Eurasia Specialized Veterinary Publication

**International Journal of Veterinary Research and Allied Science**

**ISSN:3062-357X**

2023, Volume 3, Issue 2, Page No: 63-70

Available online at: www.esvpub.com/

# Diagnosis and Palliative Management of Thoracic Sarcoma-Associated Empyema in a Mature Beef Cow

**Marino Giorgio[1], Fontana Elena[1], Lombardi Riccardo[1]***

[1]Department of Surgery, Faculty of Medicine, University of Milan, Milan, Italy.

***E-mail** ✉ riccardo.lombardi@outlook.it

**ABSTRACT**

Neoplastic diseases in cattle are rarely documented in veterinary research. They are typically incidental findings in live animals or detected postmortem during slaughter, with few cases yielding successful therapeutic outcomes for farmers. A 9-year-old Limousine beef cow was admitted to the Ruminant Hospital of the National Veterinary School of Toulouse, France. The cow had shown signs of illness for 10 days, including anorexia, arched posture, rapid heart rate, and increased respiration, along with notably diminished cardiac and pulmonary sounds on the right thoracic side. Diagnostic examinations revealed a thoracic sarcoma accompanied by unilateral empyema. The empyema received targeted treatment, while only supportive care was given for the tumor. Despite persistence of the sarcoma, clinical recovery was substantial, and the cow was returned to her farm. Following the withdrawal period, she remained clinically stable but was slaughtered for financial reasons. This case provides a detailed progression from the onset of clinical manifestations and diagnostic workup to laboratory confirmation and postmortem findings.

**Keywords:** Neoplasm, Thoracic sarcoma, Cattle, Bovine, Case study

**Received:** 04 August 2023
**Revised:** 27 October 2023
**Accepted:** 29 October 2023

**How to Cite This Article:** Giorgio M, Elena F, Riccardo L. Diagnosis and Palliative Management of Thoracic Sarcoma-Associated Empyema in a Mature Beef Cow. Int J Vet Res Allied Sci. 2023;3(2):63-70. https://doi.org/10.51847/yuLBx5Zykz

## Introduction

Pleural conditions are relatively common in bovine practice, with pleuritis being the predominant inflammatory type. Its etiology is largely bacterial and may result from the spread of exudative bronchopneumonia, traumatic reticuloperitonitis, septicemia, or bovine tuberculosis [1–3].

Tumors in cattle are extremely uncommon, with an estimated prevalence of 0.06% in adults and 0.006% in calves [4]. The occurrence varies based on organ and tissue involvement. Thoracic neoplasms are particularly rare, often discovered incidentally in live cattle or during meat inspection [5].

Primary malignant neoplasms are categorized according to tissue of origin [6]. Carcinomas are derived from epithelial cells and include adenocarcinomas, originating in glands or organs, and squamous cell carcinomas, arising in stratified epithelium. Sarcomas originate from mesenchymal cells, forming in supportive or connective tissues such as bone, cartilage, muscle, tendon, and fat. Reported types include osteosarcoma, chondrosarcoma, hemangiosarcoma, malignant histiocytosis, lymphomatoid granulomatosis, granular cell tumor, and mesothelioma [6].

While thoracic sarcomas have been sporadically described, no cases of undifferentiated sarcoma in the thoracic cavity have been previously documented. Only two such cases are known: one involved multiple lesions in the maxilla, lungs, kidneys, spleen, and limb musculature [7], and another was a congenital suborbital mass invading bone and muscle tissue [8].

The present report details a case of thoracic sarcoma associated with unilateral empyema in a beef cow.

*Detailed case description*

*Clinical presentation and gross observations*

A 9-year-old Limousine beef cow was brought to the Ruminant Clinic of the National Veterinary School of Toulouse, France. The cow was non-pregnant and had calved four months earlier. Symptoms began 10 days before referral, consisting of moderate fever (39.5–39.6 °C), firm feces, reduced rumination and feed intake, an arched posture, and muffled heart sounds. The local veterinarian initially treated the animal with amoxicillin trihydrate (Vetrimoxin 48 heures, CEVA©, Marseille, France, 15 mg/kg body weight) for 5 days and two doses of dexamethasone phosphate (Dexadreson, MSD Animal Health©, Beaucouzé, France, 0.06 mg/kg) at 48-hour intervals. Since the condition did not improve, the cow was referred for further evaluation.

