

# Tutorial Article

## Macroscopic haematuria of horses

JOHN SCHUMACHER, JIM SCHUMACHER AND D. SCHMITZ\*

*Department of Clinical Sciences, College of Veterinary Medicine, Auburn University, Alabama 36849-5522 and \*Department of Veterinary Large Animal Medicine and Surgery, College of Veterinary Medicine, Texas A&M University, College Station, Texas 77843-4475, USA.*

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### Introduction

Macroscopic haematuria in horses can originate from the kidney, ureter, bladder, urethra or reproductive tract. Haematuria is obvious if the urine is so heavily contaminated with blood that blood clots are voided during urination, but when urine is only blood-tinged, distinguishing haematuria from haemoglobinuria or myoglobinuria may be difficult. To establish that a reddish discolouration of urine is caused by red blood cells, urine can be centrifuged to observe a layer of red cells covered by clear urine. Urine remains discoloured after centrifugation if haemoglobin or myoglobin has caused the discolouration. Horse owners may report erroneously that their horse has voided bloody urine if they are unaware that horse urine may change colour after urination. Normal equine urine contains an oxidising agent, pyrocatechine, which may cause urine to turn brown or red after exposure to air or after contact with snow (Holt *et al.* 1995).

**In this article, we present clinical aspects of diagnosis, treatment and outcome of cases involving haematuria in horses.**

### Evaluation of horses with haematuria

**Initial evaluation of horses with haematuria should include** palpation *per rectum* of the accessible portion of the urinary tract, urine analysis, urine culture and endoscopic examination of the urethra, bladder and ureteral orifices. The reproductive tract of mares can be examined by digital palpation, observation through a speculum and by endoscopy.

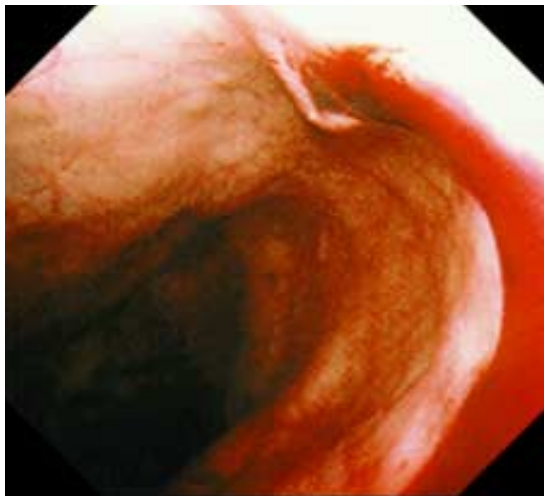
Urine analysis may be difficult if the urine contains a large quantity of peripheral blood. For urine collected during spontaneous urination, a midstream sample is usually most desirable because contaminants are flushed before collection. Cells that have settled out in the bladder, such as neoplastic cells, may be found in an end-stream sample. Cells indicative of upper urinary tract disease are more likely to be found in a **midstream sample** of urine, and cells indicative of lower urinary tract disease in an **end-stream sample**.

**Quantitative urine culture** should be performed when urinary tract infection is suspected as a cause of haematuria. To avoid collection of contaminating bacteria, urine to be submitted for enumeration of pathogenic bacteria should be collected by **catheterisation** rather than during spontaneous urination. Recovery of more than 10,000 colony-forming units per ml urine collected by catheterisation is diagnostic of urinary tract infection.

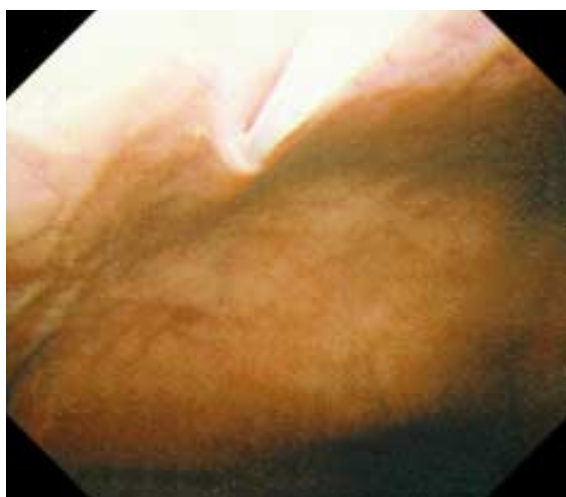
Because some horses with haematuria become **anaemic** and **hypoproteinaemic**, a complete blood count and serum protein concentration should be determined. Evaluation of serum concentrations of blood urea nitrogen, creatinine and electrolytes may help to determine if the horse has renal disease. **Coagulation tests** for horses with haematuria should be considered if the cause of haematuria is not obvious after physical, ultrasonographic, endoscopic or clinicopathological examination.

