Scientific Works. Series C. Veterinary Medicine. Vol. LXXII (1), 2026
ISSN 2065-1295; ISSN 2343-9394 (CD-ROM); ISSN 2067-3663 (Online); ISSN-L 2065-1295

SURGICAL STABILIZATION OF FLAIL CHEST IN CATS USING FIRST-GENERATION U-GRIP ANATOMICAL PLATES: THREE CLINICAL CASES

Seralp UZUN[1], Jacqueline MOCANU[1], Iuliana IONAȘCU[1], Mateusz PAWLIK[2, 3], Daria Teodora GĂNESCU[1]

[1]University of Agronomic Sciences and Veterinary Medicine of Bucharest,
59 Mărăști Blvd, District 1, Bucharest, Romania
[2]Cabiomede Ltd., 21 Karola Olszewskiego, Kielce, Poland
[3]Faculty of Biomedical Engineering, Silesian University of Technology,
40 Roosevelta, Zabrze, Poland

Corresponding author email: seralp.uzun@gmail.com

Abstract

Thoracic trauma in cats frequently results in rib fractures which may progress to flail chest and severe respiratory compromise. Three feline patients diagnosed with multiple rib fractures and flail chest were presented to the University Veterinary Emergency Hospital "Prof. univ. dr. Alin Bîrțoiu", Faculty of Veterinary Medicine, Bucharest. Diagnostic evaluation included thoracic radiography and computed tomography (CT) to assess the extent of rib fractures and associated thoracic injuries. Initial stabilization included oxygen therapy, analgesia and thoracocentesis in cases presenting pneumothorax. Due to severe thoracic wall instability, surgical stabilization of the fractured ribs was performed using U-GRIP™ first-generation plates developed in collaboration with Cabiomede, representing a novel fixation option in veterinary thoracic surgery. In one case, a fractured rib perforated the lung parenchyma requiring lung lobectomy, while another patient presented pulmonary bullae that also required lobectomy. The third cat underwent surgical stabilization of the rib fractures. Appropriate stabilization of the thoracic wall together with management of associated pulmonary injuries may improve respiratory function and clinical outcome in cats with severe thoracic trauma.

Key words*: rib fractures, flail chest, thoracic trauma, cats, U-GRIP plate.*

INTRODUCTION

Flail chest is a severe thoracic injury characterized by the fracture of multiple consecutive ribs, resulting in a segment of the thoracic wall that moves paradoxically during respiration. This condition leads to impaired ventilation, decreased pulmonary compliance, and significant respiratory compromise. In both human and veterinary patients, flail chest is associated with increased morbidity due to pain, pulmonary contusions, and compromised gas exchange (Olsen et al., 2002; Cabon et al., 2015).

In human medicine, surgical stabilization of rib fractures (SSRF) has become an increasingly accepted treatment modality for flail chest and severe thoracic trauma. Multiple studies have demonstrated that surgical fixation improves respiratory mechanics, reduces the duration of mechanical ventilation, decreases intensive care unit stay, and lowers complication rates compared to conservative management (Tanaka et al., 2002; Granetzny et al., 2005; Slobogean et al., 2013; Pieracci et al., 2017; Liu et al., 2019; Fokin et al., 2020). As a result, SSRF is now considered a standard or strongly recommended approach in selected human patients.

In contrast, veterinary management of flail chest remains predominantly conservative, relying on analgesia, oxygen therapy, and external stabilization techniques. Although these approaches may be effective in some cases, they do not directly restore the structural integrity of the thoracic wall and may be insufficient in patients with severe instability or associated pulmonary injury (Olsen et al., 2002; Cabon et al., 2015). Surgical stabilization techniques have been described in dogs, including interfragmentary wiring and external splinting; however, these methods present limitations and are not widely adopted in clinical practice (Ahn et al., 2016; Min et al., 2016).

