Intussusception secondary to retroflexion of a proximal jejunal diverticulum, leading to Type 3 vagal indigestion with severe hypochloraemia in an adult Simmental bull (Bos taurus)

Vet Record CaseReports

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TITLE OF CASE ***Do not include "a case report"***

Intussusception secondary to retroflexion of a proximal jejunal diverticulum, leading to type three vagal indigestion with severe hypochloraemia, in an adult Simmental bull (*Bos taurus*).

SUMMARY ***Up to 150 words summarising the case presentation and outcome (this will be freely available online)***

Intussusception is a rare but well described cause of intestinal obstruction in several species, including cattle, and is often associated with enteritis, intestinal parasitism or intestinal neoplasia. Clinical signs are non-specific and include anorexia with reduced faecal output.

This report describes a four-year-old Simmental bull that presented with anorexia and reduced faecal output, along with severe ruminal bloat and a large, dilated intestinal loop palpated rectally. Serum biochemistry identified severe hypochloraemia, consistent with proximal intestinal obstruction and a poor prognosis. Although supportive and symptomatic treatment was provided, the bull died before a definitive diagnosis could be made.

Post-mortem examination identified a segmental intestinal intussusception, within the proximal jejunum, which had resulted in intestinal obstruction. The primary cause of this intussusception was a retroflexed intestinal diverticulum, which formed the intussusceptum.

BACKGROUND ***Why you think this case is important – why did you write it up?***

Intestinal intussusception is a well-characterised disease entity which typically involves the telescoping of one segment of intestine (the intussusceptum) into another (the intussuscipiens). Intussusceptions have been identified in numerous species, including cattle, in which their development has been associated with a number of underlying disease processes, including enteritis, intestinal parasitism or neoplasia (1-3). In cattle, the most commonly affected locations are the small intestine (approximately 83.6% of cases), followed by colocolic (10.7%), caecocolic (3.6%) and ileocolic (2.1%) intussusceptions, with an increased frequency in calves (4). Typically, such cases initially present with hyporexia to anorexia, along with a reduction in faecal output (5).

Dehydration, an inflammatory leukogram and hypochloraemic metabolic alkalosis are typically identified on haematology and biochemistry profiles (1). Rapid surgical intervention is often required and may involve resection and anastomosis of the affected segment; rates of post-operative return to productivity range from 70% to less than 50% (4,6). This variability is likely to be related to differing duration of the obstruction prior to surgical intervention (7), which is often only attempted in high value animals.

Intestinal diverticula occur in all species as either 'true diverticula' involving all layers of the intestinal wall, or 'pseudodiverticula', which typically arise due to a defect in the muscularis layer, allowing invagination of the overlying mucosa and submucosa. Both types of diverticula have been associated with intussusception in a range of species. This is best described in human beings, with multiple reports identifying intussusceptions secondary to retroflexion of a pre-existing congenital malformation known as Meckel's diverticulum (8,9) or retroflexion of a diverticulum elsewhere in the intestinal tract (10–12). However, in cattle, intestinal diverticula are only sporadically described and there is minimal published literature describing progression of an intestinal diverticulum to an intussusception (13).

This report describes post-mortem identification of a proximal jejunal intussusception secondary to retroflexion of an intestinal diverticulum in a 4-year-old Simmental bull (*Bos taurus*), with resultant intestinal obstruction and type three vagal indigestion. This identifies a significant, albeit rare, differential diagnosis that could be considered in cases of suspected vagal indigestion.

Furthermore, as in all areas of veterinary medicine, it can often be challenging to discuss treatment options with a farm client in the absence of clinical findings or parameters which suggest an expected prognosis. In addition to the typical findings on clinical examination, such as dehydration and tachycardia, biochemical parameters, including haptoglobin and lactate, have been suggested to aid determination of the expected prognosis in such cases in ruminants (14–18). However, these are typically inaccessible in a reasonable time frame to the farm animal clinician and were not readily available in this case. Measurement of serum chloride levels provides an alternative method of assessing the prognosis in such cases (19) and may be more accessible as in this case. Identification of a severe hypochloraemia alongside a marked hyperglobulinaemia was used to indicate a likely poor prognosis, due to an extensive and chronic abomasal outflow impairment. Furthermore, the extremely low serum chloride of 59mmol/L in this animal was of a much greater reduction than would be typically expected in other abomasal disease such as left displaced abomasum (LDA), right displaced abomasum (RDA) or abomasal volvulus, all of which typically do not present with serum chloride lower than 80mmol/L. In such cases, the rumen chloride levels are often markedly elevated due to regurgitation of chloride rich fluid from the abomasum, although this was not measured in this case.

