



Closure-related complications after median sternotomy in cats: 26 cases (2010–2020)

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Abstract

Objectives The aim of this study was to determine closure-related complications and outcome after median sternotomy (MS) in cats.

Methods This was a retrospective, multicentric study. The medical records of cats undergoing MS from six referral hospitals were reviewed (2010–2020). Data retrieved included signalment, history, presenting complaints, surgery, patient outcomes and complications. Follow-up was performed via patient records and email/telephone contact with both owners and referring veterinarians. Descriptive statistics were performed.

Results Data on 36 cats were collected; four were excluded due to insufficient follow-up and six died less than 5 days after surgery. Twenty-six cats survived to discharge (survival rate 81%). Three cats had a full sternotomy (FS) performed and 23 cats a partial sternotomy (PS). Of the cats that underwent a PS, six included the manubrium (PSM) and three included the xyphoid process. For 14 cats, the length of sternotomy was unknown. Sternotomy closure was performed with suture in all cats. Two cats (7.7%) developed closure-related complications, both after PSM, during the long-term follow-up, one mild, slightly displaced sternal fracture and one severe, sternal dehiscence (without skin wound dehiscence) requiring revision surgery. No seroma, surgical site infection or wound dehiscence occurred. The most common reason for MS was the presence of a thoracic mass (17/26; 65%), with thymoma being the most common (11/17; 65%).

Conclusions and relevance MS has a low closure-related complication risk in cats when compared with dogs. Complications in cats present differently to what has been previously described in dogs.

Keywords: Surgery; complication; sternotomy; multicentric study

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Introduction

Despite the advances in minimally invasive surgery, median sternotomy (MS) remains the preferred thoracic approach when full exploration of the thoracic cavity is indicated. It provides exposure of both sides of the thorax simultaneously, especially in feline patients, where it allows access to treat conditions involving the cranial mediastinum or the entire thoracic cavity.^{1–4} This approach has historically been considered more challenging than a lateral thoracotomy due to higher rates of complications, mainly reported in dogs, ranging from 17% to 78%.^{1,5–7} However, whether this approach is associated with a higher occurrence of complications in dogs and cats is uncertain.⁸ In humans, seroma formation,

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sternal osteomyelitis, surgical site infection, pain and sternal dehiscence are the main complications described after sternotomy, and have been associated with postoperative sternal instability.^{9,10} Recent data gathered from a large cohort of dogs, comparing wire and suture closure, indicate that these complications are also associated with sternotomy closure.¹¹ In that study the incidence of postoperative complications was lower than previously reported (14%) and was not associated with the method of closure, irrespective of body weight.¹¹ However, to our knowledge, there is a paucity of literature related to MS in cats, particularly pertaining to sternal closure complications. Some studies suggest that small dogs and cats may be less susceptible to complications arising from sternotomy closure,^{12,13} and body weight has been correlated with increased risk of sternotomy closure-related complications in dogs.¹¹

Burton and White reviewed nine cats that underwent an MS over a period of 5 years.¹ Sternotomies were closed with a polypropylene figure-of-eight suture pattern. Four cats were euthanased or died in hospital (three due to the underlying pathology and one that never fully recovered from anaesthesia) and five cats were available for long-term follow-up (median 5.5 months). No complications were reported. This study represents the only veterinary published report to date describing indications, outcomes and complications following MS in cats. Although not described in veterinary literature, sternal instability and fracture are potential complications in cats, despite their small stature compared with dogs.

The purpose of this retrospective study was to describe indications, outcomes and complications after MS in cats, focusing on closure-related complications. Our hypothesis was that the rate of closure-related complications in cats would be lower than that reported in dogs.

Materials and methods

The medical records of client-owned cats that underwent MS at six different referral centres between 1 January 2010 and 1 August 2020 were reviewed. Centres were invited to participate by direct contact with the senior author. Cases were recruited from the Small Animal Referral Hospital of the University of Bristol, Anderson Moores Veterinary Specialists, North Downs Specialist Referrals, the Small Animal Teaching Hospital of the University of Liverpool, University College Dublin Veterinary Hospital, and Dick White Referrals. Contributing surgeons were invited to search the medical records at their institutions and extract data from cases meeting the inclusion criteria into a spreadsheet (Microsoft Excel). The study was approved by the ethical committee of the University of Bristol (VIN/18/081).

