Silica Urolithiasis in Beef Cattle

I. Observation on Its Occurrence

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INTRODUCTION

Urolithiasis is the term used to denote the formation of urinary calculi in animals including disease conditions that arise as a direct result. The terms urinary calculus and urolith on the other hand apply only to the actual calculi or uroliths formed in urolithiasis.

In cattle, urinary calculi present in the bladder, on occasions enter and obstruct the urethra. This is the common form of obstructive urolithiasis in steers and bulls. The severity of the condition is due to the fact that when urethral obstruction is complete as it often is, urine in the bladder does not have normal exit. Regardless of the obstruction, excreted urine continues to be passed into the bladder with the result that barring surgical intervention, bladder rupture (occasionally urethral rupture ensues. In cattle, bladder rupture is virtually one hundred percent fatal. The mechanism of obstructive urolithiasis and its importance in cattle is described in more detail below.

Urolithiasis in cattle is not always obstructive. In the greater majority of cattle with urolithiasis it exists without producing observed clinical manifestations and is discovered only after post mortem examination. It would appear, that, under the condition of the present studies, clinical urolithiasis is merely a function of the incidence and prevalence of a much more extensive subclinical urolithiasis in the cattle population. Therefore, in this paper the unmodified term “urolithiasis” is used with reference to urolithiasis generally, irrespective of whether it is subclinical or clinical. On the other hand when reference is made to clinical urolithiasis the term “urolithiasis” is appropriately modified. “Obstructive urolithiasis” implies urethral obstruction unless otherwise stated, because this is the common clinical form of the disease in cattle.

The concept that defines urinary calculi as consisting necessarily of crystalline material requires modification, since silica calculi of cattle are not crystalline (1), but none-the-less calculi. Likewise definitions that restrict the location of uroliths to some point between the renal papillae and the urethra should be enlarged to include any point between the renal glomerulus and the urethra, provided all urinary calculi found in cattle are to be included in the broad definition. Essentially, urolithiasis involves an abnormal development of stones or concretions in the urinary tract, either by crystallizing out of insoluble salts, supersaturation of soluble salts, or in the case of the non-crystalline silica calculi, by some other process.

REVIEW OF LITERATURE

The literature on urolithiasis is voluminous and no extensive review shall be attempted here. Steyn and Roinach (2) have comprehensively reviewed the pertinent literature published prior to 1939.

Field and laboratory studies by Eveleth et al (3), Lindley et al (4), and Swingle and Marsh (5) have tended to eliminate, or at least, minimize vitamin A deficiency as a component of the etiological complex. Swingle and Marsh (6) found also that restricting the water intake of steer calves was not in itself productive of cases of obstructive uro-

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lithiasis. Lindley et al (4) and Elam et al (7) have shown that the addition of phosphorus, potassium and sugar beet pulp to the feedlot ration of male sheep resulted in an increased incidence of urolithiasis. In this last study the calculi were composed almost entirely of calcium and magnesium phosphates. In areas where calculi are predominantly of the silica type, Beeson et al (8) observed no increase in incidence of urolithiasis following the addition of silica to the ration. On the other hand, Earle and Lindahl (9) found that lambs fed one percent sodium silicate in their ration had increased numbers of calculi consisting of magnesium phosphates in their bladders.

DISTRIBUTION

From surveys conducted by mail, and enquiries directed to the Veterinary Research Laboratory, it would appear that, geographically, obstructive urolithiasis in cattle occurs in all parts of Saskatchewan and Alberta and to a lesser extent in the other provinces of Canada. However, over the greater part of the area the occurrence of obstructive urolithiasis is sporadic. More cases occur during some years than others, but for the most part it does not give rise to a serious problem, except in certain areas. The latter areas are shown in Fig. 1, which was drawn from data collected during the last eight years. From these data it was found that 87.4 percent of the 207 premises reporting cases of obstructive bovine urolithiasis were located in the areas shown, while 12.6 percent were premises reporting sporadic cases from widely scattered points — Weyburn, Moose Jaw, Saskatoon, Peace River District, and other points — outside the area shown. Thus approximately nine-tenths of all premises reporting cases of obstructive urolithiasis in the last eight years are located in the shaded areas. These areas collectively will be referred to as problem area. In the problem area obstructive urolithiasis is usually not sporadic in its occurrence. Losses in herds vary from year to year and from herd to herd, from nil to about

![Map of Saskatchewan and Alberta](image_url)
five percent of the steers kept, and occasionally as high as ten percent.