Upon admission, general examination revealed slight depression but an adequate body condition (score 3.5/5). The cow weighed 738 kg—normal for her age and breed—although the owner noted some recent weight loss. Appetite was completely absent, and the rumen fill score (2/5) suggested prolonged anorexia. A persistently arched posture indicated nonspecific pain. Noticeable edema at the dewlap and bilateral jugular vein distension were observed. The jugular compression test was positive bilaterally, meaning there was no return of blood flow between the point of pressure and the heart, consistent with venous circulatory impairment.

Close Clinical Evaluation

On thorough examination, the ocular, oral, and vaginal mucosa appeared noticeably pale. The cow exhibited pronounced tachycardia (105 bpm) and accelerated respiration (44 breaths/min). Breathing was costo-abdominal with normal depth, but respiratory sounds were muted on the right thoracic side. Cardiac auscultation revealed a duplicated first heart tone (S1). On the left side, heart sounds were distinct and loud, whereas on the right, they were faint. No evidence of rumination was noted either through observation or auscultation. The skin-fold test at the withers was positive and did not cause curvature, indicating discomfort in the thoracic or cranial abdominal region, consistent with the animal's posture. The body temperature was within normal limits (38.7 °C). Palpation revealed slight enlargement of the right superficial cervical lymph node. No internal abnormalities were found during transrectal assessment of the digestive and reproductive organs.

The urine obtained during spontaneous urination was macroscopically normal. Defecation was also typical, and feces appeared normal in both volume and consistency.

The primary abnormalities were localized in the thoracic cavity, particularly on the right side. Differential diagnoses included cardiac pathologies (exudative pericarditis, endocarditis, myocardial tumor), pleural fluid accumulation on the right (purulent, exudative, transudative, or modified transudate), thoracic or mediastinal masses (abscess, hematoma, neoplasia), and traumatic reticuloperitonitis.

Blood was collected for a full biochemical and hematological profile. Biochemical values showed normal fibrinogen, mild hypoalbuminemia, and elevated total protein levels—findings consistent with a chronic inflammatory process. Hematological results showed leukocyte counts at the higher end of normal with neutrophilia and an inverted leukocyte ratio (increased neutrophils, decreased lymphocytes), supporting an ongoing inflammatory response.

Ultrasound of the thorax and heart was carried out using a convex transducer (MyLab One©, Easote, France Hospimedi, Saint-Crépin-Ibouvillers, France). A large, echogenic intrathoracic structure (approximately 30 × 25 cm) was detected on the right side, exerting significant pressure on the right cardiac chambers and reducing ventricular space, accompanied by an anechoic pleural effusion **(Figure 1)**. Aside from this compression, the cardiac and pericardial anatomy appeared normal. The reticulum also appeared normal except for absent biphasic contractions, correlating with clinical symptoms.