Cats were included in the study if they underwent an MS between 1 January 2010 and 1 August 2020, and if information regarding closure of the sternotomy,

postoperative management and follow-up period were available. Case records were reviewed for information regarding signalment, body weight, indication for MS, surgical details of material used for closure (including size and pattern), intraoperative and postoperative complications, postoperative medical management and duration of hospitalisation. Complications were listed as short-term (<14 days postoperatively) and long-term (>14 days postoperatively).¹⁴ All surgeries were performed either by a supervised small animal surgery resident or a board-certified surgeon. A particular emphasis was placed on recording postoperative complications potentially related to the closure method, such as seroma formation, wound dehiscence, surgical site infection and sternal dehiscence.

The MS was recorded as either full sternotomy (FS), including the manubrium and the xyphoid process, or partial sternotomy (PS). In the cases recorded as partial, when possible, it was specified if the manubrium (PSM) or the xyphoid process (PSX) was included in the sternotomy. In accordance with the Accordion classification reported by Follette et al,¹⁵ complications were classified as mild, moderate, severe and those that resulted in death. A postoperative complication was classified as an adverse event associated with and attributed to surgical intervention in the period after skin closure.¹⁵ A surgical site infection was classified as an infection within 90 days of the operative procedure involving the skin, subcutaneous tissue and/or the deep soft tissues of the incision.¹⁶ Cases were excluded if previously mentioned information was absent and/or if there was follow-up of less than 5 days postoperatively. Data were reported as mean \pm SD or as median and interquartile range (IQR). Data were analysed using descriptive statistics.

Results

A total of 36 cases were collected. Four were excluded owing to insufficient follow-up and six died or were euthanased in hospital less than 5 days postoperatively due to the underlying disease. Twenty-six cases were available for descriptive analysis.

Eight cats were neutered females and 18 were neutered males. Domestic shorthair ($n = 17$) was the predominant breed, followed by British Shorthair ($n = 4$). Other breeds included British Longhair, British Blue, Maine Coon, Ragdoll and Somali. The age of one cat was not available; for the remainder the median age at time of surgery was 95 months (IQR 60–120). Median weight was 4.5 kg (IQR 3.5–5).

The most common reason for MS was the presence of a mediastinal mass ($n = 17/26$; 65%) with thymoma being the most common ($n = 11/17$; 65%). Other thoracic masses included lymphoma ($n = 2$), cyst ($n = 1$), abscess ($n = 1$), carcinoma ($n = 1$) and an unknown mass ($n = 1$) (Table 1). Pyothorax was noted in seven cats, one cat had

Table 1 Reason for performing median sternotomy and type of sternotomy carried out in 26 cats

Condition	Type of sternotomy (n)	Number of cats
Mass removal	PS (8), PSM (6), FS (3)	17
Pyothorax	PS (6), PSX (1)	7
Trauma	PSX	1
Diaphragmatic hernia	PSX	1

PS = partial sternotomy; PSM = partial sternotomy, including manubrium; FS = full sternotomy; PSX = partial sternotomy, including xiphoid

Table 2 Diagnosis for the mass removal cases and type of sternotomy performed

Masses	Type of median sternotomy (n)	Number of cats
Thymoma	PSM (4), PS (5), FS (2)	11
Lymphoma	PS (1), PSM (1)	2
Carcinoma	PS	1
Abscess	FS	1
Cyst	PS	1
Unknown	PSM	1

PSM = partial sternotomy, including manubrium; PS = partial sternotomy; FS = full sternotomy

a ballistic injury and another had a diaphragmatic rupture and herniation of organs into the thorax.

Three cats had a FS performed and 23 had a PS. Of the cats that underwent PS, six included the manubrium (PSM) and three the xiphoid process (PSX). Fourteen cats were reported to have had a PS, but the extent of the sternotomy was not specified (Table 2).

The closure pattern of the sternotomy site was a cruciate pattern in 19 cats, encircling suture in one cat and unknown in six cats. The sternum was closed in all cases with suture using polydioxanone (PDS), ranging from 2 to 4 metric. Two metric (3-0 USP) PDS sutures were used in one cat, 3 metric (2-0 USP) in 14 cats, 3.5 metric (0 USP) in nine cats and 4 metric (1 USP) in two cats. The

reason for the choice of pattern and suture type was either unknown or described as the surgeon's preference.