The application of surgical stabilization in cats presents additional challenges. Feline ribs are

small in diameter, typically measuring approximately 3-4 mm, and exhibit pronounced curvature, making conventional fixation techniques such as wiring technically demanding and often unreliable. Furthermore, external splinting methods may lead to patient discomfort and inadequate stabilization, particularly in active or stressed patients (Ahn et al., 2016; Min et al., 2016). These anatomical and practical limitations highlight the need for alternative fixation methods specifically adapted to feline thoracic anatomy.

In response to these challenges, a first-generation U-GRIP™ anatomical plate system was developed to allow effective stabilization of fractured ribs in small patients. The design enables secure engagement of the rib while minimizing soft tissue trauma and facilitating a reproducible surgical technique (Uzun et al., 2023).

The aim of this study is to describe the clinical application of this novel fixation system in three feline cases presenting with flail chest, and to evaluate surgical feasibility and short-term outcomes.

MATERIALS AND METHODS

Study Design and Case Selection

This study describes three feline patients diagnosed with flail chest and treated surgically at the University Veterinary Emergency Hospital. Cases were selected based on the presence of thoracic wall instability characterized by multiple rib fractures resulting in paradoxical motion, accompanied by respiratory compromise requiring clinical intervention (Table 1).

Table 1: Clinical Case Summary

Case	Trauma Type	Ribs Fractured	Ribs Stabilized	Pulmonary Injury	Surgical Procedure
#1	Dog bite trauma	Bilateral rib fractures (multiple)	8th (R)	Right middle lung lobe perforation	Lung lobectomy + thoracic wall reconstruction
#2	Unknown trauma	Left ribs 9, 10, 11, 12	9th and 10th (L)	Pulmonary contusions	Thoracic wall reconstruction
#3	Hit-by-car (polytrauma – CMF + thoracic trauma)	Right ribs 4, 5, 6	6th (R)	Pulmonary bullae and blebs (right caudal, R-Cr and accessory Acc., lobes)	Partial lung lobectomy + thoracic wall reconstruction

Clinical Evaluation and Stabilization

All patients underwent emergency stabilization focused on restoration of respiratory function compromised by blunt thoracic trauma and associated pulmonary injury, as well as adequate pain control.

Supplemental oxygen was delivered using flow-by and mask techniques with high flow rates. Opioid analgesia was administered in all patients. Thoracentesis was performed in cases presenting pneumothorax to relieve respiratory distress.

Intercostal nerve blocks were applied both during emergency stabilization and intraoperatively in order to improve analgesia and reduce thoracic pain associated with rib fractures.

Clinical examination was followed by thoracic imaging. Thoracic radiography was performed after initial stabilization to identify rib fractures and assess thoracic wall integrity. Computed tomography (CT) was subsequently performed to accurately determine the number and location of fractured ribs and to identify associated pulmonary injuries, including lung parenchymal damage or bullae.

Indications for Surgical Intervention

Surgical stabilization was indicated in patients presenting with marked thoracic wall instability consistent with flail chest, as well as in cases where rib fractures resulted in penetration or risk of penetration into the thoracic cavity, potentially compromising pulmonary structures. Only ribs contributing to thoracic instability or posing a direct threat to intrathoracic structures were selected for surgical stabilization. Fractures that remained aligned and did not significantly affect respiratory mechanics were managed conservatively.

Surgical Technique

All procedures were performed under general anesthesia via intercostal thoracotomy. Surgical stabilization of rib fractures was performed using U-GRIP™ first-generation titanium plate (prototype system currently under intellectual property protection) developed in collaboration with Cabiomede. This titanium implant is specifically designed for small-diameter ribs and features a hook-based mechanism that allows the plate to engage the rib from the cranial aspect, thereby avoiding the intercostal neurovascular bundle located on the caudal margin. The system is applied without circumferential encirclement of the rib, reducing the risk of vascular or nerve injury.