Clinical obstructive urolithiasis occurs in range and feedlot steers, most often steer calves, occasionally bulls, usually from October to March, reaching peak incidence as a rule in mid-winter.

ANATOMICAL AND CLINICAL FEATURES

The problem of obstructive urolithiasis in steers and bulls depends on the fact that uroliths in the bladder often become large enough to obstruct the urethra and prevent the passage of urine if they should be swept into the urethra during the act of urination. If the obstruction is not removed the bladder becomes so distended that it ruptures, a condition that is almost invariably fatal in cattle. Less commonly, rough, irregular uroliths damage the urethral lining and urethral rupture rather than bladder rupture results. In such cases urine escapes into the tissues surrounding the point of rupture leading to the production of oedema-like swelling in tissues of the inguinal and ventral abdominal regions.

The urethra in the steers, as a result of castration, is relatively narrow (10), and its obstruction may be brought about by a relatively small stone. Another consideration related to ease of obstruction is the presence of two sharp bends in the portion of the urethra that traverses the sigmoid flexure of the penis. These two bends serve as catch points, where relatively small stones may be slowed in their passage. Scratching of the urethral lining induces reflex spasm in the surrounding musculature. These muscle spasms impede and fix the stone. A third "catch" point exists near the tip of the penis where the lumen is less expansible than elsewhere.

Urolithiasis occurs not only in steers and bulls; it is also prevalent in heifers and cows (11), but in heifers and cows the urethra is relatively large in diameter and obstruction is of very rare occurrence. Hence, compared to females, the susceptibility of males to obstructive urolithiasis would seem to be due to sexual differences in anatomy, and not to less frequent urolith development in females.

The ureters have strong muscular walls and carry the urine from the kidney to the bladder by peristaltic action. The ureters thus prevent damaging backing up of urine pressure on the kidneys. It appears to be the muscular strength of the ureters that creates the pressure that ruptures the bladder in urethral obstruction, rather than kidney secreting pressure. The increased muscular activity of the ureters in urethral obstruction is perhaps reflexly stimulated by relatively slight pressure increases affecting the kidneys.

CHEMICAL CHARACTERISTICS OF BOVINE UROLITHS

In the problem area bovine uroliths have silica as the principle constituent (1), whereas, outside the problem area, the uroliths contain little or no silica.

PATHOLOGICAL FINDINGS

Since 1955, the authors have carried out a number of studies in an effort to collect specific information about the condition (11). These studies comprised feeding trials and survey observations to determine if variations in the rations fed would affect the incidence of urolithiasis and the number of calculi formed. Obstructive urolithiasis was not considered to be a satisfactory criterion in these studies because its incidence is relatively low, and is believed to be only a terminal phase of the general problem. The authors felt that perhaps the factors involved in the genesis of uroliths might be of greater fundamental importance than the factors immediately preceding attainment of obstructive size. Therefore, each animal was killed at the termination of its experimental period, its kidneys and urinary tract collected intact and carefully examined.

In studies on urolithiasis reported in separate papers (11, 1), a total of 204 steers were killed, the urinary tracts of
which were examined for the presence of uroliths. The procedures and methods used in examining the urinary tracts are described by Whiting et al (11). To round out the pathological picture of urolithiasis, a few additional data, selected from pathological records in the Veterinary Research Laboratory have also been utilized.