All cats had thoracostomy tubes placed during surgery. Two cats underwent a second surgery. One cat had a second MS performed 5 weeks after the index surgery related to disease progression. Another cat had revision surgery 17 days postoperatively due to a breakdown of the MS site.

Sixteen cases were discharged with non-steroidal anti-inflammatory drugs (15 meloxicam and one robenacoxib), two cats with gabapentin and in six cases pain relief in addition to meloxicam in the form of gabapentin, tramadol or sublingual buprenorphine hydrochloride. Two cats were discharged without analgesia, having received appropriate analgesia during hospitalisation.

All cats recovering from surgery were hospitalised for a duration ranging from 2 to 10 days (median 4, IQR 3–5). Median follow-up after discharge was 124 days (IQR 40–302). Six of the 26 cats died or were euthanased in the follow-up period (respiratory arrest post-secondary surgery on day 40; sudden death on day 41; road traffic accident on day 72; euthanasia due to renal lymphoma on day 206; cardiac disease on day 329; myasthenia gravis deterioration on day 335) (Table 3).

Twelve of 26 cats (46.1%) had imaging performed post-discharge. Three cats had CT, five had radiographs and four had an ultrasound scan of the chest. In five cats, thoracic imaging did not identify any significant abnormalities. Six cats had abnormalities related to the disease process. One cat had radiographs performed and a mildly displaced sternal fracture was noted.

No short-term (<14 days) postoperative sternotomy closure complications occurred. Long-term complications related to sternotomy closure occurred in 2/26 cases (7.7%), which both occurred in cats undergoing partial sternotomy, including the manubrium (Table 4). One cat had a mild complication noted on day 21 postoperatively and consisted of the identification of a mildly displaced sternal fracture on radiographs, which did not require revision surgery or medical intervention. This was an incidental finding while monitoring the evolution of the underlying disease. The second cat sustained a severe

Table 3 Details of the outcome of the six cats that died or were euthanased in the follow-up period

Cause of death	Number of cats	Initial diagnosis	Reason	Survival (days)
Euthanased due to diagnosis	3	Lymphoma	Lymphoma	206
		Thymoma	Myasthenia gravis	335
		Pyothorax	Respiratory arrest post-second surgery	40
Other	3	Pyothorax	Road traffic accident	72
		Thymoma	Congestive heart failure	329
		Thymoma	Sudden death	41

Table 4 Details of the case description and outcome of the two cats that experienced post-median sternotomy-related complications

Breed	Age at time of surgery	Indication for sternotomy	Approach	Closure sternotomy	Complication	Intervention	Outcome + last follow-up postoperatively
British Blue, MN	8 years 11 months	Cavitated large cranial mediastinal mass; thymoma	PSM	PDS 2-0; cruciate sutures circumsternal	Complete sternal osteosynthesis Dehiscence noted 17 days postoperatively	Revision surgery – debridement and closure	40 days post-initial surgery: sudden death
British Shorthair, MN	9 years 1 month	Thymoma	PSM	PDS 0; Cruciate mattress sutures	Sternal fracture: mild displacement sternbrae fragments Noted 21 days postoperatively	No intervention	335 days postoperatively: death due to deterioration myasthenia gravis – unknown if euthanased

MN = male neutered; PSM = partial sternotomy, including manubrium; PDS = polydioxanone

complication on day 17 postoperatively (thymoma resection), when the owner noted an acute development of a billowing of the wound while the cat was breathing. There was a complete breakdown of the MS site, with dehiscence and failure of sternal osteosynthesis (Table 4). There was no evidence of infection or excessive mobility of the patient postoperatively. This cat required revision surgery. Other long-term complications were recorded; however, these complications (thoracic adhesions, chylothorax, vomiting, ascites, abscess formation due to migrating foreign body and lymph node enlargement) were related to the underlying disease and not the method of closure.

Discussion

This study demonstrated that the closure-related complication rate in cats was low after MS (7.7%). To our knowledge, this is the largest study to date regarding MS closure in cats and the first to describe MS closure-related complications in cats.

