**TITLE**

**Use of computed tomography in the diagnosis of caecal inversion in a dog and a cat**

**SUMMARY**

Case 1: A 9-month old male entire Beagle presented with a history of chronic diarrhoea, intermittent haematochezia and rectal prolapse. An exploratory laparotomy performed prior to presentation reported visualisation of a suspected caecocolic intussusception. Physical examination revealed a non-painful, mid-abdominal mass and laboratory findings were consistent with non-specific gastrointestinal disease. Abdominal computed tomography (CT) identified intraluminal inversion of the caecum into the ascending colon. Intraoperatively, the inversion was unreducible and a colotomy followed by stapled typhlectomy was performed.

Case 2: An 8-year old male neutered domestic shorthair presented with a history of chronic haematochezia and intermittent partial rectal prolapse. Physical examination and laboratory findings were unremarkable. Abdominal CT revealed a caecal inversion. A midline coeliotomy followed by manual correction of the inversion and a stapled typhlectomy were performed.

In both animals, CT allowed an accurate diagnosis and appropriate management of caecal inversion, a rarely reported small animal large intestinal disease.

**BACKGROUND**

Intestinal intussusception is defined as one segment of the gastrointestinal tract telescoping into the lumen of an adjacent segment, and is a relatively uncommon finding in dogs and cats. Normally occurring as a result of enteritis (parasitic, viral, bacterial), intestinal foreign body, neoplasia or metabolic disorders, the consequent intestinal hyperperistalsis results in intestinal invagination and partial or complete obstruction.1

This condition is more prevalent in juvenile dogs with 75% of them being younger than 1 year-old and most often affecting the ileocaecocolic junction,2,3 with a colonic location representing only 4.1% of all intussusceptions.4

Caecal inversion, also referred to as a caecocolic intussusception, occurs when the caecum inverts in on itself at its base and invaginates into the adjoining ascending colon, resulting in 4 separate wall layers. Only few cases of caecal inversions have been reported in veterinary literature.5-8

Caecal inversion typically presents as a chronic condition due to the lack of functional obstruction. Consequently, animal patients will often have unremarkable physical examination and laboratory findings, making its diagnosis challenging.9

Whilst ultrasonography and endoscopy are the preferred methods of investigation for the diagnosis of caecal inversion, their effectiveness is strongly associated with operator’s experience, can be time-consuming and the quality of the acquired images can be significantly affected by secondary factors, such as the presence of faeces or gas within the gastrointestinal tract, or a pneumoperitoneum.10 Computed-tomography (CT) is a common screening test in people with abdominal disease,11 and modern multi detector helical scanners used in veterinary practice can provide rapid diagnostic studies and more detailed visualisation of the abdominal structures, especially the large intestine.12,13,14

These two case reports describe the tomographic findings and surgical management of a caecal inversion in a juvenile dog and an adult cat where the use of contrast enhanced CT provided an accurate diagnosis, lesion localisation and novel imaging description of a rarely reported gastrointestinal disease.

**CASE PRESENTATION**

Case 1

A 9-month-old entire male Beagle presented with a 5 month history of colitis with intermittent haematochezia. Severe tenesmus with numerous episodes of partial rectal prolapse and hyporexia were reported in the 2 weeks preceding presentation. Prior to referral, the dog underwent an exploratory laparotomy which showed a suspected caecocolic intussusception.

On presentation the dog was quiet but alert and responsive, weighed 9.7 kg with a body condition score (BCS) of 3/9. Physical examination was unremarkable aside from a poorly-defined, non-painful, mobile abdominal mass palpated in the mid-caudal abdomen.

Case 2

An 8-year-old neutered male Domestic Shorthair presented for further investigation of a 4 month history of haematochezia and recurrent partial rectal prolapse not associated with tenesmus. On presentation the cat was bright and alert, with a weight of 4.8 kg and a BCS of 4/9. Physical examination revealed a dull hair coat and rectal prolapse, but was otherwise unremarkable.

**INVESTIGATIONS**

Case 1

Haematology revealed moderate neutrophilia (18.32 x 109/L, reference interval [RI] 3-12) and mild monocytosis (1.28 x 109/L, RI 0-1.2). Abnormalities in serum biochemistry included mild hypoproteinaemia (total protein 42.37g/L, RI 58-73) and hypoalbuminaemia (23.28g/L, RI 26-35). Serum cobalamin concentration (vitamin B12)was elevated (438pg/ml, RI 140-300) and serum folate concentration was decreased (4.18ng/ml, RI 11-30). Canine trypsin-like immunoreactivity (cTLI) was decreased (3.82ng/ml, RI 5.4-32.0). A faecal cytology was negative for parasites.

