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OBSTRUCTIVE UROLITHIASIS IN FEEDLOT CATTLE

B A Vanselow
NSW Agriculture Regional Veterinary Laboratory PMB (UNE) Armidale 2351

SUMMARY

A devastating outbreak of obstructive urolithiasis occurred in a 13,000 head feedlot; predominantly affecting "finisher" cattle, i.e. cattle greater than 200 days on feed. Over a 7 week period approximately 1000 animals were diagnosed with urethral obstruction and immediately sent for salvage slaughter. As a result of early detection, very few animals died from the condition and few carcasses were condemned. Significant financial loss occurred when animals sent for salvage slaughter did not reach the required weight for export to Japan.

The stones were composed predominantly of magnesium ammonium phosphate but calcium oxalate and calcium carbonate were also identified. The urinary pH for 14 obstructed animals was alkaline (mean pH 8.1). A treatment regime of dietary ammonium chloride (1%), additional sodium chloride (1%), and a reduction in dietary sodium bicarbonate (to 0.25%) resulted in a drop in urinary pH after one week (from 26 animals mean pH 6.4) and after two weeks there was a virtual cessation of clinical cases.

Predisposing factors which may have initiated the outbreak included sorghum as the sole grain fed, alkalizing agents in the diet (sodium bicarbonate and calcium carbonate), and alkaline drinking water high in calcium carbonate and magnesium salts as well as marginal tissue levels of vitamin A.

Monitoring of urinary pH has now become a routine practice at this feedlot when steers are brought through the race for weighing. Sophisticated equipment is required; a plastic container strapped to the end of a broom handle for collecting the specimen and a hand-held pH meter (from Dick Smith's Electronics) for the measurement.

INTRODUCTION

Feedlot cattle are prone to form uroliths and develop blocked urethras because:-

-Steers have a narrow urethra: related to castration at an early age.

-Grain concentrates have a high phosphorus content. The most common urolith to form on a high grain diet is struvite (magnesium ammonium phosphate).

-Pelleted feed rather than a loose concentrate ration decreases salivation and the less roughage in the diet, the less salivation. With decreased salivation, phosphorus, normally lost in saliva and faeces, is excreted in the urine.

-High concentrate diets produce high levels of low molecular weight peptides in the urine: these have strong ion binding potential, thus favouring calculi formation. Sorghum is recognized as "calculi provoking".

Other predisposing factors that may be involved in urolith formation in feedlot cattle are:-

- Historically, the hormonal growth promotant, diethylstilboestrol (no longer available) increased the urinary polyelectrolytes, including peptides, proteins, and mucoproteins, and hence calculi formation.
-Vitamin A deficiency predisposes to urolithiasis because of an increase in desquamation of epithelial cells into the bladder.
-Water quality and consumption. Restricted water intake causes concentration of urine and precipitation of crystals.

The predisposing factors have been reviewed by Jensen and Mackey (1974).

The sequence of events in struvite urolith formation is believed to be as follows:-

1.Peptides, proteins and mucoproteins aggregate to form an organic matrix.
2.The matrix binds both anions and cations. Magnesium cations and complex ammonium phosphate anions are bound.
3.Crystals form which grow into calculi. These struvite calculi are highly insoluble in alkaline urine.

MATERIALS AND METHODS

The chemical analysis of the uroliths was performed at the NSW Agriculture, Regional Veterinary Laboratory at Armidale, using a semiquantative chemical method - Merckognost (Merck).

The specific gravity of the urine was measured on a refractometer by measuring the optical density and using a prepared graph to convert it to specific gravity.

Serum and tissue vitamin A was measured by High Pressure Liquid Chromatography at the NSW Agriculture Elizabeth Macarthur Agricultural Institute, Camden. Samples for analysis were collected at the abattoir.

Urine pH was measured with a hand-held pH meter (Dick Smith Electonics).

For bacterial culture bladder stones were surface-sterilised and crushed as described by Osborne et al (1985).

CLINICAL SIGNS

The clinical signs observed were consistent with those that have been described for obstructive urolithiasis (Blood and Radostits 1989). These included signs of abdominal pain manifest as kicking at the belly, increased respiratory rate, stretching out, treading with the hind feet, grunting, grating of teeth and occasionally sternal or lateral recumbency. Repeated attempts to urinate were noted as swishing of the tail, raised tail, twitching of the penis, shaking of the prepuce, abdominal contractions and grunting. White crystalline material was sometimes observed on the prepucial hair. In cases of incomplete obstuction urine was seen to dribble out or form a narrow stream which was often blood-stained.