By using the classification reported by Follette et al,¹⁵ we aimed to categorise complications in the most unbiased manner possible, which also enabled us to compare these data with data collected in dogs. We also used a selective data collection system to focus on complications related to the sternotomy site and closure method and not the underlying disease process. Previous studies reporting outcomes of thoracotomies in cats did not report any closure-related complications.^{1,14,17} In our cohort of 26 cats, two closure-related complications were found – both occurred during the long-term follow-up (day 17 and 21, respectively). No complications occurred in the short term, which is consistent with a previous study evaluating different types of thoracic approaches in dogs and cats.¹⁸ Previous studies in dogs reported multiple mild complications after MS such as incisional oedema, seroma and skin dehiscence.^{1,6,19} One mild complication (3.8%) was identified in our study, which consisted of a minimally displaced sternal fracture found incidentally on radiographs obtained for the underlying disease. This is lower than the 8% rate of mild complications reported in dogs.¹¹ No seroma, wound dehiscence or wound effusion occurred in the cats included in our study, which were responsible for the largest portion of complications (n = 23/37; 62%) noted in dogs in one large retrospective study of MS.¹¹

Incisional complications after exploratory laparotomy have been well documented in cats, and various numbers have been reported. Crowe reported a 0% incisional dehiscence rate in 81 cats undergoing abdominal procedures, the majority of which were ovariohysterectomy and cryptorchidectomy.²⁰ Incisional hernias have been reported in 8/74 cats (10.8%) in a retrospective study of types of hernia (C Bellenger, personal communication, 1990). A 4% incisional complication rate was reported

in a large study of 174 dogs and 26 cats that underwent exploratory coeliotomy,²¹ but the exact distribution between the two species was not possible to extract. A 1.5% rate of wound dehiscence following ovariohysterectomy in female cats has also been reported, but at least five combinations of suture materials were used to close the linea alba and subcutaneous tissue in these cats, making it difficult to draw any conclusion on the cause of the dehiscence.²² Our rate of closure-related complications is commensurate with these figures, although the small number of cases and the different types of suture material and pattern make any meaningful comparison difficult. Furthermore, in all these studies on cat laparotomy, the extent of the incision was not mentioned. Studies have shown that, in cats, the post-umbilical region is biomechanically weak and may therefore be predisposed to incisional herniation.²³

It is interesting to note that, in the study presented here, both cats that experienced closure-related complications were in the PSM group. One could hypothesise that partial sternotomies (after preserving either the manubrium or xiphoid process) might also be biomechanically different to each other and to a complete sternotomy, accounting for a higher risk of closure-related complication. The very small number of complications recorded in our study can allow us to merely suggest this hypothesis, and biomechanical studies on partial sternotomies along with clinical studies, including a larger number of cases, would be needed to strengthen this hypothesis.

Other common complications recorded following laparotomy in cats include seroma formation, surgical site infection and wound dehiscence.²⁴ None of these complications were found in this study. Seromas occur secondarily to the disruption of lymphatics during surgical dissection and the creation of dead space.²⁴ No information was obtained regarding dissection of the pectorals during the approach and whether steps were taken to reduce the amount of dead space while closing the subcutaneous layer. An explanation for the absence of these complications could be that cats appear subjectively to require less dissection over the sternum than dogs, and thus less dead space is formed. However, compared with dogs, cats have reduced wound perfusion in the acute healing phase, lower density of collateral blood vessels in their subcutaneous layer, lower wound tensile strength and greater dependence on the subcutaneous tissues for wound healing.^{25,26} One could argue that cats have less subcutaneous tissue over the sternum than dogs, or than the feline midline, which could predispose them to mild complications after surgery in this area.

One cat (3.8%) experienced a severe complication and had to undergo revision surgery for a complete breakdown of the MS site with sternal osteosynthesis dehiscence. The initial sternotomy was performed to remove a thymoma and no evidence of surgical site infection was found. The cat appeared to be properly rested and had

not been reported to interact with the skin wound, which healed uneventfully. For those reasons, instability of the sternotomy closure may possibly be responsible for the dehiscence in this case. Severe complications were also noted in 3.8% of dogs undergoing MS. The distribution of complications was different between dogs and cats regarding the type of sternotomy. The number of dogs that experienced complications following PSM was the lowest of all categories, with only four dogs included compared with eight dogs that had PSX and 12 dogs that underwent FS.¹¹ In contrast, the two cats that experienced complications had undergone PSM and no complication was found in the group of cats undergoing PSX. The small number of complications in this cohort of cats preclude any definitive interpretation, but the data could support the idea that sternotomy including the manubrium could be more unstable and therefore more prone for complications. In vitro data on the biomechanics of PS vs FS are lacking.