The use of serum chloride and its associated pathophysiology is reviewed in this report, which will provide farm animal clinicians with another parameter to consider as an aid to guide clinical decision making in cases of small intestinal or abomasal disease.

CASE PRESENTATION *Presenting features, clinical and environmental history*

This four-year-old Simmental bull originated from Ireland and was brought onto a farm on the west coast of Scotland at two years of age. The animal was to be used as one of four breeding bulls in a late-spring calving beef suckler herd of approximately 80 cows with followers. Like much of the herd, the bull was managed extensively at pasture during April to November and housed for the winter months (December to March). At housing each year, the bull was routinely given

anthelmintic treatment (once per annum), usually a persistently acting macrocyclic lactone. No previous abnormalities were identified by the farm staff or veterinary clinical staff during breeding soundness examinations of this bull, either at purchase or subsequently each year prior to breeding.

Approximately four months prior to presentation, the bull had been used to serve a group of approximately 60 cows at pasture without incident. Three weeks prior to presentation, the bull was moved into a new field to serve a new group of approximately 20 cows. At this time, another bull from the same farm escaped into the field and fought with the incumbent bull. After the animals were separated, no external injuries were noted, and the bulls both made uneventful recoveries. In the week following the initial change in pasture, the bull developed a moderate, intermittent, green diarrhoea. The diarrhoea resolved spontaneously, and the owner considered it an incidental response following the dietary change to lush grass. The bull was otherwise in good condition (body condition score of 3.5 - 4 throughout the service period) and had no recent history of illness in the past 12 months.

INVESTIGATIONS ***If relevant***

On 15th October 2021, the bull was noted to be isolated from the group, recumbent, anorexic and not passing faeces. A clinical examination by a veterinary surgeon identified bloating of the left side of the abdomen, with minimal rumen sounds and a doughy ruminal fill. This was initially suspected to be related to vagal indigestion and symptomatic treatment was initiated with dosages appropriate for an estimated 800 kg bull, including tilmicosin (Elanco, Micotil, 300 mg/ml), meloxicam (Norbrook, Loxicom, 20 mg/ml) and vitamin B12 (Dechra, Vitbee 1000, 0.1% w/v). Tilmicosin and meloxicam were administered to treat a potential pneumonia, which can be a predisposing factor for vagal indigestion (due to the associated compromise of the vagal nerve), although there was no overt dyspnoea or other clinical signs associated with pneumonia in this animal. Vitamin B12 was also given as an appetite stimulant. Over the following days, there was little improvement, despite additional symptomatic treatment, including butylscopolamine bromide and metamizole (Boehringer Ingelheim, Buscopan, 4 mg/ml and 500 mg/ml, respectively), in addition to stomach tubing twice daily to release excess ruminal contents and various oral mineral drenches administered by the farmer. Volumes of up to two litres of fluid were retrieved per stomach tubing and no free gas bloat was identified.

Considering this poor progression, the bull was referred to the Farm Animal Hospital at the Royal (Dick) School of Veterinary Studies on the 18th October 2021. Clinical examination, while the animal was standing, identified the animal was quiet, alert and responsive, with mild enophthalmos (presumed related to approximately 2% dehydration), severe bloating on the dorsal left, with additional moderate distention of the right ventral abdomen giving an L-shaped profile to the abdomen when viewed from behind. No ‘pings’ were identified by abdominal percussion and auscultation. On rectal examination, an approximately 10 cm x 20 cm, gas-filled, balloon-like structure was palpated in the right mid-ventral abdomen, which was considered to be consistent with a dilated loop of intestine. No melaena was identified. A stomach tube was passed orally (Selekt pump) which released a large volume of gas and watery green to brown ingesta (approximately 2l). All other vital signs (including heart rate, respiratory rate and temperature) were within normal limits.

A blood sample was taken from the ventral tail vein for biochemical and haematological analysis as in table 1 (although results were not received until the next day).

DIFFERENTIAL DIAGNOSIS *If relevant*

The severe hypochloraemia and approximately 2% dehydration (estimated based on the degree of enophthalmos) identified in this animal are relatively non-specific findings, which are typically reflective of a reduced outflow of chloride rich abomasal content into the duodenum and proximal intestine. This results in a chloride-depleted metabolic alkalosis due to the reduced resorption of chloride in the duodenum (20), but with maintenance of normal sodium levels. It is here that the chloride is normally resorbed. The combination of a severe hypochloraemia and severe ruminal fluid distention were strongly suggestive of extensive impairment of this abomasal content outflow. Furthermore, the severe hypochloraemia of 59mmol/L is much lower than would typically be expected with a LDA, RDA or abomasal volvulus as these typically do not result in a serum chloride below 80mmol/L. In addition, the severe marked hyperproteinaemia was driven by a marked hyperglobulinaemia, consistent with a chronic inflammatory response, suggesting this animal's pyloric outflow obstruction may have been present but clinically silent for some time.

