureterocele;
- suspected ureteral rupture or investigation of renal trauma;
- failure to identify kidneys on plain radiographs or ultrasound;
- evaluation of the bladder when catheterisation is not possible; and
- postoperative assessment of the urinary tract.

Potential contraindications of injected CM may be due to hypotension, hypertonicity and/or chemotoxicity. IVU is contraindicated in dehydrated patients or those with severe renal disease, due to the risk of inducing acute renal failure, or in patients with a previous reaction to IV iodine contrast. Clinical signs may include retching, vomiting, drooling (if conscious), pulmonary oedema and cardiovascular problems.

Prior to performing an IVU study, laboratory tests may be indicated to assess renal function. Post-contrast administration, the urine specific gravity (USG), urine protein ratio, serum blood urea nitrogen (BUN), serum creatinine ratio and/or packed cell volume (PCV) may be altered.

Food should be withheld from the patient for 12 to 24 hours and an enema administered (preferably prior to general anaesthesia). Any dehydration in the patient should be corrected prior to the study.

A conscious or sedated patient during lateral abdominal radiography prior to induction of anaesthesia is useful (provided patient temperament allows a radiograph to be obtained without manual restraint). This allows assessment of the abdomen, and particularly the colon, to ensure no faeces are present. An IV catheter should be placed for contrast injection.

After the patient is anaesthetised, and prior to performing a contrast study, control radiographs of the abdomen should be obtained (ventrodorsal and laterolateral). These are important as they allow a starting point from which to compare the contrast radiographs and may reveal pathology without needing to progress to the contrast study.

The bladder should be catheterised and emptied. If the purpose of the study is to identify the termination of the ureters into the bladder (for example, study to investigate ectopic ureters), a negative contrast cystogram is recommended prior to the IVU.

Intravenous urogram

Dose: 880mg iodine/kg iodinated contrast given as a rapid IV bolus with the patient in dorsal recumbency. At the author's institution, non-ionic watersoluble iodinated CM (for example, Iopamidol) is used routinely for IVU contrast studies due to the reduced risk of side effects compared to ionic CM.

It is possible to perform high volume/low constant rate infusions of the CM, which optimises visualisation of ureters due to osmotic diuresis. It is not possible to visualise the angiogram phase during a longer infusion.

X-rays should be obtained at zero, one, five, 15 and 30 minutes. Both ventrodorsal and laterolateral radiographs should be obtained. Practically, the radiograph at zero minutes should be ventrodorsal, with the first laterolateral radiograph being obtained immediately after the one minute ventrodorsal radiograph. In cases of poor renal function, radiographs may need to be taken after 45, 60, 90 and 180 minutes due to delayed opacification. Oblique views are recommended to check the trigone region and distal ureters if ectopic ureters are suspected (three to 15 minutes following IV contrast administration).

Positive contrast antegrade nephropyelography

In patients with suspected ureteral obstruction where positive contrast IVU is non-diagnostic, positive contrast antegrade pyelography may be indicated. However, that is beyond the scope of this article.

Cystography

Many indications for cystography exist including:

- haematuria;
- stranguria;
- pyuria;
- visualisation of the bladder post-trauma;
- assessment of the bladder wall;
- differentiation of the bladder from abdominal masses; and
- visualisation of the urethra, assessment of obstruction, radiolucent uroliths and masses.

The patient should be prepared as described above for IVU. General anaesthesia or deep sedation is required. Control radiographs should be obtained prior to any contrast study. A urinary catheter should be placed. Injection of 2% lidocaine into the bladder may assist in reducing straining.

Care should be taken to palpate the bladder throughout the infusion of CM into it, and to stop the injection if the bladder feels overly distended. Care is required as a diseased bladder has the potential to rupture even when using published doses of CM.

Negative contrast cystography is a quick and useful tool to evaluate the position of the bladder within the abdomen.