Abdominal ultrasonography (Logic 9, General Electric) revealed an abnormal number of wall layers of the wall of the ascending colon, known as a ‘concentric ring sign’15 (Figure 1) and absence of visualisation of a normal caecum. The ileum had a normal appearance. A moderate amount of free peritoneal gas was present, consistent with recent abdominal surgery, and impeded accurate examination of the entire gastrointestinal tract.

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**Figure 1**: Transverse section at the level of the caecal inversion in the abdomen of case 1 using a 11 MHz microconvex probe. The thick line represents the wall of the colon, the thin line the wall of the caecum and the \* the invaginated mesenteric fat.

An abdominal CT scan was performed using an 80-slice multidetector scanner (Aquilion Prime, Toshiba Medical Systems, Tokyo, Japan) with the animal in sternal recumbency. The main scanning parameters used were: 120 kVp, 150 mA, tube rotation time 0.5 s, and 512×512 matrix dimensions. Reconstructions were generated using a soft tissue kernel with a slice thickness of 1 mm. The images were acquired pre and post intravenous administration of iodinated contrast medium (Xenetix, iobitridol, 300mg I/ml, Guebert, Roissy CdG, France) at a dose of 600 mg I/kg. The intravenous injection of contrast was performed using a pressure injector (Medrad Stellant CT injection system, Newbury, UK) and the post-contrast images were acquired using a bolus-tracking software for the arterial phase and 60 seconds following contrast medium administration for the venous phase.

CT images revealed a markedly abnormal segment of intestine between the terminal ileum and ascending colon. The caecum was inverted and invaginated into the lumen of the ascending colon. The caecum was swollen with thickening of the caecal wall (up to 6 mm width). Mild thickening of the remaining colonic wall was also observed (Figure 2). The ileocolic junction was visible and not involved in the intussusception. The mesenteric lymph nodes were subjectively slightly enlarged (1 cm width). A diffuse increase in attenuation of the mesentery and peritoneum was seen, more so ventrally and focally around the ventral abdominal midline (site of the coeliotomy). There were multiple pockets of free peritoneal gas, and gas was also present within the swollen subcutaneous tissue of the ventral midline (figure 3).

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**Figure 2:** Right parasagittal contrast-enhanced computed tomographic image of the abdomen of Case 1, using a soft tissue reconstruction algorithm and soft tissue window. the caecal wall (blue arrow) is diffusely thickened and inside out, with the strongly contrast enhancing mucosa located peripherally (orange arrow). The caecum is surrounded with the wall of the ascending colon (red arrow). A mixed soft tissue and fat attenuating centre within the caecum represents the invaginated mesenteric fat and caecal branch of the ileocolic vessels (pink arrow). Mild fat stranding is visible surrounding the inverted caecum (black star). pneumoperitoneum (white star) secondary to the previous laparotomy is visible.

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**Figure 3:** Transverse contrast-enhanced computed tomographic image of the abdomen of Case 1, using a soft tissue reconstruction algorithm and soft tissue window. The caecal wall (blue arrow) is diffusely thickened and inside out. The caecum is surrounded with the wall of the ascending colon (red arrow) and the reflection of the wall at the base of the inverted caecum is visible (green arrow). The wall of the ileum is thickened (yellow arrow). pneumoperitoneum (white Star) and ventral abdominal wall thickening and emphysema (white arrow) secondary to the previous laparotomy are also visible.

Case 2

Haematology revealed a mild lymphopenia (0.53 x 109/L, RI 1.5-7.0) while serum biochemistry was within normal limits. Feline Leukaemia virus and Feline Immunodeficiency virus SNAP tests (SNAP FIV/FeLV Combo Test, Idexx) were negative. Microscopic evaluation of a faecal sample was normal.

CT scan of the thorax and abdomen showed an inversion of the caecum into the ascending colon, with mesenteric fat visible centrally within it (Figure 4 and 5). The ileocaecocolic junction was displaced towards the left side of the abdomen with multiple small mineral opacity structures trapped within the colonic lumen. The remainder of the colon and the rectum were otherwise unremarkable.