**Endoscopy of the male urinary tract** is performed using a sterile, 100 cm or longer, flexible endoscope with a diameter no larger than 12 mm. The endoscope can be sterilised according to the manufacturer's recommendations or with a glutaraldehyde-based product and then rinsed with sterile water (Traub-Dargatz and McKinnon 1988). The accessory channel should also be lavaged with disinfectant and rinsed with sterile water. **Male horses usually must be sedated** for endoscopic examination of the urinary tract. Using endoscopy, urine can be collected from the bladder or ureters to more accurately locate the site of haemorrhage and to assess function of each kidney (**Fig 1**). To collect urine from a ureter, polyethylene tubing, passed through the accessory channel of the endoscope, is inserted through a ureteral orifice (**Fig 2**). Placement of a ureteral catheter in the mare without aid of an endoscope has been described (Schott *et al.* 1990).

**Ultrasonography** of the kidneys or **renal biopsy** should be considered if, based on history, clinical signs or initial examination, lesions of the lower portion of the urinary tract are unlikely or if, during endoscopy, haemorrhage is seen emanating from a ureteral orifice. Percutaneous ultrasonographic examination of the kidneys is performed using a real time B-mode ultrasound scanner with



**Fig 1:** Endoscopic view of blood emanating from a ureteral orifice.



**Fig 2:** Endoscopic view of a ureteral opening through which polyethylene tubing has been inserted.

a 2.5–5.0 MHz sector transducer (Ramirez and Seahorn 1996; Traub-Dargatz and Wrigley 1998). The right kidney is usually imaged ventral to the transverse processes at the 14th to 16th intercostal spaces, and the left kidney at the 17th intercostal space and paralumbar fossa in a space between horizontal parallel lines drawn from the *tuber coxae* and *tuber ischii* (Rantanen 1986).

If haematuria is renal in origin, biopsy of the kidney may provide the aetiological diagnosis and prognosis. **A haemostatic profile should be performed** before a kidney is biopsied, because evidence of a coagulopathy is a contraindication for performing the procedure (Bayly *et al.* 1980). The horse should be restrained adequately during the renal biopsy procedure because **movement during the procedure can result in laceration** of the kidney or spleen. A Franklin-modified or Tru-Cut style biopsy needle is typically used to biopsy a kidney. The kidney can be blindly biopsied percutaneously, but ultrasonographic guidance of the biopsy



**Fig 3:** Diagram of a cross-section of an equine penis. A urethral rent is depicted by the arrow. CCP = corpus cavernosum penis; CSP = corpus spongiosum penis; U = urethra; BS = bulbospongiosus muscle.



**Fig 4:** A urethral rent appears as a slit-like opening on the convex surface of the urethra at the level of the ischial arch. A hypodermic needle has been inserted percutaneously into the urethra at the level of the ischial arch for orientation during an endoscopic search for the rent.

needle allows accurate identification of the site for biopsy and increases the safety of the technique because large blood vessels can be avoided with the biopsy instrument (Ramirez and Seahorn 1996).

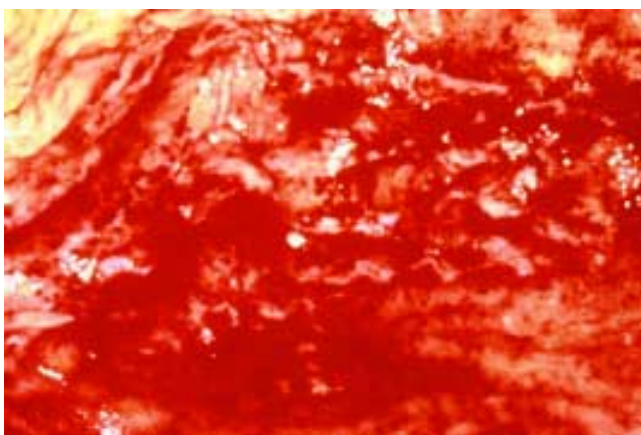
### Urethral rents

Urethral rents that occur on the convex surface of the urethra at the level of the ischial arch cause haematuria in geldings and haemospermia in stallions (Lloyd *et al.* 1989; Schumacher *et al.* 1995; Divers 1996). Blood in urine that results from a rent is characteristically discharged at the end of urination (i.e. terminal haematuria). Some horses with urethral rents display signs of dysuria (e.g. tenesmus, grunting). Stallions with

haemospermia usually have no gross evidence of haematuria, even though the lesion that causes haemospermia is of similar appearance to the lesion that causes haematuria in geldings.