In 204 experimental cattle killed, the findings, in summary, were as follows:

Calculi found in kidneys, bladder and urethra ........................................... 8
Calculi found in kidney and bladder ......................................................... 93
Calculi found in kidneys only ................................................................. 29
Calculi found in bladder only ................................................................. 31
Total positive ................................................................. 161
No calculi found ................................................................. 43
Total ................................................................. 204

Of the 161 positive cases, 130 (80.7 percent of positives) yielded renal urolithic material. The distribution of urolithic matter in the kidneys was quite uniform, but in a few instances unusual and unexpected. In most, the urolithic matter was found only in the calyces. This consisted usually of rather fine gritty material, in some cases throughout the calyces of both kidneys and at the other extreme localized in a calyx minor of one pole of a single kidney. In some, the renal uroliths were thin, often perforated plates, or scales, extending over a variable area and moulded to the shape of a calyx minor. Such scale calculi were of a size that would preclude their passage down an ureter. Most renal urolithic matter, however, was fine enough to allow passage down the ureters.

One kidney in each of two animals showed calculary obstruction of collecting tubules that resulted in back-up of urine and formation of retention cysts. In these cases the obstructing uroliths were in the terminal portions of tubules and extended into the kidney tissue from the papillary orifices. Conceivably the obstructions could have originated in the tubules or grown into the tubules from points of origin at the duct orifices on the papillary surface. The most unusual finding, however, was a cystic condition in 10 animals (13 kidneys), in which cysts containing calculi were found in the renal cortex. The exact nature and origin of these cysts was not determined. They may have been congenital or may have resulted from urolith formation — perhaps essentially from infection and lobule infraction. The largest of these cortical cysts was 12 mm. in diameter. In this specimen, as well as in others, the contained mass of urolithic matter appeared to have created pressure on lobular structures, because externally the kidney presented a gross appearance of containing an infarct.

One kidney from one animal contained an amount of pus along with urolithic matter. This proved on bacteriological examination to be a case of bovine pyelonephritis. Another case of pyelonephritis with quantities of greenish caseous pus in both kidneys and bladder was free of urolithic matter. In one animal both kidneys were swollen, pale and showed multiple necrotic foci, and yielded considerable amounts of urolithic matter.

Uroliths were found in the bladders of 132 animals, in 31 of which bladder calculi only were found. Bladder calculi ranged in size from very fine to more than obstructive size (ca. 5-mm. diam.), and in color from chalk white, through cream color, to light brown, to graphite black. The last when sperical, looked like shot. From bladder calculi it was obvious that calculi could produce obstruction in any one of three ways, (a) by single uroliths obtaining obstructive size, (b) by agglomeration and cementing together of numerous small uroliths, and (c) by numerous small stones of sub-obstructive size passing into the urethra at once. The last mentioned type of obstruction is likely to occur as the result of the accumulation of a considerable quantity of small calculi in the bladder, numbers of which enter the urethra at once during an act of urination. The irritation produced results in urethral spasm which stops passage of the stones.
This chain of events frequently leads to a formidable form of urethral obstructions, sometimes with 12 to 14 inches of the urethra packed and occluded with small calculi.

The bladders of 17 animals when opened showed variable local changes in the mucosal surface. These varied from one or more small patches of reddening in the ventral wall to large patches of deep reddening, in one case with evidence of hemorrhage. This irritation of the bladder lining perhaps was due to rolling back and forth of calculi because the changes mentioned occurred in the ventral wall.

In the bladder of one animal there was a considerable quantity of material resembling coagulated egg white. The material in the gross appeared free of grittiness, there was no cystitis, no gross nephritis, although there were calculi in the kidneys. In attempting to wash the material in distilled water, it dispersed completely and was lost.

An additional form of obstructive urolithiasis, observed from time to time in the field was not observed in the group of animals under study. Although the condition was no part of the studies carried out, we shall describe it briefly to round out the pathological picture.

This condition consists in obstruction of the prepuce. Occasionally top-shaped, agglomerated stones develop in the prepuce that act as floating valves occluding the flow of urine from the preputial orifice. As a result, urine is trapped in the prepuce and infiltrates the ventral abdominal tissues. This type of obstruction if recognized is not difficult to remedy.

The study of histological sections from kidneys containing urinary calculi has not been enlightening. No changes were observed in cases of urolithiasis that tended to suggest how the uroliths originated. Many workers have suggested that the origin of uroliths takes place in pathological nidi. The reasoning is logical, but if such is the case, the pathology is generally so obscure that it escapes detection. After a considerable amount of histopathological work, the authors are still left with the question — is discernible histopathology, as such, essentially involved in the origin of silica uroliths?