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**Figure 4:** Dorsal oblique contrast-enhanced computed tomographic image of the abdomen of Case 2, using a soft tissue reconstruction algorithm and soft tissue window. The caecal wall (blue arrow) is diffusely thickened and inside out. The caecum is surrounded with the wall of the ascending colon (red arrow) and the reflection of the wall at the base of the inverted caecum is visible (green arrow). A mixed soft tissue and fat attenuating centre within the caecum represents the invaginated mesenteric fat and caecal branch of the ileocolic vessels (pink arrow).

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**Figure 5:** Transverse contrast-enhanced computed tomographic image of the abdomen of Case 2, using a soft tissue reconstruction algorithm and soft tissue window. The caecal wall (red arrow) is diffusely thickened and inside out, with the strongly contrast-enhancing mucosa located peripherally (orange arrow). The caecum is surrounded with the wall of the ascending colon (blue arrow).

**DIFFERENTIAL DIAGNOSIS**

In both cases the imaging findings were suggestive of caecal inversion. A colonic intussusception could not be fully ruled out. Other pathologies affecting the large intestinal wall, such as polyps, enteritis, colitis or neoplastic changes, were considered unlikely based on the diagnostic imaging. Surgical correction of the inverted caecum was advised in both cases.

**TREATMENT**

Case 1

A ventral midline coeliotomy revealed an approximately 2 cm dilated ileum and a firm, tubular structure within the ascending colon at the level of the ileocaecocolic junction. The cecum was not visible however a 1 cm diameter focal indentation was present at the expected location of the caecum consistent with a cecum inversion. The colic lymph nodes were mildly enlarged, and a single large (20 mm x 10 mm x 6 mm) jejunal lymph node was found.A small amount of free abdominal fluid was also present. The caecal inversion could not be corrected via digital manipulation, therefore a colotomy was performed, allowing visualisation of the oedematous inverted caecum. A typhlectomy was performed using a surgical stapler (TA 30 stapler, Covidien) across its base. Wedge biopsies were taken from the enlarged jejunal lymph node, the duodenum and the jejunum. The resected caecum and biopsy samples were submitted for histopathology and a sample of free abdominal fluid was submitted for cytology and bacteriology examination. The abdomen was copiously lavaged with warmed sterile saline prior to a routine abdominal closure.

Case 2

A ventral midline coeliotomy was performed and an ileocolic intussusception was identified with no visible change in colour or vascularisation of the associated intestines. The inverted caecum was visualised and manually corrected to its normal position by digital pressure. A typhlectomy was performed across the base of the caecum using a surgical stapler (TA30-3.5mm stapler, Covidien). A colopexy was also performed, anchoring the anti-mesenteric border of the descending colon to the musculature of the left abdominal wall. The abdomen was lavaged with warmed sterile saline prior to a routine abdominal closure.

**OUTCOME AND FOLLOW-UP**

Case 1

The animal recovered from surgery without complications and post-operative analgesia was continued with 0.2 mg/kg methadone (Comfortan, Dechra) intravenously (IV) every 4 hours for the initial 24 hours followed by 0.02 mg/kg buprenorphine (Vetergesic, CEVA) IV every 8 hours for a further 24 hours, and 10 mg/kg paracetamol (Paracetamol Solution for infusion, BRAUN) IV every 8 hours for 48 hours.

Antibiosis was initially provided peri-operatively with 20 mg/kg cefuroxime (Zinacef, GSK) IV. Following the culture of an *Enterococcus coli* resistant to penicillin/cephalosporins and *Streptococcus canis* with susceptibility only to fluoroquinolones,12.5 mg/kgamoxicillin-clavulanate (Synulox, Zoetis) per os (PO) and 5mg/kg enrofloxacin (Baytril, Bayer) PO were initiated.

Despite initial improvement the day immediately post-surgery, the dog became more lethargic and hyporexic. Repeat abdominal ultrasonography demonstrated small intestinal corrugation and significantly reduced motility consistent with ileus. The dog was started on 1 mg/kg omeprazole (Omeprazole , Sofarimex Industria) IV every 12 hours and a 2 mg/kg/day metoclopramide (Emeprid, CEVA) continuous rate infusion. The dog showed significant improvement in demeanour and appetite over the following two days. He was discharged 4 days post operatively with 12.5mg/kg amoxicillin-clavulanate (Synulox, Zoetis) PO every 12 hours, 10mg/kg metronidazole (Metrobactin, Dechra) PO every 12 hours, 5mg/kg enrofloxacin (Enrox, KRKA) PO every 24 hours, 10mg/kg paracetamol/codeine (Pardale-V, Dechra) PO every 8 hours and 0.1mg/kg meloxicam (Metacam, Boehringer Ingelheim) PO every 24 hours.