Urethral rents communicate with the *corpus spongiosum* penis (CSP) (**Fig 3**). Haemorrhage through the rent into the urethral lumen occurs when pressure within this cavernosal space increases at the end of urination or during ejaculation. The increase in cavernosal pressure is caused by contractions of the *bulbospongiosus* muscle that occur to expel the contents of the urethra at the end of urination or during ejaculation (Sisson and Grossman 1953).

**We believe the reason for the difference in clinical signs between stallions and geldings** is probably because, during urination, the CSP of geldings has higher pressure than the CSP of stallions (J. Taintor and Jim Schumacher, unpublished data). The CSP of geldings is not as well



**Fig 5: Endoscopic view of the bladder mucosa of a horse with cystitis.**



**Fig 6: Ultrasonogram of a kidney of a horse with recurrent renal haematuria and suspected pyelonephritis. Arrows indicate haemorrhage in the renal pelvis. Diagnosis was based on cystoscopy, analysis of ureteral urine and ultrasonographic findings (pyelectasia, loss of corticomedullary definition and the presence of a wedge-shaped hyperechoic lesion suggesting infarction).**

developed as that of stallions, and the difference in volume of this cavernosal space, between geldings and stallions, results in different pressures in the CSP at the end of urination.

**Urethral rents are diagnosed during endoscopy of the urethra.** A 5 to 10 mm linear defect can be identified on the convex surface of the urethra, distal to the openings of the bulbourethral glands, near the level of the ischial arch (**Fig 4**). Gross evidence of inflammation or haemorrhage surrounding the defect is not observed. The cause of urethral rents is not known but, because the defect is invariably found on the convex surface of the urethra at the level of the ischial arch, the *tunica albuginea* of the CSP in this location may be inherently weak.

**Urethral rents often heal without treatment**, but if haematuria persists or if the gelding becomes anaemic, surgical treatment is recommended (Schott 1998a). Affected geldings can be treated successfully for haematuria by temporary ischial urethrotomy or by an ischial incision that extends into the CSP but does not enter the lumen of the urethra (Sullins *et al.* 1988; Schumacher *et al.* 1995). Surgery is performed after administration of epidural or local anaesthesia with the horse standing and sedated. An endoscope or catheter is inserted into the urethra and advanced proximal to the defect to facilitate recognition of the urethra during surgery. An 8 cm, vertical, cutaneous incision is created on the perineal raphe and centred on the ischial arch. The incision is extended through the retractor penis and *bulbospongiosus* muscles and the *tunica albuginea* that surrounds the CSP. The incision can be extended through the CSP and urethral mucosa, but incision into the urethral lumen is probably not necessary to bring about resolution of the lesion. The incision is allowed to heal by second intention.

Although horses may bleed significantly from the perineal wound, especially at the end of urination, haemorrhage from the urethral orifice and evidence of pain during urination are not observed after surgery (Schumacher *et al.* 1995). The perineal incision is usually healed within 3 weeks. Incising the CSP temporarily converts this semiclosed space into an open



**Fig 7: Endoscopic view of a cystic calculus.**

space and encourages haemorrhage to exit the subschial incision rather than the urethral rent during contraction of the *bulbospongiosus* muscle at the end of urination, thereby allowing the rent to heal (Schumacher *et al.* 1995). Opening the CSP without entering the urethra appears to be effective in eliminating haematuria caused by urethral rents, and might reduce the risk of complications associated with urethrotomy, such as development of urethral fistulas (Sullins *et al.* 1988) or strictures (Laverty *et al.* 1992).

## Urethritis

Urethritis is claimed to be a cause of haematuria (Holt *et al.* 1995), but the diagnosis of urethritis as a cause of haematuria is, in some reports, **probably based on misinterpretation of endoscopic observation of the urethra** (Schott 1998b). The vasculature and cavernosal spaces surrounding the urethra are prominent, especially in the proximal portion of the urethra, and become more prominent when the urethra dilates with air during endoscopic examination (Schott and Varner 1997). The prominent vasculature and cavernosal spaces may be mistakenly interpreted as inflammation or even haemorrhage of the urethra. Although urethritis may be an actual cause of haematuria or haemospermia, a diagnosis of urethritis as a cause of haematuria is probably an erroneous interpretation of the endoscopic appearance of the normal male urethra.