Fixation was achieved using 1.5 mm locking screws adapted to the limited cortical thickness of feline ribs, providing stable anchorage while minimizing additional trauma to surrounding tissues. The implant design allows rapid application and facilitates reproducible stabilization in anatomically challenging conditions.
In cases where pulmonary injury was identified, additional procedures, including lung lobectomy, were performed as indicated.

Postoperative Management
Postoperative care included oxygen supplementation, analgesia, and continuous clinical monitoring. Thoracic drainage was performed when necessary, using chest tubes connected to a Heimlich valve system to manage residual pneumothorax.
Patients were closely monitored for respiratory function, pain control, and potential complications during the postoperative period.

RESULTS AND DISCUSSIONS

Three feline patients diagnosed with flail chest underwent surgical stabilization. Clinical outcomes, respiratory recovery, and postoperative evolution were evaluated.

Case 1 – Dog Bite Trauma with Bilateral Flail Chest
The first patient was presented following a dog bite injury affecting the thoracic region. Although no external penetrating wounds were identified, the compression force of the bite resulted in bilateral flail chest with multiple rib fractures. Clinical examination revealed severe respiratory distress and marked paradoxical thoracic wall movement.
Thoracic imaging confirmed multiple rib fractures affecting both hemithoraces. On the right side, a displaced rib fragment had penetrated the thoracic cavity and perforated the right middle lung lobe (R-M), while fractures on the left side did not result in pulmonary penetration. Pneumothorax was identified and managed with thoracentesis during emergency stabilization.
Surgical intervention was performed due to thoracic instability and lung injury. Lung lobectomy of the right middle lung lobe (R-M) was carried out because of traumatic perforation. Thoracic wall stabilization on the right side was achieved using a U-GRIP™ first-generation plate applied to the rib responsible for instability. On the left side, thoracic wall integrity was restored by reconstruction of the disrupted intercostal musculature.
Postoperatively, the patient demonstrated rapid improvement in respiratory function, with complete resolution of paradoxical thoracic wall movement. No recurrence of pneumothorax was observed. Thoracic wall stability was maintained, and no implant-related or infectious complications developed.

Case 2 – Unknown Thoracic Trauma with Unilateral Flail Chest
The second patient was presented following unknown thoracic trauma and exhibited respiratory distress and thoracic pain consistent with flail chest. Thoracic imaging revealed multiple rib fractures affecting the left thoracic wall, involving ribs 9, 10, 11 and 12 (Figure 1). Pulmonary contusions were also identified.

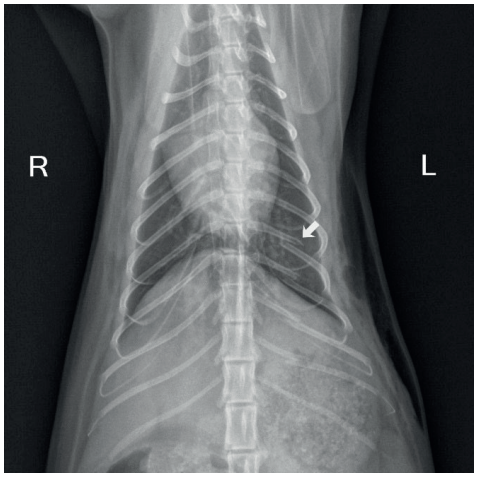


Figure 1. Thoracic radiograph showing multiple fractures of the left ribs (9-12)

Fractures of ribs 9 and 10 were displaced toward the thoracic cavity and considered at risk for penetration of intrathoracic structures. Due to thoracic wall instability and the risk of further displacement, surgical stabilization was indicated.
Intraoperative exploration confirmed the absence of lung parenchymal injury. Stabilization of ribs 9 and 10 was performed

using U-GRIP™ first-generation plates. Fractures of ribs 11 and 12, which remained aligned and did not contribute to thoracic instability, were managed conservatively.
Postoperatively, the patient showed progressive improvement in respiratory function, with resolution of thoracic pain and restoration of stable chest wall mechanics. No pneumothorax or respiratory deterioration was observed.