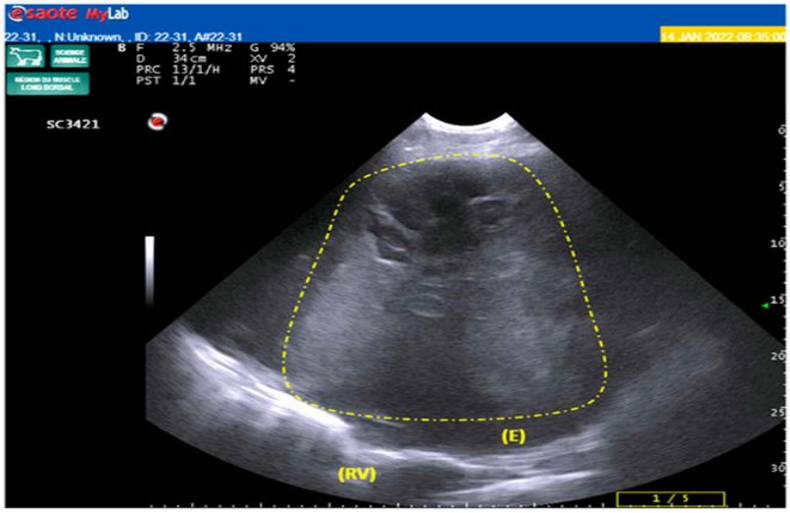



**Figure 1.** Ultrasonographic view of the right-sided intrathoracic lesion (yellow outline) with associated anechoic effusion (E) and compression of the right ventricle (RV). Source: Clinic of Ruminants, National Veterinary School of Toulouse, France.

A pleural sample was collected aseptically under ultrasound guidance using a 14-gauge, 2-inch disposable needle for further cytological and biochemical assessment. The fluid was moderately turbid and orange-brown in color. Analysis confirmed it as a nonspecific septic exudate.

*Definitive diagnosis*

The thoracic mass was sampled simultaneously under ultrasound guidance using a Tru-Cut needle (14 gauge, 6 inches; Merit Medical®, South Jordan, UT, USA) under full asepsis and local anesthesia (procaine chlorhydrate, Procamidor, Axience©, Pantin, France, 15 mL injected near the puncture site).

Tissue samples were routinely processed and examined histologically. One specimen revealed a moderately cellular tumor of mesenchymal origin, comprising large spindle-to-polygonal cells irregularly arranged in a hyalinized collagen framework. The cytoplasm was faintly eosinophilic and finely granular, with indistinct cell margins and oval nuclei of varying size, each containing a distinct nucleolus **(Figure 2)**. There was marked to severe atypia with anisokaryosis, binucleation, nuclear hyperchromasia, and occasional giant nuclei. Mitotic figures were infrequent. The remaining samples consisted mainly of fibrinosuppurative material, hemorrhagic content, or dense collagenous stroma.

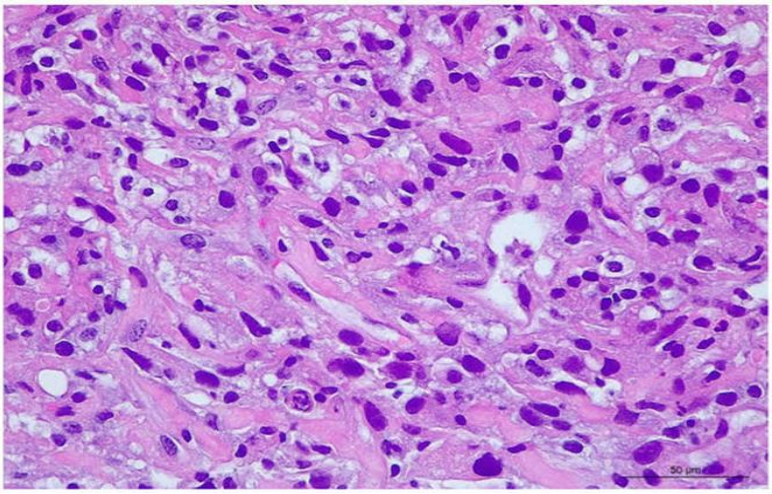
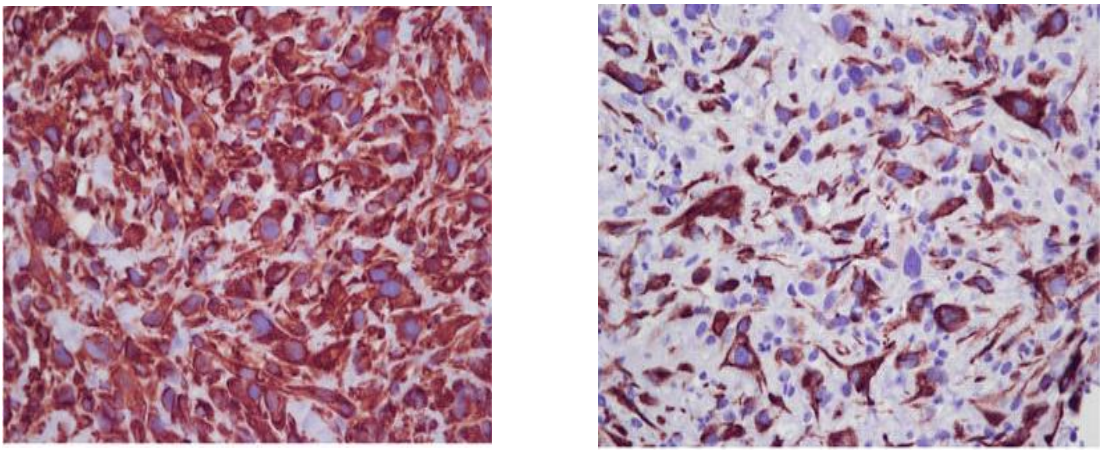