**Primary bacterial disease is undocumented as a cause of urethritis** (Schott 1998b), but urethritis may be secondary to primary cystitis or cystitis caused by a cystolith, or repeated catheterisation (Robertson 1987). Urethral swabs can be cultured for bacterial isolation, and antimicrobial sensitivity testing of cultured pathogenic organisms can be performed. Horses with bacterial urethritis usually respond to correction of a predisposing cause and to systemic antimicrobial therapy in conjunction with lavage of the urethral lumen with nonirritating antimicrobial drugs and sexual rest (Varner *et al.* 1991). Instillation of antimicrobial drugs through an ischial urethrotomy site has been suggested (Varner *et al.* 1991) and, in some cases where an undetected urethral rent is the actual cause of haematuria, a response to treatment may be the result of urethrotomy rather than topical antimicrobial therapy.

**A granuloma involving the urethral process**, caused by infestation of *Habronema* larvae, can be a cause of haematuria in horses (authors, personal observation). Erosion of the CSP by the granuloma results in haemorrhage when pressure within the CSP increases at the end of urination. Treatment of horses affected by habronemiasis involves reduction of the hypersensitivity reaction to *Habronema* larvae with a topically or systemically administered corticosteroid, or destruction of larvae by systemic or topical administration of an organophosphate. The anthelmintic ivermectin may also kill *Habronema* larvae (Herd and Donham 1981). Amputation of the urethral process is usually an effective treatment of horses affected with habronemiasis of the urethral process when medical treatment is unsuccessful (Stick 1979).

## Bacterial cystitis

**Bacterial cystitis, a cause of haematuria in horses, is rarely primary.** Bacterial cystitis is usually secondary to urine retention caused by paresis or paralysis of the bladder or by urocystoliths (Divers 1996; Rooney and Robertson 1996). Vaginitis and repeated or prolonged indwelling catheterisation are other predisposing causes of bacterial cystitis (Divers 1996). Horses with cystitis may void bloodstained urine or frank blood. The bladder usually feels normal during palpation *per rectum*, but thickening and erosions of the bladder mucosa may be seen during cystoscopy (**Fig 5**).

For horses with cystitis secondary to other conditions, correction of the underlying problem (e.g. urolithiasis) and antimicrobial therapy are indicated. For horses with idiopathic cystitis, quantitative bacterial culture of urine and antimicrobial sensitivity testing of cultured bacteria are indicated. An antimicrobial drug excreted in high concentration in urine, such as penicillin or trimethoprim-sulpha, should be chosen to treat an affected horse if microbes cultured from urine are sensitive to the drug.

## Pyelonephritis

Pyelonephritis, or suppurative bacterial infection of the renal pelvis and parenchyma, was thought to be the cause of severe haematuria for 7 horses with unilateral or bilateral renal haemorrhage (Kisthardt *et al.* 1999). The horses in that report, however, had none of the typical clinical signs or predisposing causes of pyelonephritis. Renal biopsy of one of these horses supported an ultrasonographic diagnosis of pyelonephritis but, for other horses, the diagnosis was based primarily on ultrasonographic images typical of pyelonephritis in other species (Biller *et al.* 1991). Because, for many of these horses, the diagnosis was unsupported by urine analysis or culture, the conclusions of this report are controversial. Diagnosing pyelonephritis in the horse, however, is often difficult and, consequently, pyelonephritis may be underdiagnosed as a cause of renal disease (Reef 1998).

**The ultrasonography of equine pyelonephritis has been described** (Matthews and Joal 1996; Reef 1998) **and includes the following:**

- increased renal echogenicity;
- abnormal renal outline;
- loss of corticomedullary distinction;
- detection of a large amount of echogenic to hyperechoic debris in the renal pelvis;
- pyelectasia (dilatation of the renal pelvis) (**Fig 6**).

Because only a few of these ultrasonographic changes are likely to be present at any given time, evidence may increase if the kidneys are examined sequentially (Kisthardt *et al.* 1999).

Biopsy of a kidney with abnormal ultrasonographic appearance would probably aid in diagnosis but, because severe haemorrhage can occur with renal biopsy, use of the technique in severely anaemic horses may be an unnecessary risk.

For horses suspected to have pyelonephritis, **bacterial culture** of urine and antimicrobial sensitivity testing of cultured bacteria are indicated. Trimethoprim-sulphonamide or penicillin is an appropriate antimicrobial drug for treatment. Horses with haematuria caused by renal leptospiral infection may respond to treatment with penicillin (Bernard *et al.* 1993). **The recommended minimum duration of antimicrobial therapy** for horses with infection of the upper portion of the urinary tract is 3 weeks (Prescott and Baggot 1993). Intravenously administered electrolyte solution and repeated blood transfusions may be necessary for some horses with severe urinary blood loss. In a retrospective study of 7 horses with suspected pyelonephritis and macroscopic haematuria, some horses had long-term remission of haematuria, but all eventually had recurrence of haematuria (Kisthardt *et al.* 1999; J. Schumacher, unpublished data).