In the case of complete obstruction, rupture of the urethra or bladder occurs in about 48 hours (Blood and Radostits 1989). If the urethra ruptures, urine leaks into the connective tissue of the ventral abdominal wall and prepuce causing obvious swelling. It was observed that when the bladder apparently ruptured there was an immediate disappearance of discomfort. Once clinical signs of obstruction were observed the affected animals were sent to the abattoir for salvage slaughter. In some cases the obstruction was not detected early enough and signs of urethral and bladder rupture were observed as well as depression and anorexia and occasional deaths from uraemia approximately 2 to 3 days after apparent bladder rupture. Abdominal paracentesis was a useful aid in diagnosing ruptured bladder.

POST-MORTEM FINDINGS

The post-mortem findings included either ruptured or intact bladder. If intact, the bladder was markedly distended and haemorrhagic. The urine was often blood-stained and contained a large volume (often a handful) of sand-like bladder stones. The majority of stones were creamy-white spheres with a smooth surface, their sizes mostly in the range 0.5 - 4 mm. The largest stones observed were 0.8mm diameter. Less commonly grey spherical rough surfaced stones were observed. Occasional cases of hydronephrosis were observed. Peritonitis was a common finding, with large fibrin clots observed in the abdominal cavity and overlying the viscera. Peritonitis was observed in all cases of ruptured bladder but was also observed in cases where the bladder was still intact but grossly distended presumably to the point where urine was able to leak through the wall. Aggregates of bladder stones were found at the point of blockage of the urethra. The urethra proximal to the blockage was inflamed and haemorrhagic while the distal urethra was normal in appearance. Rupture of the urethra associated with a distal blockage, resulted in massive swelling and fluid accumulation in the prepuce. Bladder stones were also observed in cattle that had no urethral obstruction and it was estimated from observing one day's 'kill' at the abattoir that 85-90% of all finisher cattle had bladder stones.

CLINICAL PATHOLOGY

Chemical analysis of the stones showed that the creamy-white stones were predominantly composed of magnesium ammonium phospate (Struvite) but most also contained calcium oxalate and some contained calcium carbonate. The rough grey stones were predominantly calcium carbonate.

The specific gravities of urine samples from cattle with and without urinary tract obstruction were found to be within the normal range.

For vitamin A analysis 7 sera samples were collected at random from slaughtered cattle. These samples were pooled into 2 groups and the measured levels were found to be within the normal range. Two liver samples were analysed; one from an "obstructed" animal and one from a normal animal. The vitamin A levels were 43.9 and 39.0 umol/kg respectively. Although these levels are not considered "deficient" they reflect little liver reserve and are much lower than those measured from two finisher cattle one month earlier where the levels were 358 and 356 umol/kg.

Prior to treatment, urine samples were collected at the abattoir from finisher cattle .
From 14 cattle with urinary tract obstruction the mean urine pH was 8.1 (SD 0.5).
From 24 finisher cattle without urinary obstruction the mean urine pH was 8.4 (SD 0.2).

Following treatment, random samples of urine were collected from finisher cattle. It was not until day 7 post-treatment that the pH was observed to have dropped significantly. From 26 animals the mean pH was 6.4 (SD 0.8).

BACTERIOLOGY

No urease producing bacteria were cultured from bladder stones.

TREATMENT AND PREVENTION

1% ammonium chloride, and 1% salt (sodium chloride) were added to the diet. The animals had been receiving 0.75% sodium bicarbonate in the diet. This was lowered to 0.25%. Urine pH levels were monitored and were not observed to fall until 1 week after treatment commenced. Seventeen days after the treatment commenced the incidence of obstructive urolithiasis suddenly dropped and bladder stones were no longer observed at slaughter. Ammonium sulphate (Crookshank, 1970) has since been introduced to replace the ammonium chloride because it is cheaper and readily available in Australia. Monitoring of urine pH has now become a routine practice in this feedlot.