Differential diagnoses which could result in similar biochemical changes include proximal intestinal obstruction (e.g. foreign body, torsion) or vagal indigestion amongst others. An RDA was considered, although the lack of the typical 'pings' on percussion and the signalment suggested these were highly unlikely. Similarly, abomasal torsion was considered, although this typically would result in an extensive 'ping', rapid clinical deterioration and severe dehydration, none of which were evident during the clinical examination.

It is worth noting that the serum biochemistry, haematology and electrolyte results were not received until the next day and therefore could not be taken into account in the initial treatment plan. An exploratory laparotomy was considered and discussed with the owner at the initial presentation at the referral centre, but this was not performed that evening as the owner wished to consider their options overnight. Unfortunately, this bull died overnight before exploratory surgery could be made.

Additional investigations were also considered to aid in refining the list of differential diagnoses, such as ultrasound-guided abdominocentesis. Since the gas-filled structure palpated per rectum was located deep within the right ventral abdomen, an ultrasound examination was considered unlikely to be unrewarding, as it may not penetrate deep enough in the abdomen to give a reliable assessment in the standing animal. The animal was scheduled for exploratory surgery the next day and could have been examined by ultrasound whilst sedated or anaesthetised. Similarly, whilst both lactate and haptoglobin could be useful markers to guide prognosis in cases such as this (14–18), such analyses were not immediately available.

TREATMENT *If relevant*

Whilst awaiting serum analysis, symptomatic treatment was continued, including procaine penicillin/dihydrostreptomycin sulphate (Norbrook, Pen & Strep Suspension, 200 mg/ml and 250 mg/ml, respectively), meloxicam (Boehringer Ingelheim, Metacam 20 mg/ml) along with a 1:20 glycerol and water drench. A change of antibiotic to procaine penicillin/dihydrostreptomycin sulphate, along with repeated meloxicam was used to treat potential abscessation, from chronic pneumonia or another site of abscessation (e.g. the liver), that may have caused vagal indigestion. An attempt was made to provide oral fluids; however, the animal became fractious on initial administration, which necessitated stopping this treatment. Therefore, the drench was given to

provide some nutritional support. These findings were reported to the owner in the early evening, with consideration given to either surgical exploration or euthanasia as the next intervention given the guarded prognosis. The owner decided to consider the options overnight.

OUTCOME AND FOLLOW-UP

Unfortunately, the bull died overnight on the 19th October 2021 and was presented to Easter Bush Pathology at the Royal (Dick) School of Veterinary Studies for post-mortem examination. Within the abdominal cavity, overlying approximately the ventral half of the rumen and the omentum, there were multifocal to coalescing areas of slightly raised, red to light red fleshy material (mesothelial hyperplasia). The rumen and reticulum contained a large amount of wet, green, fibrous ingesta. The pylorus, duodenum and proximal jejunum were markedly dilated by similar, watery green material until approximately 150 cm distal to the abomasum, where there was a large, approximately 40 cm long and 8 cm diameter dilatation of the small intestine by a large aggregate of dark red, gelatinous material (i.e., haemorrhage), with similar material present in the adjacent colonic serosa (Fig 1A). On cut section, this aggregate surrounded the small intestine (i.e. an haematoma, Fig 1B), whilst at the distal aspect of this area, within the intestinal lumen, there was a single, 10 cm long and 5 cm diameter, blind-ended structure (i.e., an intussusceptum, Fig 1C). This structure was lined by a mottled dark brown to black mucosa (necrosis and haemorrhage) and arose from the adjacent intestinal wall. No central lumen was present, consistent with a retroflexed intestinal diverticulum. The lumen from the adjacent small intestine passed on the anti-mesenteric aspect of this structure, with the opening occupied by the lateral aspect of this structure (Fig 1D). Distal to this segment, the contents of the small and large intestine were minimal and slightly mucoid throughout, although otherwise the serosa and mucosa of the gastrointestinal tract were normal.

DISCUSSION *Include a very brief review of similar published cases*

The presenting clinical signs in this case of a period of anorexia with poor to absent faecal output, alongside haemoconcentration (approximately 2% dehydration), hypochloraemia and likely chloride-depleted metabolic alkalosis, are typical findings associated with intussusception or proximal intestinal obstruction in ruminants (1). Due to the lack of specific preceding clinical signs in this case, it was challenging to determine the chronicity and therefore prognosis relating to this obstruction from ante-mortem clinical examination alone, although an L-shaped abdomen as identified in this case may be suggestive of a more chronic presentation. Biochemical parameters were unfortunately not received until after this animals' death. However, once they were available, the presence of a marked hyperproteinaemia and hyperglobulinaemia was consistent with a chronic process.