Histopathological examination of the caecum revealed a severe, chronic, fibrinosuppurative, ulcerative and granulating typhlitis affecting the majority of the caecum. The changes were chronic enough to have elicited a granulation reaction, although the mucosal changes indicated an ongoing fibrinosuppurative process with necrotic mucosa being replaced by a band of exudate. The jejunum exhibited highly active lymphoid follicles and the jejunal lymph node was active with a mild suppurative lymphadenitis. The duodenal biopsy was unremarkable.

There was no clear cause of the typhlitis. It was recommended to repeat the cTLI and serum vitamin B12 and folate levels in 8 weeks to reassess pancreatic and dietary absorption functions. Follow up blood results and clinical updates were unavailable as the owner did not return to the hospital, though no concerns or complications were ever reported.

Case 2

The cat recovered well from anaesthesia and post-operative analgesia was maintained with 0.02mg/kg buprenorphine (Vetergesic, CEVA) IV every 8 hours. Antibiosis was provided pre-operatively with 10mg/kg cefuroxime (Zinacef, GSK) IV and discontinued after surgery. The patient showed a good appetite during the postoperative period, and defecated 3 days post-operatively with no more episode of rectal prolapse. The cat was discharged 3 days post-surgery with sub-lingual buprenorphine every 8 hours following an uneventful recovery.

Histopathological examination of the caecum revealed a severe, subacute lymphoplasmacytic typhlitis, with haemorrhage within the caecal lumen. Further follow up was unavailable however no concerns were ever reported from the owner or referring veterinary surgeon.

**DISCUSSION**

Caecal inversion is a rare disorder in veterinary medicine, with only very few previously reported cases involving a cat,7 a red wolf,16 dogs5,6,8,9 and horses.17,18

Animals with caecal inversion often present with a chronic period of non-specific gastrointestinal signs, which may or may not include diarrhoea, weight loss, haematochezia and tenesmus. Caecal inversion alone rarely results in signs of acute intestinal obstruction, though these may develop if a concurrent intussusception (ileocolic, colocolic) or luminal obstruction by the inversion occurs.7 In both cases the clinical signs described were vague but both presented with haematochezia and recurrent partial rectal prolapse, consistent with the case reported by Clark & Wise.6 These findings were not corroborated by a case described by Bhandal *et al* where the cat presented with constipation and malaise.7 However, unlike in these two cases, the inversion seen in that report resulted in a complete obstruction of the colon.

Laboratory findings for caecal inversion are also vague with only hypoalbuminaemia consistently reported in approximately 50% of cases in dogs with caecal inversion. This was present in our canine patient and is believed to be associated with chronic protein loss from the gastrointestinal tract. Hypoalbuminaemia was not present in our cat nor reported in the other reported feline cases.5,6,9,16 The low serum folate and cTLI in the dog most likely reflect the chronic enteropathy present, though it is not possible to rule out concurrent exocrine pancreatic insufficiency. Therefore repeat sampling was recommended 8 weeks post-surgery to establish pancreatic function.

The lack of pathognomonic findings of caecal inversion on examination or laboratory investigations make it a diagnostic challenge, therefore the choice of the correct imaging modality is vital to achieve a successful diagnosis.

Plain and contrast abdominal radiography is readily available, easy to perform and can provide diagnostic images. In a previous report of a caecocolic intussusception, plain radiography revealed a well-defined soft tissue opacity structure within the lumen of the proximal ascending colon.19 The addition of contrast medium, either orally or per-rectal (pneumocolography or barium sulphate enema), can provide a definitive diagnosis and has been used to diagnose a partial colonic obstruction by an inverted caecum in a dog5 and a colo-colic intussusception with inversion of the caecum in a red wolf.16

Ultrasonography is recognised as the better technique for imaging the gastrointestinal tract compared to contrast radiography; it is less time consuming, does not require general anaesthesia and avoids the risk of repeated ionising radiation exposure to staff and patients.15 A retrospective study of 10 confirmed intussusceptions identified a concentric ring sign in all cases on ultrasound examination. However, correct anatomical localisation of the lesion was only possible in 50% of the cases.15 In addition, a case series by Patsikas *et al*. demonstrated that both healthy bowel and non-intussuscepted intestinal diseases, such as enteritis and postpartum uterine involution, can have a target lesion or concentric ring sign.20 False positive diagnoses of intussusceptions were only avoided by experienced ultrasonographers achieving multi-plane scanning to fully visualise the rings’ periphery.20 Colour flow doppler ultrasonography offers a further unique advantage in its ability to accurately assess perfusion within intussuscepted intestinal wall, and therefore predict manual reducibility.21 Using colour doppler, a study identified blood flow within the mesentery of 12/15 intussuscepted bowel segments, of which 9/12 were reducible; in the 3 remaining dogs and the 3 without colour doppler signal, the intussusception was found to be irreducible.21

However, orthogonal plane imaging may not be possible in some cases due to patient factors, unusual lesion localisation or secondary artefacts affecting the ultrasound image quality.

