Outcomes of paracostal herniorrhaphy in cats: a retrospective study (2019–2024)

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Abstract

Objectives The aim of the present study was to report the outcome and complications associated with the treatment of paracostal hernias in cats and to determine the prevalence of concurrent diaphragmatic hernia.

Methods A retrospective, descriptive study was conducted by reviewing the medical records of cats that underwent paracostal hernia repair between January 2019 and January 2024. The collected data, including presentation, clinical signs, surgical findings, blood parameters, imaging techniques used for diagnosis and postoperative outcomes, were retrospectively reviewed. Descriptive statistical analyses were performed.

Results A total of 19 cats were included (median age 2 years, range 2 months to 10 years). Clinical signs upon admission included tachypnoea (9/19 cats), weakness (7/19 cats) and ataxia or paralysis (4/19 cats). Radiography was the primary diagnostic tool, identifying 89.5% of the cats with paracostal hernia. Concurrent diaphragmatic hernias were present in 63% of the cases. Postoperative complications occurred in nine cats, including major complications (3/19 cats) leading to immediate postoperative mortality.

Conclusions and relevance Considering the prevalence of diaphragmatic hernias observed, this study highlights the importance of visualising the diaphragm during paracostal hernia surgery. Although major complications resulted in early death, most patients recovered without short-term complications. These findings emphasise the need for careful postoperative monitoring and highlight the favourable prognosis associated with paracostal hernia repair in cats.

Keywords: Paracostal hernia; diaphragmatic hernia; herniorrhaphy; tachypnoea

Introduction

An abdominal hernia is any full-thickness defect in the abdominal wall that may allow protrusion of abdominal contents. Hernias can be classified by their location or whether they are spontaneous or acquired.[1] The most common causes of traumatic abdominal wall hernia are traffic accidents and animal fights, resulting in a sudden increase in intra-abdominal pressure. Abdominal hernias are most frequently located in the caudoventral abdominal wall and the paracostal region in cats.[2]

Paracostal hernias develop when the origin of the external abdominal oblique and transversus abdominis muscles are avulsed from their rib or costal cartilage origin. Therefore, abdominal organs herniate lateral to the ribs or the abdominal muscles, under the subcutaneous tissues.[1]

An abdominal hernia can be diagnosed during abdominal palpation; however, in most cases, diagnostic imaging techniques are required. In a study on traumatic body wall herniation in dogs and cats, radiographs were diagnostic or suggestive of body wall hernia in 64% of cases, but no studies have documented the specific accuracy of imaging techniques to diagnose paracostal hernias.[3]

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Isolated case reports regarding paracostal hernia repair have previously been published, but no article has exclusively demonstrated its outcome in a retrospective or prospective series in cats.[4–6] The purpose of this retrospective study was to report the results and complications of paracostal hernia treatment in cats, and to determine how frequently it is associated with diaphragmatic rupture.

The authors hypothesise that the outcome of paracostal hernia is generally good to excellent and that it is usually associated with diaphragmatic hernia. Our second hypothesis is that concurrent diaphragmatic hernia will increase the incidence of complications.

Materials and methods

Medical records from the Veterinary Hospital Center of Saint Martin were retrospectively evaluated via a combination of keyword searches ('abdominal hernia', 'paracostal hernia' and 'diaphragmatic hernia') and fee code searches for cats that had undergone surgery for paracostal hernia repair between January 2019 and January 2024. Data collected included causal mechanism, breed, age, sex, clinical signs upon admission to the hospital, results of preoperative complete blood count (CBC) and serum biochemical analyses, imaging techniques used to diagnose the paracostal hernia, location of the paracostal tear, presence of diaphragmatic tears, herniated organs, surgeon's level of training, thoracostomy tube, intraoperative and postoperative complications, and postoperative survival time. Exclusion criteria included insufficient information available in the medical records or regarding the surgery and the pre- and postoperative periods.

In all cases, the paracostal hernia was approached by midline celiotomy. The herniated organs were reduced into the abdominal cavity, facilitating visualisation of the paracostal hernia. The hernia was repaired using a simple continuous suture between the muscle wall and the last rib with polydioxanone 2-0 or 3-0 suture material. Complications were categorised as 'intraoperative' if associated with a surgical event or 'postoperative' if occurring after surgery. Postoperative complications were deemed 'major' if considered life-threating or necessitating surgical revision. Minor complications were managed conservatively or medically.