Additional biochemical parameters have been used to guide decision making with regards to expected prognosis in such situations. These include both lactate (14,15,18) and haptoglobin (16,17), elevated concentrations of which are associated with a poorer prognosis in varying situations, but such parameters are not routinely available via in-house biochemical analysis and were not readily available in this case.

However, an alternative parameter is serum chloride, which may be more readily available in some situations as it was in this case. This is a biochemical marker of proximal intestinal obstruction, with severe decreases in concentration shown to be correlated with a poor prognosis (19). Under normal circumstances, chloride is excreted within the abomasum and resorbed primarily within the duodenum (20). During a proximal intestinal obstruction, this aboral

movement of the high chloride abomasal contents is prevented, resulting in regurgitation of this fluid into the rumen and decreased resorption in the duodenum, leading to a high ruminal chloride level and a hypochloraemia (19). In this case, the severely decreased chloride levels in the blood (59 mmol/l, reference 94-111 mmol/l) indicated a severe proximal intestinal obstruction, with chloride levels <70 mmol/l having been shown to be significantly correlated with a poor prognosis (7). This suggests that, whilst a proximal intestinal obstruction is a potentially correctable cause of hypochloraemia, surgery may not always be warranted due to a likely poor post-surgical outcome and euthanasia may be considered due to poor ongoing welfare in such cases. In this case blood results were not available until the next day but it would have been a useful prognostic indicator in the next stages of treatment (e.g., surgical treatment or euthanasia).

Considering the specific history of this animal, multiple potential differential diagnoses were considered. Firstly, there was a documented fight with another bull 3 weeks prior to clinical presentation. This fight could have involved abdominal trauma, which may have facilitated development of a serosal haematoma in this location and may have resulted in intestinal obstruction via compression of the intestinal lumen. If such a trauma was the primary cause, the bull would likely have deteriorated more rapidly following the initial trauma. It should be noted that such a lesion would also likely result in a similar hypochloraemia as in this case. Similarly, whilst this animal had a recent change to rich pasture, this is considered unlikely to be a primary cause of this lesion, as typically a more acute and progressive presentation would be expected following the change in pasture.

Vagal indigestion should also be considered a differential diagnosis for these clinical signs. Vagal indigestion has been associated with compressive, traumatic or inflammatory lesions targeting the forestomachs or the vagal trunks and may progress to extensive ruminal bloat (21). This can be classified clinically as types one to four, depending on the location of the impairment. Type one typically involves accumulation of gas within the rumen due to an impairment of eructation, often due to pneumonia or pleuritis. Type two is the most common form in adult cattle and involves impairment of movement of ingesta into the abomasum due to omasal transport failure. This is typically associated with reticular disease or traumatic reticuloperitonitis. Type three is associated with pyloric outflow failure which may be secondary to peritonitis associated with abomasal ulceration or pyloric obstruction due to right abomasal displacement and volvulus. Type four is typically due to compression of the intestines during advanced pregnancy and is therefore commonly referred to as vagal indigestion of pregnancy (19,22). In this case, it is likely that the functional obstruction caused by the intestinal intussusception resulted in a functional pyloric outflow obstruction, which lead to the markedly dilated abomasum and rumen identified at post-mortem examination. This is most consistent with a type three vagal indigestion. It should be noted that type one and two vagal indigestions are unlikely to lead to the same severity of hypochloraemia as there is maintenance of abomasal outflow and, therefore, duodenal resorption of chloride rich fluid.

Abdominal ultrasonography has been employed to help differentiate the underlying disease processes in an acute abdomen setting. Typically, this would allow identification of the causative lesion and allow guidance for further medical or surgical treatment, such as with visualisation of the classic ‘bulls-eye/target’ lesion, representative of the telescoping of the intussusceptum into the intussuscipiens (23). In this case, the bull unfortunately died before the abdomen could be examined ultrasonographically, although presence of this intussusception deep within the abdomen may have precluded identification of the lesion due to limitations in the depths of field of both percutaneous and per-rectum ultrasonography. This highlights the utility of serum

biochemistry, in particular the extent of hypochloraemia, in identifying both the location and severity of such a lesion where other diagnostic modalities may be limited.