DISCUSSION

Obstructive urolithiasis is a well recognised condition in feedlot cattle (Jensen and Mackey,1974 ; Tsuchiya,R. and Sato,M.,1988) and Struvite (magnesium ammonium phosphate) stones are most commonly found. Struvite urolithiasis also occurs in other animal species and in man (Osborne et al 1985). Many dietary factors can contribute to the formation of uroliths. In the outbreak described here possible contributing factors were analysed. Hormonal growth promotants were not used at the feedlot and were therefore ruled out. Water quality was good, although alkaline, and urine specific gravity measurements indicated normal water intake. Tissue levels of vitamin A were low but not deficient and therefore were unlikely to affect bladder epithelium.

Suspected contributing factors included:-

Urine pH

The urinary pH prior to treatment was very alkaline .

Possible dietary causes of this included :-

i.Sodium bicarbonate incorporated in the diet at 0.75%

ii.Calcium carbonate incorporated in the diet to balance the high phosphorus levels. These appeared to be high in July according to feedlot records with a Ca:P ratio of approx. 5:1. The drinking water also contained high levels of calcium carbonate (183.3 mg/l). Uroliths containing calcium carbonate were identified.

iii.pH of drinking water was 8.4.

iv.Magnesium in the water was 21.1 mg/l.

Sorghum

Sorghum grain has been implicated in cases of urolithiasis (Blood and Radostits,1989) but no explanation has been given for its "urolith provoking" properties. Cottonseed meal also has been implicated in urolith formation and it may be that both have some protein that bypasses the rumen and instead of being broken down to volatile fatty acids in the rumen, the protein is absorbed and ammonium is produced and excreted in the urine.(R.Leng, pers. comm.). Sorghum stubble contains oxalate, so it is feasible that the grain may contain a small amount of oxalate. Uroliths containing calcium oxalate were identified. Oxalates are also a normal by-product of catabolism and tend to precipitate out when there is obstruction to urine flow (Manning and Blaney,1986) and therefore may be secondary to other calculi.

Magnesium

Magnesium in the water was 21.1mg/l. This may have contributed to the formation of the struvite uroliths.

In man and dogs Struvite uroliths usually occur secondary to infection, especially with urease-producing bacteria (Osborne et al 1985). In ruminants there is no evidence yet that primary bacterial infection is involved. From obstructed cattle in this outbreak, no urease producing bacteria could be isolated from sterilised crushed bladder stones. If further outbreaks occur this should be investigated more thoroughly. It is puzzling that the stones contain ammonium ion in the absence of ureolysis by urease producing bacteria because under physiological conditions associated with alkaline urine, urine contains low concentrations of ammonium ions (Osborne et al,1985).

In the treatment of affected cattle, emergency surgical procedures were not feasible because of the large numbers involved and hence a policy of salvage slaughter was instigated. Once it had been established that urine pH levels were alkaline and that the stones were predominantly Struvite, measures were taken to acidify the urine (Hay, 1990). Struvite is soluble at pH<6.8 (Rahaley,1988). This was achieved by the addition of ammonium chloride (1%) to the diet. The feedlot involved have now replaced the ammonium chloride with ammonium sulphate because it is cheaper and more readily available and through constant monitoring of urine pH they have determined that it is equally effective in maintaining the low pH required. Not only does the acidity dissolve the crystals but it has also been postulated that chloride and sulphate ions bind to mucoprotein, blocking ion binding and crystal formation (Jensen and Mackey, 1974). The response to the treatment to acidify the urine took approximately 7 days. In monogastric animals urine pH can be altered quickly but in ruminants the change is much slower and probably related to the slower passage of digesta through the digestive system (H M Chapman, pers. comm.). The incidence of clinical disease did not drop until 17 days after treatment. This probably reflects the time needed for the larger stones to dissolve enough so that they can safely pass down the urinary passage. From observations made at the abattoir the stones were quick to clear from the bladder. At day 12 post-treatment there appeared to be a surge in the number of cases detected. The specific gravity of the urine was monitored before and after treatment. No significant changes were noted and therefore it seems unlikely that the treatment produced more dilute urine and a flushing effect. It is conceivable that the treatment reduced the size of larger stones thus allowing them to leave the bladder and enter the narrow urethra.

Monitoring of urinary pH has become routine practice at this feedlot. The equipment required is simple and inexpensive and the samples are collected during routine weighing of the finisher cattle.

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