Short-term follow-up was defined as less than 1 month after surgery, while mid- to long-term follow-up referred to periods exceeding 1 month postoperatively. Mid-term follow-up data were obtained through a review of medical records or via phone interviews with owners or referring veterinarians.

Statistical analysis

Data were summarised for age, sex, weight, breed, time to surgery, laboratory test results, respiratory rate upon admission, concurrent injuries, the surgeon performing the procedure, thoracic drain placement and mortality. The prevalence of paracostal and diaphragmatic hernias was also described.

Results

Data were collected from the records of 19 cats, of which 10 were castrated males. Of the remaining nine cats, seven were spayed and two were intact females. The affected breeds included domestic shorthair (n = 15), Maine Coon (n = 1), Sphynx (n = 1) and Abyssinian (n = 1). The median age of the cats was 2 years (range 2 months to 10 years). The mean weight at the time of trauma was 3.9 ± 1.4 kg.

Data on the cause of trauma were available for only 4/19 cats. Among these, three were hit by a car and one was injured by dog bites. The remaining 15 were found outside with clinical signs suggestive of trauma.

Clinical and physical examination findings upon admission were recorded for all 19 cats. Tachypnoea (respiratory rate >40 breaths/min) was the most common clinical finding (n = 9, 47.3%). Weakness was observed in seven (36.8%) cases, while ataxia or paralysis was present in four (21%) cases. Haematuria and abdominal pain were each present in two (10.5%) cases. Other clinical findings included anorexia, skin wounds, haematochezia, skin haematomas, open-mouth breathing and dyspnoea.

The median time between trauma onset and surgical intervention was 1 day (range 12 h to 6 days). Nine cats were operated on less than 48 h after trauma and the remaining cats more than 48 h after trauma.

Concurrent injuries were present in nine cats, including concurrent fractures (n = 2), neurological lesions with secondary central neurological signs or hind limb paralysis (n = 5) and superficial skin wounds (n = 2). Two cats had other pathologies: cardiomyopathy (n = 1) and a heart murmur grading 3/6 (n = 1) upon admission.

Radiography was the primary diagnostic tool and allowed diagnosis of paracostal hernia in 89.5% of cases. In most cases, radiographic images demonstrated a discontinuity of the abdominal wall in the area of the last ribs, with some dead space between cutaneous and subcutaneous tissues and the thoracic and abdominal wall (Figure 1). In some of the cases, abdominal organs were herniated into the subcutaneous space. In two cases, the hernia was diagnosed during the abdominal ultrasound examination. Of these two cases, one had questionable abdominal radiographic images that justified the ultrasound examination. In one case, the diagnosis was established based on the CT examination performed as a work-up of hindlimb paralysis. In 5/12 (41.6%) cases, a diaphragmatic hernia was suspected based on the abnormal position of the liver.

Abnormalities detected on blood analysis (n = 10) included anaemia (haematocrit <30%) (n = 2) and hypoproteinaemia (total solids <6 g/dl) (n = 3), increased alanine aminotransferase activity (>97 U/l) (n = 5) and hyperglycaemia (glucose >140 mg/dl) (n = 9).
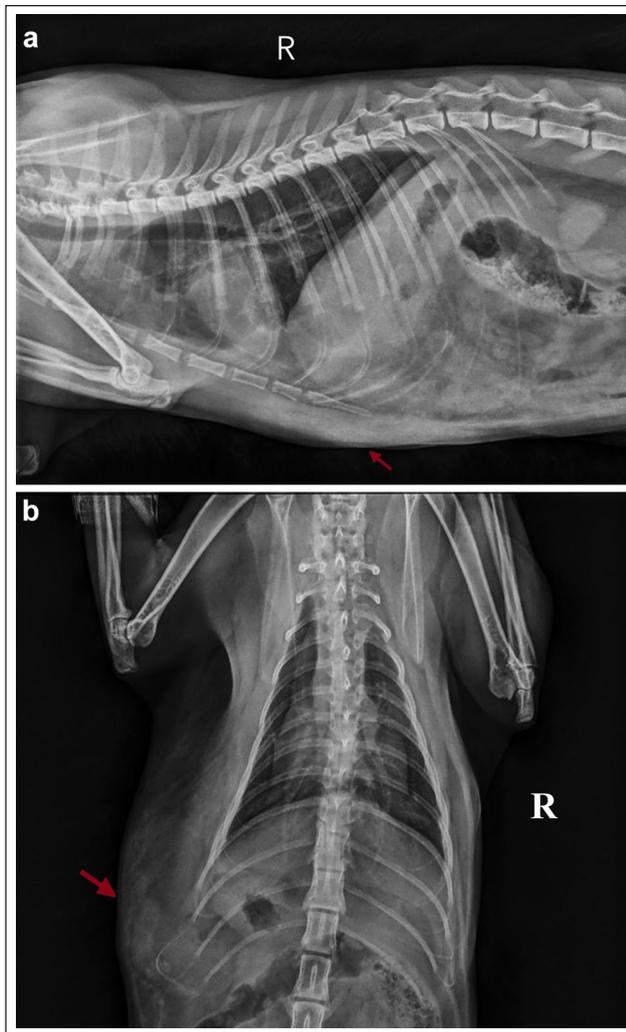
Figure 1 (a) Ventrodorsal thoracic and cranial abdominal radiograph. The red arrow highlights a discontinuity in the left abdominal wall associated with an area of tissue opacity lateral to the ribs. The diaphragmatic domes are well defined and clear, with no radiographic evidence of a diaphragmatic hernia. (b) Right lateral thoracic and cranial abdominal radiograph. The red arrow shows a discontinuity in the abdominal wall behind the sternum, with an area of dense tissue opacity ventral to the last ribs. The diaphragm is well defined with no evidence of a diaphragmatic hernia