At post-mortem examination, a large proximal intestinal intussusception was identified, which had led to substantial obstruction of the intestinal lumen, with resultant dilatation of the proximal jejunum, duodenum and forestomachs, leading to the clinically identified ruminal bloat and atony. These findings are consistent with development of type three vagal indigestion due to this proximal intestinal obstruction, resulting in functional pyloric outflow failure, with subsequent accumulation of extensive abomasal and ruminal fluid content (19). The scant contents throughout the distal intestine and colon were suggestive of almost complete obstruction at this site. Pain and inflammation associated with this lesion may have contributed to development of ruminal atony via vagal trunk compromise, further exacerbating the ruminal bloat.

Close examination of the intussusception identified the blind ended nature of the intussusceptum and the adjacent, obstructed, intestinal lumen. This suggests that this intussusceptum may have initially formed via retroflexion of a large, pre-existing jejunal diverticulum at this location, rather than the typical telescoping of intestinal segments into one another. In addition to the retroflexed diverticulum, continued peristalsis will have likely incorporated additional intestinal tissue in the lesion, in a fashion similar to a typical intussusception.

This diverticulum may represent a congenital malformation, such as a Meckel's diverticulum, although only limited published reports of such lesions in cattle are available; in these reports, the typical site is the ileum rather than the proximal jejunum, as in this case (24–26). Congenital intestinal diverticula have been identified in other locations throughout the intestinal tract in both human beings (27–29) and dogs (30,31), both of which may present in adulthood, as in this case. Whilst a genetic predisposition of intestinal diverticula has not been identified in cattle, considering the breeding history of this animal, continued monitoring of offspring for similar lesions is warranted to allow early identification of any affected offspring. However, whilst a genetic predisposition is theoretically possible, given the lack of similar reports in cattle, it is considered unlikely.

This intussusception likely led to constriction and necrosis of the local vasculature, mesentery and intestinal wall, which likely led to the locally extensive serosal haemorrhage via rupture of severely congested blood vessels within these structures. In addition, the compression of the intestinal lumen by this expanding serosal haematoma may have contributed to the intestinal obstruction. The mesothelial hyperplasia of the ruminal omentum is likely representative of an ongoing, localised peritonitis in response to the inflammation and necrosis associated with this jejunal intussusception. This chronic change is likely reflective of relatively long term peritonitis, which has been associated with a poor prognosis in other circumstances including, amongst others, Caesarean sections (32), abomasal ulcer perforation (33) or colonic perforation in calves (34). When considered alongside the hyperglobulinaemia, this indicates that the intestinal intussusception had been present for some time, which is again associated with a poor prognosis (7). Considering this, and the previously discussed severe hypochloraemia, it is likely that, if surgery had been performed, it would not have resulted in a good outcome or return to productivity in this animal. This reinforces the utility of assessment of serum chloride as a minimally invasive prognostic indicator for proximal intestinal obstruction in cattle.

Histopathology was not performed in this case and therefore a distinction between a 'true diverticulum' or 'pseudodiverticulum' could not be made. The lack of histopathology prevented identification of underlying neoplasia, although the relatively young age of this animal, the lack of

a macroscopically overt malignancy in this location or enlargement of regional lymph nodes and the lack of chronic weight loss suggests that this would be less likely. Similarly, whilst a localised enteritis could not be entirely excluded without histopathology, this was thought to be less likely due to the lack of preceding clinical signs.

In summary, this report identifies retroflexion of an intestinal diverticulum as a rare cause of proximal intestinal intussusception and type 3 vagal indigestion in cattle. Such lesions should be considered as potential differential diagnoses in cases presenting with abdominal bloat or vagal indigestion, or where consistent lesions are identified during exploratory coeliotomy or post-mortem examination.

LEARNING POINTS/TAKE HOME MESSAGES ***3 to 5 bullet points – this is a required field***

- Intestinal intussusceptions are rare causes of intestinal obstruction in cattle and are typically caused by an underlying enteritis, intestinal parasitism or intestinal neoplasia and typically present with a short period of anorexia with reduction or absence of faecal output alongside haemoconcentration and hypochloraemic metabolic alkalosis
- Serum chloride can be used to assess both the severity and prognosis of a proximal intestinal obstruction
- Intussusceptions in other species, including human beings, have been identified secondary to intestinal diverticula both within younger and older individuals
- This report describes such a case of a proximal jejunal intussusception secondary to a retroflexed intestinal diverticulum, which led to the development of type 3 vagal indigestion

CONFLICT OF INTEREST STATEMENT ***Required. A statement should be included even if there are no conflicts of interest to declare (e.g., "The author(s) declare(s) they have no conflicts of interest.")***

The authors declare no conflict of interest.