Case 3 – Polytrauma with Persistent Pneumothorax and Flail Chest
The third patient was presented following hit-by-car (HBC) trauma and was diagnosed with polytrauma, including craniomaxillofacial injuries and thoracic trauma. Thoracic CT revealed fractures of ribs 4, 5 and 6 on the right thoracic wall, accompanied by severe pneumothorax resulting in respiratory compromise (Figure 2).
Initial stabilization included thoracentesis, which was performed twice due to rapid reaccumulation of air. Because pneumothorax persisted despite repeated thoracentesis, a thoracic drain (MILA® chest tube) connected to a Heimlich valve was placed to allow continuous evacuation of air from the pleural cavity.

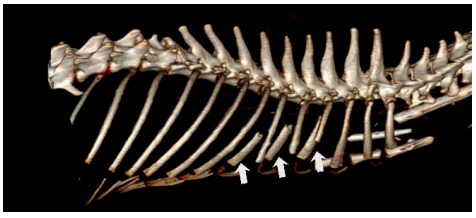


Figure 2. Three-dimensional CT reconstruction showing fractures of the right 5th–7th ribs (arrows)

Surgical intervention was subsequently performed via intercostal thoracotomy. Intraoperative examination revealed pulmonary bullae and blebs affecting the right caudal and accessory lung lobes, which required partial lung lobectomy. Thoracic wall stabilization was achieved by placement of a U-GRIP™ first-generation plate on rib 5.
Postoperatively, the patient showed marked improvement in respiratory function, with resolution of pneumothorax. The thoracic drain was removed following cessation of air leakage and stabilization of respiratory parameters.

Surgical Intervention
Surgical management was indicated in all three patients due to thoracic wall instability associated with flail chest and the presence of injuries threatening intrathoracic structures. All procedures were performed under general anesthesia using an intercostal thoracotomy approach, selected according to the location of the fractured ribs.

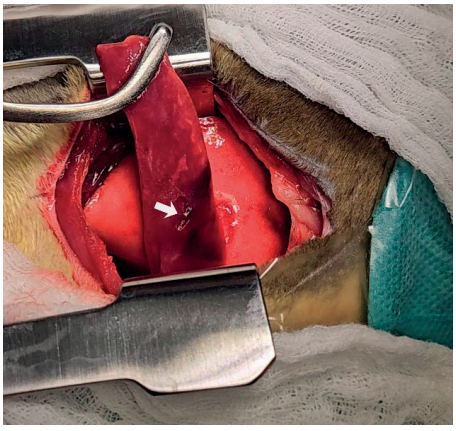


Figure 3. Intraoperative view of an atelectatic right middle lung lobe (R-M) exposed through intercostal thoracotomy. Darker areas of the lung parenchyma indicate severe pulmonary contusions, and the site of traumatic rupture caused by a displaced rib fragment is indicated by the white arrow

Thoracic exploration allowed direct assessment of rib displacement and associated pulmonary injuries.
In one patient, a displaced rib fragment had penetrated the thoracic cavity and perforated the R-M lung lobe, requiring lung lobectomy (Case #1, Figure 3).
In another patient (Case #3), persistent pneumothorax was associated with pulmonary bullae and blebs affecting the right caudal and accessory lung lobes, which required partial lung lobectomy during surgical exploration (Figure 4).