No surgical site infections were noted, which is lower than the reported surgical site infection noted in dogs after MS (2.7%).¹¹ The complications observed in the cats included in the present report and the absence of the most common complications found in dogs, such as seroma and wound dehiscence, highlight the difference between the species regarding MS closure-related complications. The most reliable imaging modality to evaluate sternal bone healing in humans has been shown to be CT.²⁷ No similar studies are available in dogs or cats.

In this study, no cats were imaged specifically for the assessment of sternotomy closure-related complications, but 12 cats underwent imaging for follow-up of their underlying disease. As the choice of imaging technique was directed by the latter, assessment of the former (in particular bone healing) was not always possible, even though we were able to identify sternal healing complication in one cat. The sternal fracture was noticed incidentally, and neither discomfort nor lameness was noted. Systematically imaging cats that underwent MS may not be relevant to assess for healing of the sternotomy site in the absence of clinical signs.

Both postoperative complications observed in this study occurred in cats that had a partial MS including the manubrium (PSM) and the sternum was closed with polydioxanone in a cruciate circumsternal pattern. The skin closure was different in both cases; however, this was considered unlikely to have contributed to the occurrence of complications. Both cats underwent surgery for thymoma removal. As eight other cats had MS for thymoma removal without any approach-related complication, we do not think it is likely to be a contributing factor.

Of the 32 cats, six did not survive to discharge. The survival rate of 81% is higher than previously reported in 13 cats after lateral thoracotomy surgery (62%)¹⁴ but lower than reported in 41 cats undergoing thoracic surgery (86%).¹⁷ In the latter study, however, the thoracic

approaches were not reported and most of the cats were treated for a diaphragmatic rupture. Overall, this survival rate could indicate that the MS approach cannot necessarily be linked to mortality,⁸ although comparison between lateral thoracotomy and MS in a similar population is not available in cats. In dogs, retrospective comparison of MS and thoracotomy for the treatment of pulmonary neoplasia has shown that both approaches are acceptable for the treatment of this condition, even though thoracotomy was found to be associated with less postoperative pain, better oxygenation and fewer complications.²⁸ Appropriate surgical access to assess the pleural cavity and to treat the disease should dictate the choice of approach.

The indications for MS were like those described in the literature for both dogs and cats.^{29,30} Most of the cats were presented with a mediastinal mass (n = 17/26; 65%) and pyothorax (n = 7/26; 27%). Mediastinal masses are not common in cats and dogs. The most common are lymphoma and thymoma, followed by idiopathic mediastinal cysts, ectopic thyroid tumour, rare sarcomas and metastatic neoplasm.³¹ In our study, thoracic masses were mostly neoplasia (n = 14/17; 82%), with thymoma being the most common with 11 cases. The high proportion of thymomas is likely to be due to a pertinent surgical indication as good prognosis and long-term survival rates have been described after complete surgical resection.³²

Only 3/26 cats in our study required an FS, showing that PS was sufficient in most cases. Stability of the sternum is thought to be of fundamental importance for uncomplicated healing. Several studies have looked at closure techniques in dogs, but no data are available in cats. In dogs, suture material and, in particular, polydioxanone and nylon have been shown to give similar results to orthopaedic wire.^{11,33–35}

This study has several limitations, one of which is its retrospective nature. It is possible that some complications might not have been included. Some may have occurred outside of the follow-up period available for review or may not have been reported. One of the complications mentioned was noted incidentally during radiographs. As radiographs were not obtained in all cases, it is possible that this complication was missed in other cases and under-reported. The follow-up in some cases was also limited and was, at times, less than 14 days. For those cats, it is possible that complications might not yet have occurred. Another limitation was the relatively low number of cases included in this study, with 36 cases collected from six referral centres over a 10-year period, and 26 available for follow-up, which only allowed for a descriptive analysis.

Conclusion

MS appears to have a low closure-related complication risk in cats. The nature of complications in cats following MS seems to be different to what has been described in dogs.

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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) 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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