### Idiopathic haematuria

**A syndrome of idiopathic haematuria in horses** has been described (Schott and Hines 1994; Schott 1998a) that closely resembled clinical findings of horses with haematuria suspected to be caused by pyelonephritis (Kisthardt *et al.* 1999). Horses with idiopathic haematuria had severe renal haemorrhage that was usually unilateral, but occasionally bilateral, with no other signs of disease. The diagnosis was made by exclusion of known causes of renal haemorrhage and, in 5 horses diagnosed with this condition, there was no evidence of upper urinary tract infection, even during histological examination of some affected kidneys. Treatment of horses with idiopathic haematuria may be warranted, because some horses have remission of clinical signs. Suggested treatment is supportive care that may involve blood transfusion. When the condition appears to be unilateral, nephrectomy may be indicated. One horse, however, developed renal haemorrhage in the remaining kidney after undergoing nephrectomy (Schott 1998a).

### Urolithiasis

**Macroscopic haematuria, observed after exercise, is the most common clinical sign** displayed by horses with a cystic calculus (Divers 1996). Macroscopic haematuria is not a clinical sign of most horses affected with nephrolithiasis or ureterolithiasis (Byars *et al.* 1989; Hope *et al.* 1989; Ehnen *et al.* 1990; Laverty *et al.* 1992). Haematuria following exercise is virtually diagnostic for cystic calculi, but exercise-induced haematuria has also been observed in horses with nephrolithiasis (Divers 1995; Divers and Yeager 1995). Haematuria caused by a cystic calculus is probably more pronounced **near the end of urination**, whereas haemorrhage associated with a urethral rent occurs **immediately at the end of urination** (Divers 1995; Schumacher *et al.* 1995).

Other clinical signs of cystic or urethral calculi include frequent urination (pollakiuria), dribbling of urine, dysuria and prolonged periods of penile protrusion (Frank 1964; DeBowes *et al.* 1984; Holt and Pearson 1984). The hindlimbs are often urine- or blood-stained.

Cystic uroliths are found more frequently in male horses than in mares. They are usually singular, round or egg-shaped, and rough. Those with a rough surface tend to be larger and more friable than smooth stones and may be embedded in mucosa (DeBowes *et al.* 1984; Hackett *et al.* 1985).

The presence of a cystic calculus can usually be confirmed by palpation of the bladder *per rectum* or by observing the calculus during endoscopic examination of the bladder (**Fig 7**). The pelvic portion of the urethra should be palpated, as well as the bladder, so that a calculus in this location is not overlooked. **A cystic calculus is more likely to be detected if only the hand and wrist are inserted into the rectum to palpate the bladder** (Divers 1996). A urethral calculus can be identified using ultrasonography and endoscopy, during passage of a urinary catheter, or by careful palpation of the urethra.

**Cystic uroliths should be removed by the method that best addresses the following factors:** size and texture of the urolith, anaesthetic risks and economic constraints. They can be removed surgically via ischial urethrotomy, celiocystotomy or pararectal cystotomy (i.e. Goekel's operation).

**Sometimes a urolith must be fragmented** (i.e. lithotripsy) before it can be removed by urethrotomy. To remove a calculus from any area of the urethra, the horse can be anaesthetised, or the procedure performed with the horse standing using chemical restraint and local or regional anaesthesia. Ischial urethrotomy and pararectal cystotomy are usually performed with the horse standing. **Urethral incisions are usually left unsutured to heal as an open wound.** Cystic and urethral uroliths can also be removed using electrohydraulic, ultrasonographic or continuous wave or pulsed dye laser lithotripsy (Howard *et al.* 1998). Pulsed dye laser lithotripsy fragments uroliths using less energy than other methods of lithotripsy and can be performed transendoscopically with the horse standing. An ischial urethrotomy, however, may be required to remove fragments.

Optical crystallography analysis indicates that almost all uroliths of horses are composed of **calcium carbonate** (Laverty *et al.* 1992). **Urinary acidification** with ammonium chloride, ammonium sulphate or ascorbic acid is often prescribed to prevent recurrence of urinary tract calculi (DeBowes *et al.* 1984; Wood *et al.* 1990). There are no studies, however, that compare the likelihood of recurrence of calculi between horses that have received urinary acidifiers and those that have not. The urinary pH at which formation of calcium carbonate calculi is inhibited in the horse is not known. A more practical approach to prevent recurrence may be to promote increased consumption of water and urine output by increasing the salt content of the ration (Keller 1986). Diuresis in horses can be promoted by adding salt to the daily ration, but there is little information to indicate the amount of salt that must be in the ration to increase water consumption and urine output.