Dosage: dogs 5ml/kg; cats 2ml/kg to 3ml/kg. Left lateral recumbent, ventrodorsal +/– oblique radiographs should be obtained. A serious potential complication of negative contrast cystogram is air embolisation. This may occur secondary to any negative contrast procedure. Patients with suspicion of cystitis, and/or presence of ulcerative disease of the bladder wall, may be at higher risk of developing an air embolus. Left lateral recumbency and use of CO_2 or NO_2 is thought to reduce the chances of an air embolus being fatal.

Positive contrast cystography

Dosage: dogs 5ml/kg; cats 2ml/ kg to 5ml/kg. Positive contrast cystography is a useful technique to evaluate for bladder patency. A small amount of non-ionic iodinated positive CM infused into the bladder can be used to investigate bladder rupture. Positive contrast cystography may be used to investigate bladder wall masses or uroliths, however the CM may mask less obvious lesions. Iodinated CM is used, barium is contraindicated.

Double contrast cystography

Dosage: dogs: positive CM dose – 5ml to 10ml and starting dose of negative CM – 5ml/kg; cats:

positive CM dose – 3ml and starting dose of negative CM – 2ml/kg to 3ml/kg.

Double-contrast cystography provides the most information about the bladder wall and bladder contents. The use of a small amount of positive contrast means that lesions or intraluminal structures are less likely to be masked. It is performed by using a small amount of positive CM and filling the bladder with negative CM to outline the bladder walls without masking lesions.

Iodinated CM should be injected into the bladder. Afterwards, the patient should be rolled over to cover the entire wall mucosa with media. The bladder must be palpated during injection to prevent overdistention and rupture.

Ventrodorsal, left lateral recumbent +/– oblique radiographs should be obtained.

Retrograde urethrography and vaginourethrography

The urethra is not visible on normal survey radiographs. Retrograde urethrography (male) and vaginourethrography (female) allows visualisation and assessment of the urethra. This procedure is helpful to evaluate for strictures, tears, congenital abnormalities, neoplasia or calculi within the urethra.

Retrograde urethrography/ vaginourethrography is useful in the diagnosis of ectopic ureters and, in the author's institution, it is used routinely following an IVU study when investigating ectopic ureters. The retrograde contrast fills ectopic ureters that enter the urethra and often gives a clearer picture than IVU.

As previously discussed, the patient should be prepared and general anaesthesia or deep sedation is required. The dosage is approximately 1.0ml/kg – around 15ml for a cat; 30ml for a small dog; 45ml for a medium dog; and approximately 90ml of iodinated CM for a large dog. The bladder should be catheterised and emptied.

Females

The tip should be cut off a Foley catheter (just in front of the balloon). The catheter should then be inserted into the vestibule – distal to the urethral orifice. The Foley balloon should then be inflated to fill the vestibule. Non-traumatic tissue clamps should be used to seal the vulva.

Contrast is injected in a rapid bolus and the radiograph taken at the end of injection. In the author's institution, the person injecting the contrast stands behind a lead screen next to the x-ray table and wears a lead gown and thyroid shield. Extension tubing connects the Foley catheter to the syringe.

Males

In males, a Foley or urinary catheter is inserted into the urethra with the tip just proximal to the penis. The Foley balloon is inflated only a small amount and the tip of the penis may be occluded with atraumatic clamps.

Before administering CM, survey x-rays should be taken: right lateral recumbent, and right lateral recumbent with the hind limbs pulled cranially to visualise the urethra. In males it may also be necessary to take ventrodorsal oblique radiographs.

Lidocaine can be injected to avoid straining, then inject 50% of the CM at 1.0ml/ kg. The x-ray has to be obtained immediately with legs pulled cranially, then the remaining CM injected and another x-ray taken to compare with the first one. It is necessary to avoid air bubble interpretation for a correct diagnosis.

In males, the urethra is divided into three parts: prostatic, membranous and penile. The urethra is also wider (prostatic part especially), whereas in females the urethra is shorter and an external urethral sphincter is present. A potential complication of retrograde vaginourethrography is rupture of the vestibule or vagina, so care should be taken when performing this study.

Summary

Urinary contrast studies should be used in conjunction with ultrasound and other diagnostic modalities and are a useful tool in the diagnosis of urinary tract disease in small animals.