Lactate was measured in eight cats. Hyperlactataemia (lactate >2.5 mmol/l) was present in half of the cases (n=4) and resolved after the administration of fluids.

Paracostal hernias were located on the right side in 10 (52.6%) cases, on the left side in five (26.3%) cases and were bilateral in four (21%) cases. The most frequently herniated organs were the small intestine (n=13, 68.4%), the omentum (n=7, 36.8%), intra-abdominal fat (n=4, 21%), the liver (n=1, 5.3%), the spleen (n=1, 5.3%) and one kidney (n=1, 5.3%).

Out of 19 cats, 12 (63.16%) had a concurrent diaphragmatic hernia located on the left side (n=5, 41.7%), on the right side (n=4, 33.3%) and bilaterally (n=3, 25%). The diaphragmatic hernia was located either on the ventral aspect (n=5, 41.7%) or on the dorsal aspect (n=7, 58.3%). Of the nine cats with tachypnoea, seven (77%) had a diaphragmatic hernia. The herniated organs within the thoracic cavity were the liver (n=7, 58.3%), the stomach (n=4, 33.3%), the small intestine (n=2, 16.7%), the spleen (n=1, 8.3%) and the omentum (n=2, 16.7%). In total, 11 cats had diaphragmatic circumferential tears, and one had a combination of circumferential and radial tears.

A total of 10 cats had a thoracic drain placed, all of which had a diaphragmatic hernia. Drain placement was verified by chest radiographs taken in the immediate postoperative period, with the cat under anaesthesia, including lateral and dorsoventral views. The tube was removed within 24h in seven cats (70%), between 24h and 48h in two cats (20%) and after 48h in one cat (10%).

All surgeries were performed by a certified board specialist or a surgery resident under direct supervision, except for one cat that underwent surgery by a surgical intern under the supervision of a third-year surgery resident.

During postoperative management, all cats received a Ringer's lactate infusion (2–4 ml/kg/h) until voluntary food intake. Analgesia was provided initially with morphine (0.2–0.3 mg/kg IV q4h) followed by buprenorphine (20 µg/kg IM q8h) and non-steroidal anti-inflammatory drugs (NSAIDs; meloxicam, 0.05 mg/kg SC). Five cats did not receive NSAIDs: one cat exhibited increased renal values, two cats were anorexic and two cats were administered corticosteroids (prednisolone at 0.5–1 mg/kg PO q24h) because of concurrent neurological disorders. In addition, two cats received maropitant (1 mg/kg IV q24h) and one was treated with mirtazapine (3.75 mg PO q72h). Two cats required a nasoesophageal feeding tube, which remained in place for 3 and 4 days, respectively. The administration and duration of antibiotics beyond the intraoperative prophylaxis period were at the clinician's discretion.

After hospital discharge, the decision to continue analgesic and antibiotic treatment was clinically dependent. When deemed necessary, a prescription was issued for meloxicam (0.05 mg/kg PO q24h for 5 days) and amoxycillin and clavulanic acid (15 mg/kg PO q12h for 5 days). Six cats were discharged with a prescription for antibiotics, of which two had concurrent diaphragmatic hernias, two had associated hindlimb fractures, one had been bitten by a dog and one had a tail wound.