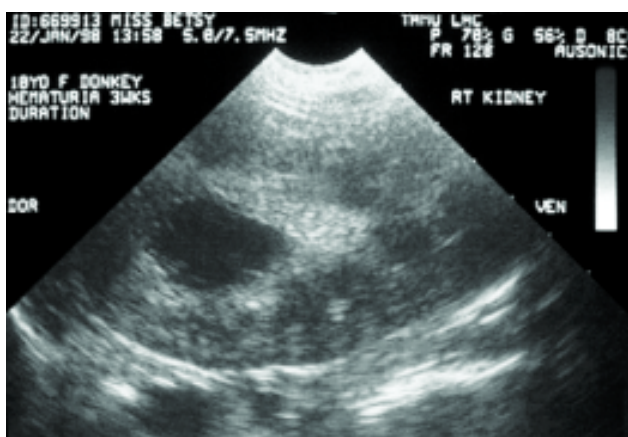
**Addition of 200–500 g salt to the diet has been recommended to increase water consumption and urine output** in horses (1.7–4.4% salt in the ration of a 450 kg



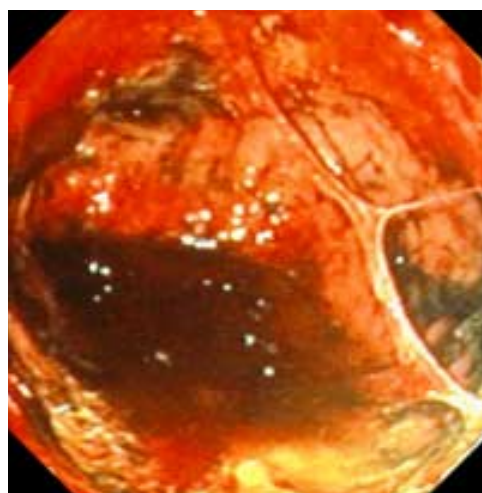
**Fig 8:** A kidney of a donkey with haematuria caused by *H. delitrix*. A large granuloma can be seen in the renal parenchyma.



**Fig 10:** Ultrasonogram of a kidney of a horse with haematuria. An adenocarcinoma is outlined by arrows.



**Fig 9:** Ultrasonogram of the kidney shown in Figure 8 before nephrectomy. A well-delineated, anechoic mass involving both the renal cortex and medulla can be seen.



**Fig 11:** Haemorrhagic mucosa of the bladder of a horse with cantharidin poisoning caused by consumption of blister beetles.

horses consuming 2.5% of its bodyweight) (Keller 1986). However, in a metabolism study, horses consuming a diet containing 5% salt showed no higher water consumption or urine output compared to horses that consumed a diet containing 1% salt (Schryver *et al.* 1987). Sheep fed a ration of 4% or greater concentration of salt had a significantly lower incidence of urolithiasis than did sheep fed a urinary alkalinising ration. Sheep fed the high salt diets had significant increase in urine output, but the decreased incidence of urolithiasis was speculated to be caused also by a direct effect of salt on inhibition of formation of uroliths (Udall 1962).

Several long-term, follow-up evaluations of horses that had calculi removed by celicystostomy indicate that recurrence of cystic urolithiasis is not likely (Lowe 1965; Holt and Pearson 1984), but that a cystic urolith is more likely to recur if the urolith was fragmented before removal (Lavery *et al.* 1992). **If a cystic urolith is fragmented for removal**, the bladder should be examined by endoscopy after surgery to ensure that no fragments of the calculus are left to act as a nidus for formation of new cystic uroliths.

## Verminous nephritis

Haematuria in horses caused by renal infection with *Halicephalobus deletrix* (Rubin and Woodard 1974; Keg *et al.* 1984; Blunden *et al.* 1987; Ruggles *et al.* 1993) or *Strongylus vulgaris* (Mahaffey and Adam 1963) has been reported. *Halicephalobus deletrix*, previously known as *Micronema deletrix* and recently suggested to be *H. gingivalis* (Anderson *et al.* 1998), is a saprophytic nematode that rarely causes disease in horses. The nematode can invade the central nervous system to cause neurological signs; bone to cause osteomyelitis; and the kidneys, where it creates granulomas that may cause haematuria (Fig 8). The nematode may be found during urinalysis of affected horses (Mayhew 1989). Horses with renal disease caused by *H. deletrix* often have concurrent signs of neurological disease or osteomyelitis, especially of the mandible or maxillae.