ETHICS STATEMENT ***Required. A statement explicitly describing the ethical background to this study and any institutional or national ethical committee approval must be included within the manuscript.***

The authors confirm that the ethical policies of the journal, as noted on the journal's author guidelines page, have been adhered to. No ethical approval was required as this is a single case report detailing a clinical case managed in-keeping with the RCVS (Royal College of Veterinary Surgeons) professional guidelines.

FUNDING STATEMENT ***Required. Please list all funding sources. If no funding was received, please provide a statement to this effect. Authors are responsible for the accuracy of their funder designation.***

No funding was required for this case report as all work was performed on a clinical basis.

AUTHOR CONTRIBUTION STATEMENT ***Required. Please list the contributions of each author (e.g., AA and BB conceived and designed the project, AA, CC and DD acquired the data, AA and CC analysed and interpreted the data, AA and BB wrote the paper).***

- LA Wilson – Pathology resident who performed the post-mortem examination and wrote the majority of the manuscript including editing and revisions following peer review
- RF Kelly – Farm clinician who managed the case within the farm animal hospital, wrote the associated areas of the manuscript and provided advice on revisions to the manuscript
- AW Philbey – Pathologist who supervised the post-mortem examination and provided advice on revisions to the manuscript

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REFERENCES **Vancouver style**

1. Anderson DE, Ewoldt JMI. Intestinal surgery of adult cattle. Vet Clin Food Anim Pract [Internet]. 2005 Mar;21(1):133–54. Available from: http://www.vetfood.theclinics.com/article/S0749072004000957/fulltext

2. Pravettoni D, Morandi N, Rondena M, Riccaboni P, Zani DD, Scandella M, et al. Repeated occurrence of jejuno-jejunal intussusception in a calf. Can Vet J [Internet]. 2009 Mar;50(3):287. Available from: /pmc/articles/PMC2643455/

3. Milnes EL, McLachlan A. Surgical management of small intestinal intussusception associated with jejunal adenocarcinoma in a dairy cow. N Z Vet J [Internet]. 2015 Sep;63(5):288–90. Available from: https://www.tandfonline.com/doi/abs/10.1080/00480169.2014.999843

4. Constable P, St Jean G, Hull B, Rings D, Morin D, Nelson D. Intussusception in cattle: 336 cases (1964-1993). J Am Vet Med Assoc [Internet]. 1997 Feb;210(4):531–6. Available from: https://europepmc.org/article/med/9040842

5. Sartelet A, Guyot H, Vandeputte S, Touati K. Intestinal intussusceptions in cattle: a retrospective study (22 cases). In: XXVth World Buiatrics Congress [Internet]. Budapest; 2008. p. 1. Available from: https://agris.fao.org/agris-search/search.do?recordID=BE2014111098

6. Nishant R, Shilpa R, Monika T. Surgical Correction and Management of Bovine Intestinal Intususception-A Clinical Study of Seven Cows-Indian Journals. Intas Polivet [Internet]. 2019 [cited 2021 Oct 26];20(1):61–4. Available from: https://www.indianjournals.com/ijor.aspx?target=ijor:ipo&volume=20&issue=1&article=0

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7. Desrochers A, Anderson DE. Intestinal Surgery. Vet Clin Food Anim Pract [Internet]. 2016 Nov;32(3):645–71. Available from: http://www.vetfood.theclinics.com/article/S0749072016300305/fulltext

8. Barry WE, Rosenberg DM, Warren M, Kim ES. Small bowel intussusception secondary to inverted Meckel's diverticulum. J Pediatr Surg Case Reports. 2017 Oct 1;25:49–51.

9. Dujardin M, Op de Beeck B, Osteaux M. Inverted Meckel's diverticulum as a leading point for ileoileal intussusception in an adult: Case report. Abdom Imaging [Internet]. 2002 Sep [cited 2021 Nov 17];27(5):563–5. Available from: https://link.springer.com/article/10.1007/s00261-001-0070-3

10. Zhang B, Wang J, Li X, Wang Z, Zhang Y, Yang H. Intussusception caused by an inverted colonic diverticulum: A case report. J Med Case Rep [Internet]. 2018 Apr 27 [cited 2021 Nov 17];12(1):1–4. Available from: https://jmedicalcasereports.biomedcentral.com/articles/10.1186/s13256-018-1652-9

11. Syed H, Syed L, Parampalli U, Uheba M. Adult intussusception secondary to diverticular disease Unusual association of diseases/symptoms. 2018 [cited 2021 Nov 17]; Available from: http://group.bmj.com/group/rights-licensing/permissions.