**Figure 2.** Histopathological image (H&E stain, ×40). Source: LAPVSO, Toulouse, France. The neoplastic tissue displayed irregularly oriented pleomorphic spindle and polygonal mesenchymal cells with marked atypia in a thin hyalinized collagen matrix.

Immunohistochemical assays were conducted on paraffin-embedded tissue sections (3 µm thick). Antibodies used were anti-vimentin V9 (1:50, low pH; M0725, Agilent©, Santa Clara, CA, USA), anti-desmin D33 (1:50, high pH; M0760, Agilent©), anti-actin HHF35 (1:25; M0760, Agilent©), and anti-cytokeratin MNF116 (1:300, low pH; M0821, Agilent©). Antigen retrieval was carried out for 30 minutes at 96 °C (except for HHF35). Endogenous peroxidase activity was blocked for 5 minutes (S2023; Agilent©), followed by 25 minutes of incubation in normal goat serum (X0907; Agilent©) to prevent nonspecific binding. Primary antibodies were applied for 50 minutes at room temperature, and visualization was achieved using the ENVISIO FLEX HRP detection system (Agilent©) with DAB chromogen according to standard protocols.
Neoplastic cells demonstrated diffuse vimentin positivity, variable labeling for desmin and actin, and complete absence of cytokeratin reactivity **(Figure 3)**.



a) b)

**Figure 3.** Immunohistochemistry (magnification: 40×). (a) Vimentin V9, (b) desmin D33; courtesy of the Department of Basic Sciences, IHAP, Université de Toulouse, INRAE, ENVT, Toulouse, France. The neoplastic cells displayed diffuse immunoreactivity for vimentin, whereas desmin expression was inconsistent.

Based on the examined tissue sections, the space-occupying thoracic lesions were identified as an undifferentiated sarcoma.
To evaluate possible metastatic spread, further assessments were undertaken. A complete biochemical panel was conducted, showing normal renal and hepatic enzyme activities (urea/creatinine and AST/CK/GGT/bilirubin, respectively). Ultrasonography (MyLab One©, Easote, France; Hospimedi, Saint-Crépin-Ibouvillers, France) was then performed. Using a convex probe, the peritoneum, liver, gastrointestinal tract, abomasum, and right kidney were inspected transabdominally, while the reproductive system, bladder, and left kidney were examined transrectally with a linear probe. No pathological alterations were detected in any of these organs, ruling out metastatic disease.

*Treatment and clinical outcome*
Thoracic fluid drainage was carried out completely. The sixth intercostal area was cleaned and disinfected using chlorhexidine-based soap, followed by a 4% chlorhexidine solution. With light sedation (xylazine, Sedaxylan, Dechra©, Montigny-Le-Bretonneux, France, 0.05 mg/kg IV) and local anesthesia (procaine chlorhydrate, Procamidor, Axience©, Pantin, France, 15 mL near the puncture site), a 2 cm skin incision was made between the 4th and 5th ribs using a No. 22 surgical blade for catheter placement. Under ultrasound guidance, a 12 mm × 50 cm drainage catheter was inserted using a rigid guide until seropurulent fluid flowed out. Approximately 20 liters of exudate were removed. The catheter was secured using the Roman Sandal suture technique with absorbable monofilament (PDS* Plus, dec. 0, Ethicon©, Issy-les-Moulineaux, France). The right thoracic cavity was then irrigated twice daily with a 5% chlorhexidine-saline solution until the effluent became clear, over a period of five days, after which the catheter was removed.
Simultaneously, antibiotic therapy was provided with daily intramuscular amoxicillin procaine (amoxicillin trihydrate, Vetrimoxin 48 heures, CEVA©, Libourne, France, 15 mg/kg) for 12 days. An NSAID (meloxicam,