Ultrasonography of affected kidneys has been described for at least 2 horses (Ruggles *et al.* 1993; Reef 1998). **Renal**



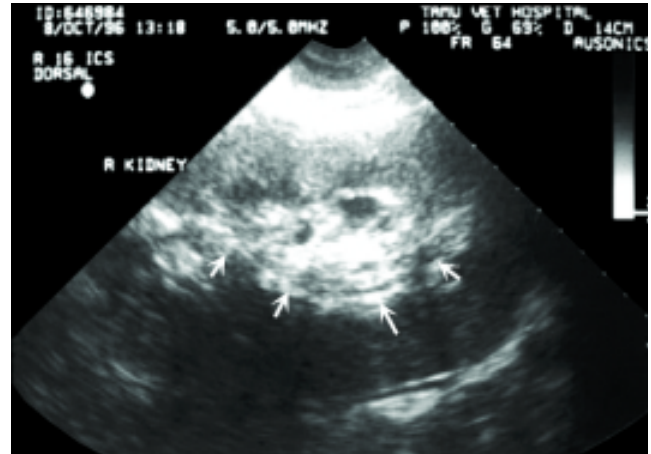
**Fig 12: A striped blister beetle (*Epicauta* spp.).** Striped blister beetles are the most frequent cause of cantharidin toxicosis in horses in the southwestern United States.

**masses**, similar in echogenicity to the renal cortex, were imaged in these cases. One kidney, however, had a normal appearance during ultrasonography but contained firm renal masses when examined during necropsy (Reef 1998). One of the authors (DS) examined a miniature donkey with a granuloma of one kidney caused by *H. delitrix*. In this case, the renal lesion had the ultrasonographic appearance of a focal, well-delineated, anechoic area that involved both the renal cortex and medulla. Acoustic enhancement on the deep edge of the granuloma was not apparent (**Fig 9**). This donkey responded well to a unilateral nephrectomy.

Horses suspected to have a renal infection of *H. delitrix* should be treated with an anthelmintic that has larvicidal activity (Ruggles *et al.* 1993). Inflammation associated with death of the nematode may cause clinical signs of renal infection soon after an infected horse is administered an anthelmintic (Alstad *et al.* 1979; Ruggles *et al.* 1993). Consequently, horses thought to be infected with *H. delitrix* should be treated with an anti-inflammatory drug, in addition to an anthelmintic with larvicidal activity. Although successful medical treatment of horses with verminous nephritis has not been reported, similar treatment of horses with verminous encephalitis is often successful (Mayhew 1989). When a kidney infected with *H. delitrix* appears to have no residual function, unilateral nephrectomy, rather than medical treatment, should be considered.

### Renal and vesicular neoplasia

Neoplasia of the urinary tract is an uncommon cause of haematuria of horses. Adenocarcinoma (also known as a renal cell carcinoma) and lymphosarcoma are the most common tumours affecting the kidney, but adenocarcinoma is more likely than lymphosarcoma to cause haematuria (Reef 1998). Haematuria is the result of neoplastic invasion of the renal vasculature (Brown and Holt 1985). An *antemortem*



**Fig 13: Ultrasonogram of a kidney of a horse with haematuria.** Arrows point to an area of medullary necrosis.

diagnosis of neoplasia is unlikely if ultrasonographic examination of the neoplastic kidney is not possible, unless the left kidney is affected and has a change in its palpable characteristics (Ramirez and Seahorn 1996). Large masses of mixed echogenicity are typically seen during ultrasonography of kidneys affected with adenocarcinoma (**Fig 10**) (Reef 1998; Ramirez and Seahorn 1996). Horses with a renal adenocarcinoma are usually inoperable because the neoplasm is often not diagnosed until the affected horse is terminally ill, and because **the tumour is likely to metastasise** to the liver, lungs and adjacent lymph nodes (Rooney and Robertson 1996).

**Squamous cell carcinoma**, the most commonly reported bladder tumour of horses, and transitional cell carcinomas are reported to cause haematuria in horses (Fischer *et al.* 1985; Turner *et al.* 1995; Patterson-Kane *et al.* 2000). Clinical findings of bladder tumours are similar to those of cystic calculi, such as haematuria and stranguria with a palpable mass in the bladder. Bladder tumours are readily diagnosed by identifying neoplastic cells during urine analysis or by endoscopic examination of the bladder. Tissue samples for cytology or histology can be obtained using the biopsy instrument of the endoscope (Fischer *et al.* 1985). Prognosis for survival of horses with neoplasia of the bladder is poor but, in one case, intracystical administration of 5-fluorouracil arrested the growth of a squamous cell carcinoma (Fischer *et al.* 1985).