A recent study comparing efficacy of ultrasound to CT in dogs with acute abdominal signs found that in 53% of ultrasound examinations only part of the abdominal organs were visualised due to one or more of the aforementioned reasons.10 In our canine case the presence of intra-abdominal gas and significant inflammation precluded a complete evaluation of the gastrointestinal tract and motivated the decision to perform a CT scan. As the feline patient was referred for a suspected rectal mass, the decision was made to perform CT immediately for neoplastic staging as well as imaging the mass itself.

To the author’s knowledge, the cases presented here are the first to report the use of advanced cross-sectional imaging in the diagnosis of caecal inversion in small animal patients.

Currently, targeted helical CT is the standard modality in the assessment of a human acute-abdominal patient.22 Conversely, survey radiography and B-mode ultrasonography are the current gold standards in preliminary investigations in veterinary patients.10 The conclusions of an imaging comparison study by Shanaman *et al*. found that whilst the use of survey radiography and ultrasonography concurrently would give an accuracy of 100% for the differentiation between surgical and non-surgical abdominal conditions, the high speed of acquisition and accurate diagnosis of contrast-enhanced CT, along with minimal patient discomfort and its reduced limitations, make it an excellent and safe preliminary imaging screening modality.10 The authors suggest that given their finding of an improved sensitivity of contrast-enhanced ultrasonography over CT for the evaluation of intestinal wall perfusion, they recommend focused ultrasonographic evaluation of lesions identified on an initial screening CT abdominal scan.10 In our cases CT allowed accurate description and localisation of the lesion, despite the presence of concurrent pneumoperitoneum in the canine case which adversely affected the previous ultrasound examination.

As reported here, the aetiology of caecal inversion remains elusive in the majority of the cases. Caecal inversion has been previously associated with intestinal parasitic burdens, typhlitis and infiltrative diseases of the intestine such as inflammatory bowel disease (IBD) or neoplasia.9 Histopathology of the small intestine was obtained in our canine patient yet only revealed non-specific inflammatory changes in the jejunum and a normal duodenum. These findings were in agreement with endoscopic intestinal biopsies from a previous case of caecal inversion in a dog, where only a mild eosinophilic enteritis affecting the duodenum and ileum was present.6 Caecal inversion has been previously described in association with Anoplocephala app. infestation in a horse.18 Faecal parasitology performed in both presented cases was negative, consistent with several previously reported cases.6,7

Surgical excision of the inverted caecum was curative in our cases, as previously reported.5-8 Manual reduction of the inversion in case 1 was not possible due to the chronicity of the disease; therefore, a colotomy and typhlectomy were performed. The authors suggest that, where possible, manual reduction and typhlectomy should be attempted without the additional surgical risk of a separate enterotomy site. The caecal histopathology results were similar between the two cases and as reported in the literature,6-8 suggesting that the degree of typhlitis at surgery should not affect post-operative recovery.

In the presented cases, CT has been successfully used to diagnose caecal inversion and should be considered as a suitable imaging modality, especially if other imaging modalities have been unsuccessful or in the presence of factors that could compromise the accuracy of ultrasound examination. The CT findings in our cases were consistent with a caecal inversion, therefore surgical exploration and typhlectomy were performed; in both cases the immediate post-surgical outcome was excellent. To the author’s knowledge, these are the first reports of CT being used in the diagnosis of caecal inversion in the veterinary literature.

**LEARNING POINTS**

* Caecal inversion should be included in the list of differentials when presented with a history of non-specific gastrointestinal signs including chronic diarrhoea, weight loss and haematochezia
* Caecal inversion could be the cause of recurrent rectal prolapse
* If available, computed tomography allows for accurate lesion localisation and diagnosis
* Manual reduction of the cecum and typhlectomy are the preferable surgical approach for cases with caecal inversion
* A prompt diagnosis and surgical treatment of a caecal inversion leads to a favourable outcome

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