Recocam, Bimeda©, Rennes, France, 0.4 mg/kg SC) was given at the time of catheter insertion. The following day, a corticosteroid injection (Dexalone solution®, 0.044 mg/kg) was administered twice for its anti-inflammatory and appetite-stimulating effects.

Within several days, heart rate and respiratory rate normalized (72 bpm and 28 breaths/min, respectively). The cow's appetite markedly improved, consuming around 11 kg of hay and 3 kg of concentrate daily, divided into three feedings (morning, midday, evening).

Due to the challenging surgical accessibility of the thoracic sarcoma and the cow's apparent clinical recovery, she was discharged after 21 days of hospitalization. Considering the long-term outlook, the farmer was instructed to wait through the 18-day antibiotic withdrawal period before humane culling.

A follow-up call confirmed that after the withdrawal period, the animal was sent to slaughter with stable body condition and no recurring symptoms. The abattoir's official veterinarian noted a unilateral, right-sided chronic pleurisy and a round, 35 cm-diameter intrathoracic mass located between the right heart and parietal pleura. No photographic record or extended tissue sampling was performed for further histopathological analysis. The findings prompted partial seizure of the right thoracic cavity. Upon detailed examination of the carcass—including all organs and skeletal structures—no evidence of metastasis was found. The remainder of the carcass was declared suitable for human consumption and entered the food chain.

In bovine medicine, oncology remains an underexplored discipline, despite certain neoplastic diseases—such as viral bovine leukemia—having been extensively researched and controlled for decades [9]. Because cattle have comparatively long lifespans, they exhibit a lower natural occurrence of cancer than species like laboratory rodents. However, in contrast, their productive life is often curtailed for economic reasons before neoplastic diseases can fully manifest [10, 11].

Thoracic neoplasms in cattle are predominantly metastatic in nature, although primary tumors have also been identified [12]. Among all bovine neoplasms, pulmonary tumors represent approximately 2.8% of recorded cases [6].

While ultrasonography is not a standard diagnostic tool in the assessment of respiratory disorders in adult cows, previous studies have demonstrated its precision and reliability for detecting both clinical and subclinical pneumonia in young dairy calves [13–15].

In this report, auscultation of the lungs and heart revealed a clear asymmetry between the right and left thoracic regions, with diminished sound intensity on the right. Consequently, ultrasonographic evaluation was performed bilaterally. On the right lower thoracic side, imaging showed a mass closely attached to the chest wall, displacing both the lung and heart. The proximity of the lesion made full visualization possible, and a fine-needle aspiration was subsequently attempted for cytological examination. Ultrasound also identified a localized pleuritic reaction in the upper right lung (image not included). Since no other abnormalities were evident during the overall clinical examination, and ultrasonography of the reproductive tract and left abdominal region revealed no lesions, it was inferred that all symptoms stemmed from the affected right lung.

Pulmonary malignancies are categorized according to cellular origin—either epithelial or mesenchymal [16–18]. Benign "pseudotumors" may occur in the form of hamartomas [19].

In the current case, the proliferation of mesenchymal cells displaying prominent nuclear atypia, mitotic activity, and necrosis supported the diagnosis of a malignant mesenchymal tumor, classified as a sarcoma. Nonetheless, a sarcomatoid subtype of mesothelioma could not initially be ruled out from the differential diagnosis.