### Less common causes of macroscopic haematuria

Haematuria is not a common clinical finding in horses with **blister beetle toxicosis** (Helman and Edwards 1997), but this condition should be considered as a cause of haematuria for horses fed alfalfa hay that have concurrent signs of abdominal pain. Haematuria caused by ingestion of blister beetles occurs late in the syndrome (Pancieria 1982), by which time other clinical signs may make the cause of haematuria obvious. **Cantharidin**, the toxic principle of blister beetles, is irritating to the digestive and urinary tracts. Irritation of the urinary tract

may cause pollakiuria and haemorrhage of the urinary mucosa (**Fig 11**) (Schmitz and Reagor 1987).

Poisoning by ingestion of the dead beetle occurs **almost exclusively in horses fed alfalfa hay**, but horses fed other types of hay, contaminated with weeds used by the beetle as a food source (e.g. nightshade plants), may also develop blister beetle toxicosis (Ray *et al.* 1989). Beetles (**Fig 12**) are not always found during a search of the contaminated hay and, therefore, the condition is definitively diagnosed by finding cantharidin in the urine, stomach contents or contaminated hay, using gas chromatography or mass spectrometry (Osweiler 1996). To detect cantharidin, at least 500 ml urine or 200 g stomach contents should be submitted to a toxicology laboratory in a refrigerated container (Schmitz and Reagor 1987). Treatment of horses with blister beetle toxicosis is symptomatic.

**Macroscopic haematuria** was reported in horses with anuric or oliguric renal failure that also had intravascular haemolysis (MacLachlan and Divers 1982; Morris *et al.* 1987). Histological lesions found during necropsy included arteriolar microangiopathy. These cases were compared to the haemolytic-uraemic syndrome of man, a syndrome of renal failure and haematuria caused by verotoxins produced by specific types of *Escherichia coli* and associated with the consumption of raw milk or undercooked hamburger (Martin and Shipman 1988). For horses with this syndrome, bacterial toxins or possibly other agents may have caused endothelial damage in glomerular capillary loops and small arterioles leading to renal failure and haemorrhage. Intravascular haemolysis was probably caused by damage to red blood cells as they flowed through fibrin strands deposited in small renal vessels.

This syndrome should be suspected in horses that have haematuria, intravascular haemolysis with red blood cell fragmentation, and clinicopathological evidence of renal failure. Although horses reported to have haemolytic, uraemic-like syndrome died, treatment of affected horses should include polyionic fluids and diuretics administered *i.v.* to induce polyuria.

Macroscopic haematuria in horses can be caused by **chronic administration of nonsteroidal anti-inflammatory drugs (NSAIDs)**, usually phenylbutazone, to dehydrated or hypotensive horses or when administered in excess of recommended doses (Behm and Berg 1987; Edwards and Carter 1991; Divers 1996). Chronic administration of NSAIDs causes decreased renal medullary blood flow that can result in medullary and pelvic necrosis. Increased echogenicity of the renal papilla and echogenic debris in the renal pelvis may be seen on echography of affected kidneys (Reef 1998) (**Fig 13**). **Clinicopathological evidence of renal failure and history of administration of NSAIDs supports the diagnosis.** Treatment of affected horses involves discontinuation of administration of NSAIDs and correction of fluid volume and electrolyte deficits (Divers 1996).

Macroscopic haematuria is observed **occasionally in exercising horses**. Repeated concussion of the bladder during exercise can be sufficient to cause mucosal damage

and haemorrhage. A small amount of urine in the bladder may act as a cushion to prevent this injury and, therefore, urination immediately before exercise may predispose to injury of the bladder mucosa (Schott and Varner 1997).

**Vascular anomalies that can be congenital or acquired** are a rare cause of haematuria in the horse. A congenital renal arteriovenous fistula was a cause of haematuria in a foal (Schott *et al.* 1996). The haematuria and renal lesion in this foal resolved within weeks, but another horse with a renal vascular anomaly did not develop haematuria until it was mature (Divers 1999). A fistula between an aneurysm of the terminal portion of the aorta and a ureter was the cause of haematuria in another foal (Latimer *et al.* 1991). The aetiology of the vascular anomaly in this foal was not determined.

Diagnosis of vascular anomalies is aided by ultrasonography of the urinary tract. Colour-flow Doppler ultrasonography may be particularly useful in diagnosis of vascular anomalies (Schott *et al.* 1996). If the contralateral kidney is functioning normally, the kidney responsible for the haematuria can be removed (Divers 1999), but more conservative treatment may be effective (Schott *et al.* 1996). Creating a thrombus within the vascular lesion by selective renal arterial embolisation (a procedure during which an occlusion device is placed, using fluoroscopic guidance, within the vascular lesion) may be effective in resolving haematuria. Spontaneous formation of a thrombus within a renal vascular anomaly resulted in resolution of haematuria in a foal (Schott *et al.* 1996).

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