12. Kim HJ, Kim JH, Moon OI, Kim KJ. Giant ascending colonic diverticulum presenting with intussusception. Ann Coloproctol [Internet]. 2013 [cited 2021 Nov 17];29(5):209–12. Available from: /pmc/articles/PMC3837087/

13. Uzal F, Plattmer B. Alimentary System. In: Maxie MG, editor. Jubb, Kennedy and Palmer's Pathology of Domestic Animals. Sixth. Missouri: Elsevier; 2016. p. 52–3.

14. Coşkun A, Aydogdu U, Altan S, Erol M, Erol H, Guzelbektes H, et al. Hematologic, blood gas, cardiac biomarkers and serum biochemical parameters in Calves with Atresia Coli and theirs relationship with prognosis. Acta Sci Vet. 2017;45.

15. Andrade IM, Simões PBA, Lamas LP, Carolino N, Lima MS. Blood lactate, pH, base excess and pCO2 as prognostic indicators in caesarean-born kids from goats with pregnancy toxaemia. Ir Vet J [Internet]. 2019 Oct 14 [cited 2021 Dec 6];72(1). Available from: /pmc/articles/PMC6822279/

16. Scott PR, Murray LD, Penny CD. A preliminary study of serum haptoglobin concentration as a prognostic indicator of ovine dystocia cases. Br Vet J [Internet]. 1992 [cited 2021 Dec 6];148(4):351–5. Available from: https://pubmed.ncbi.nlm.nih.gov/1498647/

17. Alsemgeest SP, Kalsbeek HC, Wensing T, Koeman JP, van Ederen AM, Gruys E. Concentrations of serum amyloid-A (SAA) and haptoglobin (HP) as parameters of inflammatory diseases in cattle. Vet Q [Internet]. 1994 [cited 2021 Dec 6];16(1):21–3. Available from: https://pubmed.ncbi.nlm.nih.gov/8009814/

18. Buczinski S, Boulay G, Francoz D. Preoperative and postoperative L-lactatemia assessment for the prognosis of right abomasal disorders in dairy cattle. J Vet Intern Med [Internet]. 2015 Jan 1 [cited 2021 Dec 6];29(1):375–80. Available from:

https://pubmed.ncbi.nlm.nih.gov/25307271/

19. Foster D. Disorders of Rumen Distension and Dysmotility. Vet Clin North Am - Food Anim Pract. 2017;33(3):499–512.

20. Fecteau G, Desrochers A, Francoz D, Nichols S. Diagnostic Approach to the Acute Abdomen. Vet Clin Food Anim Pract [Internet]. 2018 Mar;34(1):19–33. Available from: http://www.vetfood.theclinics.com/article/S0749072017300816/fulltext

21. Attia NES, Eisa EF, Bayoumi YH. Clinical, ruminal, hematobiochemical alterations and ultrasonographic examination of vagal indigestion in cow calves. Adv Anim Vet Sci [Internet]. 2021;9(9):1400–7. Available from: http://dx.doi.org/10.17582/journal.aavs/2021/9.9.1400.1407

22. Soares GSL, Afonso JAB, Souto RJC, de Paula Cajueiro JF, da Conceição ÂI, Ribeiro ACS, et al. Vagal indigestion in cattle: a retrospective study. Semin Agrar. 2022;43(6):2579–94.

23. Streeter RN, Step DL. Diagnostic Ultrasonography in Ruminants. Vet Clin Food Anim Pract [Internet]. 2007 Nov;23(3):541–74. Available from: http://www.vetfood.theclinics.com/article/S0749072007000527/fulltext

24. Koch DB, Robertson JT, Donawick WJ. Small intestinal obstruction due to persistent vitelloumbilical band in a cow. J Am Vet Med Assoc [Internet]. 1978 [cited 2021 Oct 19];173(2):197–200. Available from: https://pubmed.ncbi.nlm.nih.gov/681224/

25. Yeruhma I, Goshen T, Perl S. Meckel's diverticulum in a male calf. Can Vet J. 2004;45:264–6.

26. Erol H, Alkan F. Meckel's Diverticulum in a Male Calf. J Heal Sci. 2014;26:163–5.

27. Eusébio M, Ramos A, Guerreiro H. Intraluminal Duodenal ("Windsock") Diverticulum: A Rare Cause of Gastrointestinal Bleeding. GE Port J Gastroenterol [Internet]. 2016 Mar 1 [cited 2021 Dec 8];23(2):113–5. Available from: /pmc/articles/PMC5580164/

28. Rangan V, Lamont JT. Small Bowel Diverticulosis: Pathogenesis, Clinical Management, and New Concepts. Vol. 22, Current Gastroenterology Reports. Springer; 2020.