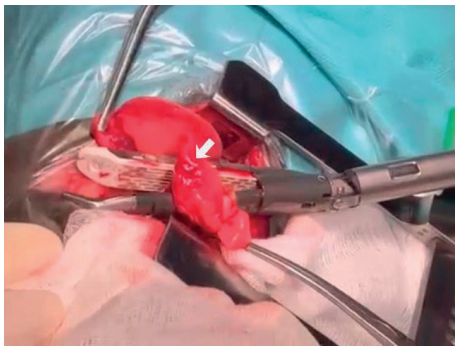


Figure 4. Intraoperative view of the right caudal lung lobe (R-Ca) demonstrating pulmonary blebs (white arrow). Partial lobectomy was performed using surgical staplers

Following surgical management of pulmonary injuries, attention was directed toward restoration of thoracic wall stability. Stabilization of rib fractures was performed using U-GRIP™ first-generation plates (prototype system currently under intellectual property protection). These titanium plates (2 mm thickness) use 1.5 mm locking screws and are designed
to grasp the rib from the cranial aspect, thereby avoiding compression of the intercostal neurovascular bundle located along the caudal rib margin. In this patient (Case #2), stabilization of a single rib restored thoracic wall alignment and improved the position of adjacent fractures.

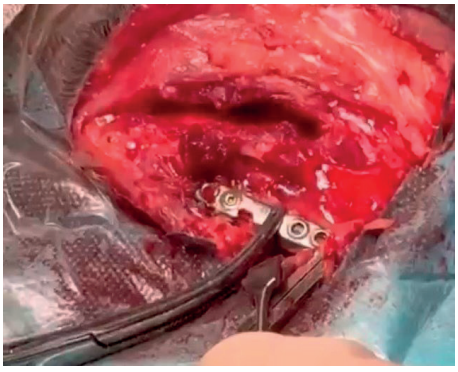


Figure 5. Intraoperative view demonstrating thoracic wall stabilization of a fractured rib using a single U-GRIP™ first-generation plate

Plates were applied only to ribs responsible for thoracic instability or posing a risk of intrathoracic penetration.

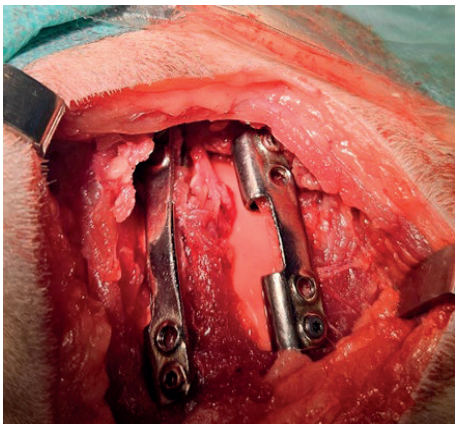


Figure 6. Intraoperative view demonstrating stabilization of multiple rib fractures using two U-GRIP™ first-generation plates, shown prior to reconstruction of the thoracic wall

Thoracic drainage was established in all patients using MILA® chest tubes, which were placed before complete thoracic closure. Heimlich valves were applied in one patient. The duration of surgical procedures ranged between 60 and 110 minutes, depending on the complexity of the pulmonary injuries and the number of ribs requiring surgical stabilization.

Outcomes

Postoperative recovery was monitored in all patients with particular attention to respiratory pattern, thoracic pain and chest tube output. Thoracic drainage allowed continuous evacuation of residual intrathoracic air during the early postoperative period and chest tubes were removed once respiratory stability and absence of further air leakage were confirmed (between 36 to 72 hours).

All patients showed improvement in respiratory function following surgical stabilization of the thoracic wall and management of associated pulmonary injuries.

Follow-up evaluations were performed at 15, 30 and 60 days after surgery, with further monitoring performed through communication with the owners.

Two patients recovered uneventfully and returned to normal respiratory function. One patient developed feline panleukopenia approximately 10 days after surgery and died due to complications unrelated to the thoracic surgical procedure.