The overall postoperative complication rate was 47.3%. Major postoperative complications occurred in three (15.7%) cats that died during the immediate postoperative period. These three cats had a concomitant diaphragmatic hernia. One cat experienced cardiac arrest a few hours after surgery; it had a diaphragmatic hernia, and re-expansion oedema was the primary suspected

cause. The second cat died 3 days postoperatively while it was paralysed on its hindlimbs and after developing concurrent anaemia and jaundice. Another cat died the night after discharge due to an unknown cause. Minor complications were observed in the postoperative days and were identified in six (31%) cats, including anorexia or hyporexia (n = 3), anaemia (n = 1), icterus (n = 1) and wound seroma (n = 1).

The median duration of hospital stay was 3.5 days (range 1–7).

Long-term follow-up was available for 10/16 cats. The median follow-up time was 2 years and 2 months (range 5 years to 3 months). One cat died from cholangiohepatitis 6 months after surgery. Another cat was euthanased as a result of chronic enteritis 6 months postoperatively. One cat was lost by its owner 3 months after discharge, with no reported surgical complication noted during this period. Of the seven remaining cats, six recovered well without any respiratory, digestive or locomotor signs, but one cat developed respiratory signs associated with feline asthma.

Discussion

This study reports the clinical and diagnostic test findings and the outcome of paracostal hernia management in 19 cats. Despite a postoperative complication rate of 47.3%, the majority of cats recovered well.

The radiographs were diagnostic for paracostal hernia in 89.5% of the cases. For cats with clinical signs in favour of paracostal hernia, radiographs can be performed as a first-line diagnostic test. In cases for which the abdominal wall rupture cannot be confirmed on radiographs, ultrasound examination or even CT may be necessary. Imaging findings suggestive of abdominal wall rupture on ultrasound are free abdominal fluid or gas, displaced organs and lack of continuity of the body wall.[7]

The results of this study provide evidence of a significant correlation between paracostal and diaphragmatic hernias. Therefore, it is essential to fully assess the integrity of the diaphragm when performing surgical correction of a paracostal hernia. The mechanisms involved in the development of a diaphragmatic hernia are well studied.[6] The onset is often attributed to a sudden increase in abdominal pressure. It is very likely that the same pathophysiological processes are involved in cases of paracostal tear.[1]

Currently, there is also no consensus regarding the optimal timing of surgical management for paracostal hernias. Also, as highlighted by several studies, there is no consensus regarding the timing of surgical treatment for diaphragmatic hernias.[8,9] In general, paracostal hernias do not typically require immediate surgical correction; however, it is generally recommended that the cat undergoes surgery as soon as possible after medical stabilisation. In this case series, the median time from admission to surgery was 24h. Only one case had an indication of urgent surgical management. In that case, herniation of the spleen was associated with secondary active bleeding. Another potential indication for early surgical management could be the herniation of the stomach.[1] However, the stomach and the liver are less likely to herniate through a paracostal tear because of their strong paramedian attachments. In contrast, diaphragmatic hernias more commonly involve the stomach and/or liver because of their close proximity. In our study, only four cats had their stomach partially involved in the diaphragmatic hernia at the time of the operation. In addition, these four cats exhibited tachypnoea.

In this study, the small intestine was the organ most frequently herniated in the paracostal region. In cases of concomitant diaphragmatic hernia, no small intestine herniation into the thorax was observed.[9] The intestines are mobile within the abdomen in these cases and may be more prone to herniate through the paracostal hernia as the liver and the stomach may partially obliterate the diaphragmatic hernia.

Various ways to approach abdominal hernias have been described, including incision of the skin and subcutaneous tissue directly over the hernia.[1] However, in the case of paracostal tears, a local incision would make it difficult to accurately assess the diaphragm. Considering the prevalence of diaphragmatic hernias in this study, a midline laparotomy is recommended in cases of paracostal hernias.

Although paracostal hernias generate dead space, no cats in our study required wound drain placement. We deemed it unnecessary, and only one cat developed a seroma. Placement of subcutaneous drains may increase the risk of infection.[10] Systematic uses of a wound drain in the subcutaneous space for simple paracostal hernia repairs may not be necessary, given the low occurrence of seroma formation.

The overall postoperative complication rate was 47.3%. Major complications occurred in 15.7% of cats that died during the postoperative period. Of the cats, 31% experienced minor complications, mainly anorexia or hyporexia. Although these minor complications did not result in immediate mortality, they justified additional monitoring and treatment, extending the length of the hospital stay and increasing the financial impact for owners. In the present study, the two cats that exhibited anorexia during hospitalisation had the longest hospital stays, lasting 6 and 7 days, respectively.