29. Keese D, Rolle U, Gfroerer S, Fiegel H. Symptomatic Meckel's diverticulum in pediatric patients-case reports and systematic review of the literature. Front Pediatr [Internet]. 2019 Jun 26 [cited 2021 Dec 8];7(JUN):267. Available from: https://www.frontiersin.org/article/10.3389/fped.2019.00267/full

30. Lorigados CAB, Zoppa AM, Schiller A, Tiburcio I, Calderón FG, Pantano M. Partial Obstruction and Intestinal Bleeding Secondary to a Congenital Duodenal Diverticulum in a Dog. Acta Sci Vet [Internet]. 2021 Jan 21 [cited 2021 Dec 8];49(0). Available from: https://www.seer.ufrgs.br/ActaScientiaeVeterinariae/article/view/100991

31. Mills K, Haugland S, Welsh E. Ruptured congenital jejunal diverticulum resulting in a mechanical gastrointestinal tract obstruction in a dog. Companion Anim [Internet]. 2017 May 2 [cited 2021 Dec 8];22(5):270–3. Available from:

http://www.magonlinelibrary.com/doi/10.12968/coan.2017.22.5.270

32. Djebala S, Evrard J, Moula N, Gille L, Bayrou C, Eppe J, et al. Comparison between generalised peritonitis and parietal fibrinous peritonitis in cows after caesarean section. Vet Rec [Internet]. 2020 Oct 26 [cited 2021 Dec 8];187(7):49. Available from: https://onlinelibrary.wiley.com/doi/10.1136/vr.105867

33. Gouda SM, Abdelaal AM, Elgaml SA, Ezzeldein SA, Eisa EF, Hashish EA. Local peritonitis and omental bursitis as sequelae of abomasal ulceration in buffaloes (Bubalus bubalis): clinical findings and outcome of treatment. Vet Q [Internet]. 2020 Jan 1 [cited 2021 Dec 8];40(1):51–7. Available from: https://www.tandfonline.com/doi/full/10.1080/01652176.2020.1718796

34. Metre DC Van, Callan RJ, Holt TN, Garry FB. Abdominal Emergencies in Cattle. Vet Clin Food Anim Pract [Internet]. 2005 Nov;21(3):655–96. Available from: http://www.vetfood.theclinics.com/article/S074907200500054X/fulltext

FIGURE/VIDEO CAPTIONS ***figures should NOT be embedded in this document***

Figure 1: Macroscopic images of a retroflexion/intussusception of an intestinal diverticulum in a 4-year-old Simmental bull. (A) This image shows the relation of the area of haemorrhage and necrosis in the proximal jejunum (red arrow) in relation to the abomasum (yellow arrow). (B) Following dissection, the intestinal lumen was identified centrally (yellow arrow) within the large haematoma. (C) At the distal aspect of this area, a blind ended intussusceptum was identified (yellow arrow). (D) Adjacent to this intussusceptum, the intestinal lumen could be identified passing from oral to aboral (highlighted by the haemostats) without communication with the blind-ended intussusceptum.

Table 1: Biochemical, haematological and electrolyte parameters. Values outside the reference range are highlighted (*).

OWNER'S PERSPECTIVE ***Optional***

IMAGE QUIZ ***Optional (but highly encouraged) – please provide 1 or 2 sentences to describe one of the images in your article. The "Image quiz" will be published with your article if accepted. Don't forget to indicate which image the quiz relates to***

Table 1: Biochemical, haematological and electrolyte parameters. Values outside the reference range are highlighted (*).

MULTIPLE CHOICE QUESTION ***provide one multiple choice question based on the description above (may be "what's the likely diagnosis?")***

An adult bull presents to you with a short history of anorexia and not passing faeces. On clinical examination you identify severe abdominal distention and palpate a large, distended loop of intestine via rectal examination. You take a blood sample from the ventral tail vein which reveals

the parameters given in table 1. In what anatomical location does this suggest the causative lesion is located?

POSSIBLE ANSWERS TO MULTIPLE CHOICE QUESTION ***Max 6***

A) Proximal small intestine
B) Distal small intestine
C) Proximal large intestine
D) Caecal

CORRECT ANSWER ***With a brief explanation (the answer will also be linked to the published case)***

Correct answer A - During a proximal small intestinal obstruction, this aboral movement of the high chloride abomasal contents is prevented, resulting in regurgitation of this fluid into the rumen and decreased resorption in the duodenum, leading to a high ruminal chloride level and a hypochloraemia.

PLEASE SAVE YOUR TEMPLATE WITH THE FOLLOWING FORMAT:

Corresponding author's last name and date of submission, e.g.,

Smith_June_2017.doc