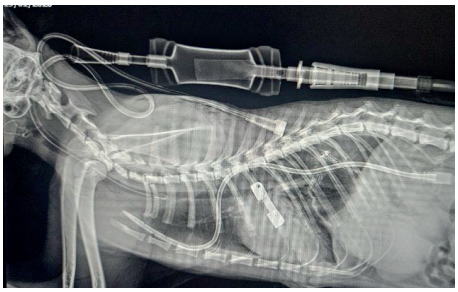


Figure 7. Postoperative lateral thoracic radiograph demonstrating thoracic wall stabilization using a U-GRIP™ first-generation plate. A MILA® chest tube connected to a Heimlich valve system is visible in situ for continued evacuation of intrathoracic air

Flail chest represents one of the most severe manifestations of thoracic trauma and is characterized by paradoxical movement of a segment of the thoracic wall caused by multiple consecutive rib fractures. This condition disrupts normal respiratory mechanics and can lead to significant respiratory compromise.

While surgical stabilization is well established in human medicine (Tanaka et al., 2002; Granetzny et al., 2005; Liu et al., 2019), veterinary literature remains limited (Olsen et al., 2002; Ahn et al., 2016; Min et al., 2016).

In human medicine, surgical stabilization of rib fractures (SSRF) has become an established therapeutic approach for severe thoracic wall instability. Multiple clinical studies have demonstrated that rib stabilization improves respiratory function, reduces ventilator dependence, and shortens intensive care unit stays (Tanaka et al., 2002; Slobogean et al., 2013; Liu et al., 2019). The development of specialized rib plating systems has facilitated reliable stabilization of fractured ribs in human trauma patients (Fokin et al., 2020; Pieracci et al., 2017).

In contrast, surgical stabilization of rib fractures in veterinary patients presents unique technical challenges. The ribs of cats are extremely small, highly curved, and fragile, which significantly limits the applicability of conventional fixation systems. Additionally, thoracic anatomy varies widely depending on patient size, breed, and body condition, further complicating implant positioning and stability.

Several techniques have been described for stabilization of rib fractures in veterinary medicine, including circumcostal sutures, interfragmentary wiring, and external thoracic bandaging (Olsen et al., 2002; Ahn et al., 2016; Min et al., 2016). However, these techniques often fail to provide sufficient rigidity in cases of true flail chest, particularly when multiple adjacent ribs are fractured (Olsen et al., 2002).

Interfragmentary wiring may be technically limited in feline ribs due to reduced bone stock and risk of iatrogenic damage, while external splinting may result in discomfort and inconsistent stabilization (Ahn et al., 2016; Min et al., 2016).

In the present case series, thoracic wall stabilization was achieved using a U-GRIP™ first-generation plate, a prototype implant specifically designed for the stabilization of small and curved ribs. The implant provides secure mechanical engagement without relying solely on screw purchase in minimal cortical bone, making it particularly suitable for feline thoracic anatomy.

This design allows faster application, improved stability, reduced surgical trauma, and greater reproducibility compared to traditional techniques.

In addition to thoracic wall stabilization, associated pulmonary injuries were addressed surgically when required. Lung lobectomy was performed in cases of traumatic pulmonary injury, allowing removal of non-viable lung tissue and contributing to overall respiratory stabilization.

Surgical stabilization resulted in restoration of thoracic wall integrity and allowed adequate lung expansion during respiration. These findings suggest that surgical management of severe flail chest in cats is feasible and may offer advantages over conservative treatment in selected cases, particularly in the presence of significant respiratory compromise.

The U-GRIP™ first-generation plate used in these cases represents an early prototype currently undergoing further development. Further biomechanical studies and larger clinical series are required to evaluate its performance and define its role in veterinary thoracic surgery.

Severe thoracic trauma in cats remains a significant clinical challenge. While surgical stabilization is widely adopted in human trauma care, its application in veterinary medicine has

been limited by anatomical and technical constraints. The present cases demonstrate that anatomically adapted stabilization systems may overcome these limitations and provide effective thoracic wall stabilization in feline patients.

This approach may represent an important step toward establishing surgical rib stabilization as a viable and reproducible treatment option in veterinary trauma surgery.