The decision to prescribe antibiotics after hospital discharge was based on the presence of concomitant injuries or suspected contamination. None of the cats in this study presented with postoperative infection. These results support the use of a case-by-case approach to antibiotic therapy after paracostal herniorrhaphy, as routine use of postoperative antimicrobials may not be necessary in the absence of risk factors for infection.

The prognosis of paracostal hernia, whether associated with diaphragmatic hernia or not, is favourable. Immediate postoperative mortality was only observed in cases with diaphragmatic hernia. The perioperative mortality rate in this study was lower than reported in previous studies about abdominal wall herniation (80% of survival rate).[2] It is comparable to rates reported for diaphragmatic hernia, with 13.8% in the study by Gibson et al[9] and 11.7% in the study by Legallet et al.[8]

The limitations of this study are related to its retrospective nature, with data and follow-ups that may be heterogeneous and incomplete, as the level of detail in medical records varies depending on the clinician managing the case. In addition, owner perception bias and the absence of a validated quality-of-life questionnaire further limit the assessment of mid- to long-term outcomes. Surgeries were performed by different surgeons; this variability may introduce inconsistency in outcomes. Further studies with larger sample sizes are needed to better define the risk factors for complications and to optimise treatment protocols.

Conclusions

Our study highlights a significant correlation between paracostal and diaphragmatic hernias, emphasising the importance of evaluating the diaphragm during paracostal hernia repair. Major complications, although not frequent, resulted in early postoperative mortality. However, most cases recovered without major long-term complications.

Ethical approval The work described in this manuscript involved the use of non-experimental (owned or unowned) animals. Established internationally recognised high standards ('best practice') of veterinary clinical care for the individual patient were always followed and/or this work involved the use of cadavers. Ethical approval from a committee was therefore not specifically required for publication in *JFMS*. Although not required, where ethical approval was still obtained, it is stated in the manuscript.

Informed consent Informed consent (verbal or written) was obtained from the owner or legal custodian of all animal(s) described in this work (experimental or non-experimental animals, including cadavers, tissues and samples) for all procedure(s) undertaken (prospective or retrospective studies). No animals or people are identifiable within this publication, and therefore additional informed consent for publication was not required.

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References

1 Smeak D. **Abdominal wall reconstruction and hernias**. In: Johnston SA and Tobias KM (eds). Veterinary surgery: small animal. Vol 2. 2nd ed. Elsevier, 2018, pp 1564–1578.

2 Hennet JM and Williams J. **Traumatic abdominal wall rupture in cats: decision-making and recommended repair techniques.** *J Feline Med Surg* 2021; 23: 234–240.

3 Shaw SR, Rozanski EA and Rush JE. **Traumatic body wall herniation in 36 dogs and cats.** *J Am Anim Hosp Assoc* 2003; 39: 35–46.

4 Trindade AB, Basso PC, Gonzalves MC, et al. **Laparoscopic paracostal herniorraphy in a dog: case report.** *Arq Bras Med Vet Zootec* 2013; 65: 1641–1646.

5 Akgül MB, Yıldırım O, Kılıç S, et al. **Right lateral paracosto-abdominal hernia in a cat.** *Turk J Vet Res* 2023; 7: 47–52.

6 Wilson GP III, Newton CD and Burt JK. **A review of 116 diaphragmatic hernias in dogs and cats.** *J Am Vet Med Assoc* 1971; 159: 1142–1145.

7 Lisciandro GR. **Abdominal and thoracic focused assessment with sonography for trauma, triage, and monitoring in small animals.** *J Vet Emerg Crit Care* 2011; 21: 104–122.

8 Legallet C, Thieman Mankin K and Selmic LE. **Prognostic indicators for perioperative survival after diaphragmatic herniorrhaphy in cats and dogs: 96 cases (2001–2013).** *BMC Vet Res* 2017; 13. DOI: 10.1186/s12917-016-0926-y.

9 Gibson TW, Brisson BA and Sears W. **Perioperative survival rates after surgery for diaphragmatic hernia in dogs and cats: 92 cases (1990–2002).** *J Am Vet Med Assoc* 2005; 227: 105–109.

10 Bristow PC, Halfacree ZJ and Baines SJ. **A retrospective study of the use of active suction wound drains in dogs and cats.** *J Small Anim Pract* 2015; 56: 325–330.