The vast majority of kidneys yielding uroliths exhibited no microscopic features that could not also be demonstrated in “normal” kidneys. Descriptions of findings in relation to cortical cysts that contained calculi served no purpose here because the pathology was advanced or terminal and its description would detract rather than contribute to an understanding of the usual manner in which calculi originate and grow.

Many slices of kidneys containing uroliths were examined in the gross under the dissecting microscope, and both flake calculi and fine calculi showed no indications of being adherent to the papillae or other calyceal tissues, being immediately dislodged by a gentle stream of physiological saline solution from a wash bottle. There was some tendency, however, for calculi to be adherent to reddened areas of bladder mucosa in those cases that showed localized cystitis.

Ostensibly, uroliths can have their earliest formed beginnings anywhere between the renal glomerulus and the prepuce. It would seem probable that most obstructive calculi have their beginning at the renal papilla level. This is not necessarily exclusively so, because a percentage of cases yielded cystic uroliths only and hence it may be that uroliths may also originate in the bladder and even the prepuce. After small beginnings, calculi obviously can increase in size by accretion and/or agglomeration in kidney, bladder and prepuce. In urolithiasis with urethral obstruction, attainment of obstructive size, whether by accretion or agglomeration, occurs in the bladder. Lastly, agglomerated preputial stones must attain obstructive size in the prepuce.

DISCUSSION

Various theories have been advanced
to explain urolithiasis in cattle and many attempts have been made to produce the condition experimentally but its causation still remains obscure. Field observations made at various times and places have suggested a number of causative factors — vitamin A deficiency, insufficient water intake, intake of highly mineralized water, nutritional imbalance, especially as regards minerals, intake of certain feedstuffs, weather and climatic effects, urinary tract infection, toxic effects, and metabolic disturbances associated with abnormal excretion of salts. In general, however, bovine urolithiasis is considered to be nutritional in origin.

**SUMMARY**

Obstructive urolithiasis in beef cattle is of wide occurrence across Canada, but except for "problem" areas in Alberta and Saskatchewan, the condition is of sporadic occurrence. In the problem area urolithiasis is of considerable economic importance in range and feedlot cattle, and the greater proportion of cattle have calculi somewhere in their urinary tracts. Chemically the uroliths have silica as their chief constituent.

In most cases of non-obstructive urolithiasis, pathology, gross or microscopic, except for the presence of the calculi, was absent or at most very obscure. In some, however, definite pathology was present.

Uroliths may attain urethra obstructing size by single stones reaching obstructive size in the bladder, or by several small stones cementing together. Stones may also develop in the prepuce. The examination of genital tracts indicated that uroliths can occur throughout the urinary tract, from the renal cortex to the prepuce.

**RESUME**

L’urolithiase chez le bœuf de bouche- rie est très répandue au Canada, mais à l’exception de certaines régions de l’Al- berta et de la Saskatchewan, ce trouble se rencontre sporadiquement. Dans ces régions où l’urolithiase est un problème, elle est d’une importance économique considérable chez le bétail de pâturage ou élevé en enclos, et une plus grande proportion de bovins ont des calculs en diverses parties du tractus urinaire. Ces calculs sont, chimiquement, de na- ture siliceuse.

Dans la plupart des cas d’urolithiase non-obstructive, les lésions macro ou microscopiques, exception faite de la présence de calculs, sont absentes ou, tout au plus, peu appréciables. Dans quelques cas, cependant, on a noté des modifications pathologiques définies.

Les urolithes peuvent atteindre des dimensions suffisantes pour obstruer l’urètre soit par des pierres isolées augmentant suffisamment de volume pour obstruer la vessie, ou soit par de petites pierres se cimentant ensemble. Les pierres peuvent aussi se former sur le prépuce. L’examen du tractus génital indique que les urolithes peuvent être trouvés sur tout le tractus urinaire de- puis le cortex rénal jusqu’au prépuce.

**REFERENCES**