CONCLUSIONS

Flail chest represents a severe form of thoracic trauma that can result in significant respiratory compromise in feline patients. The present cases demonstrate that surgical stabilization of the thoracic wall can be successfully performed in cats with multiple rib fractures and flail chest, allowing restoration of thoracic stability and improvement of respiratory mechanics.

These findings support surgical intervention as a viable treatment option in selected feline trauma patients, particularly in cases of marked thoracic wall instability and persistent respiratory compromise.

The U-GRIP™ first-generation plate, used as a prototype stabilization system in these cases, proved adaptable to the anatomical characteristics of feline ribs and allowed effective surgical stabilization.

This implant design addresses key limitations of conventional techniques in small animal patients and may facilitate more consistent and reproducible thoracic wall stabilization.

Further development and evaluation of dedicated rib stabilization implants for veterinary patients are currently underway and may contribute to improved management of severe thoracic trauma in small animals.

FUNDING

This report received no external funding. All procedures and analyses were performed as part of routine clinical care and academic investigation within the university hospital.

CONFLICTS OF INTEREST

The author declares no conflicts of interest related to the content of this article.

ACKNOWLEDGEMENTS

Special thanks to the diagnostic imaging unit for their assistance with CT acquisition and interpretation.

The author also extends appreciation to the pet owners who allowed follow-up and consented to data use for academic purposes.

REFERENCES

Ahn S, Jeong S, Yoon H. Repair of flail chest using interfragmentary wiring and stability augmentation with basket-weave fashion sutures in a toy breed dog: a case report. *Veterinarni Medicina*. 2016; 61(6): 348–352.

Cabon Q, Deroy C, Ferrand FX, et al. Thoracic bite trauma in dogs and cats: a retrospective study of 65 cases. *Veterinary and Comparative Orthopaedics and Traumatology*. 2015; 28(6): 448–454.

Fokin AA, Hus N, Wycech J, Rodriguez E, Puente I. Surgical stabilization of rib fractures: indications, techniques, and pitfalls. *JBJS Essential Surgical Techniques*. 2020; 10(2):e0032.

Granetzny A, El-Aal MA, Emam E, et al. Surgical versus conservative treatment of flail chest: evaluation of pulmonary status. *Interactive Cardiovascular and Thoracic Surgery*. 2005; 4(6): 583–587.

Liu T, Liu P, Chen J, et al. A randomized controlled trial of surgical rib fixation in polytrauma patients with flail chest. *Journal of Surgical Research*. 2019; 242: 223–230.

Min BS, Jeong SW, Yoon HY. Surgical correction of pseudo-flail chest using interfragmentary wiring, latissimus dorsi flap, and external splinting in a dog. *Journal of Veterinary Clinics*. 2016; 33(2): 124–128.

Olsen D, Renberg W, Perrett J, et al. Clinical management of flail chest in dogs and cats: a retrospective study of 24 cases (1989-1999). *Journal of the American Animal Hospital Association*. 2002; 38(4): 315–320.

Pieracci FM, Majercik S, Ali-Osman F, et al. Consensus statement: Surgical stabilization of rib fractures rib fracture colloquium clinical practice guidelines. *Injury*. 2017; 48(2): 307–321.

Slobogean GP, MacPherson CA, Sun T, et al. Surgical fixation versus nonoperative management of flail chest: a meta-analysis. *Journal of the American College of Surgeons*. 2013; 216(2): 302–311.

Tanaka H, Yukioka T, Yamaguti Y, et al. Surgical stabilization of internal pneumatic stabilization? A prospective randomized study of management of severe flail chest patients. *Journal of Trauma*. 2002; 52(4): 727–732.

Uzun S, Ionașcu I, Dumitrescu DM, et al. Thoracic wall reconstruction using polypropylene mesh in traumatic injuries in dogs and cats. *Scientific Works Series C Veterinary Medicine*. 2023; 69(1): 206–212.