Mesotheliomas arise from mesothelial cells that line the serous membranes and their associated connective tissue, which are mesodermal in origin. These tumors have been well documented across several animal species, including humans and cattle [20–26]. In veterinary pathology, mesotheliomas are histologically divided into papillary epithelioid, sarcomatoid, and the more frequent biphasic type, based on tissue morphology [27]. They typically affect the peritoneum and pleura, with rare involvement of the pericardium [28]. Furthermore, the presence of effusions within the peritoneal and/or pleural cavities, often resulting in respiratory distress, has been consistently reported [29]. This finding further justified mesothelioma as a potential differential diagnosis in our case, since ultrasonography revealed a fluid accumulation within the right thoracic cavity **(Figure 1)**.

Immunohistochemical analysis provides critical differentiation among tumor types. In this case, neoplastic cells exhibited complete negativity for cytokeratin. Reports of bovine mesothelioma in the literature consistently describe cytokeratin-positive staining [30, 31]. Therefore, our results did not support mesothelioma, leading to a confident diagnosis of sarcoma. However, due to the limited sample quantity, immunohistochemistry could not

precisely classify the sarcoma subtype. Comprehensive postmortem sampling was not feasible, as euthanasia was declined by the animal's owner.

Sarcomas possess a strong potential to produce metastatic lesions in various organs [32–34]. Although the cow in this case exhibited only respiratory symptoms, further diagnostic procedures were carried out to determine whether metastases were present elsewhere. Computed tomography is considered the most accurate tool for detecting metastatic spread [35, 36]. However, this method is mainly designed for small animals such as dogs and cats and is not suitable for large species like adult cattle. Radiography serves as a common alternative for identifying metastatic foci [35]. Nevertheless, performing deep-tissue radiographs requires high-capacity equipment, available only in a limited number of institutions and not at the Ruminant Clinic of Toulouse, France. Therefore, the diagnostic workup relied on ultrasonography and biochemical evaluation of organs that can be explored in adult ruminants. A full biochemical profile was conducted and showed no organ-related abnormalities. Likewise, ultrasonographic examination of all accessible abdominal and thoracic organs revealed no detectable lesions. Based on these findings, metastasis was excluded, and the neoplastic process was considered confined to the thoracic cavity. This conclusion was later verified through macroscopic inspection of the carcass by the official slaughterhouse veterinarian, who examined potential metastatic targets—including viscera and bone structures—and found no additional lesions, thereby classifying the carcass as fit for human consumption.

Treatment options for sarcomas in animals typically include surgical resection, radiation, and chemotherapy, as reported in other species [37, 38]. Surgical removal, radiotherapy, or a combination thereof are mainly used for local tumor control, whereas chemotherapy helps limit or delay metastatic progression in cases with systemic risk [39]. Surgical management generally requires extensive excision margins of approximately 2–3 cm around the mass to ensure complete removal [37, 38]. In this particular situation, surgical intervention was impractical because of the anatomical location of the tumor in the thoracic cavity and its close proximity to the heart, which made wide-margin excision unattainable. Radiotherapy and chemotherapy were considered potential alternatives, but their high cost and limited applicability in production animals rendered them unsuitable. Additionally, as the cow's clinical condition improved following symptomatic management, the owner decided to send the animal for slaughter while it remained in good health to recover carcass value.

Sarcomas in cattle are generally associated with a poor prognosis [8, 40, 41]. The most common reasons are the presence of extensive primary lesions that prevent curative treatment and/or widespread metastasis that makes therapy ineffective [42]. In this instance, however, the tumor was localized within the thoracic cavity, and diagnostic evaluations confirmed the absence of secondary lesions. Postmortem examination at the slaughterhouse reaffirmed that no metastases were present, allowing for partial carcass retention (with only the right thoracic cavity condemned, as noted above). Consequently, this case was of particular interest due to its favorable outcome for the farmer.

## Conclusion

Although primary thoracic tumors are uncommon, they should be included in the differential diagnosis of respiratory distress accompanied by weight loss and cachexia in mature cattle. This case study demonstrates a complete sequence—from clinical presentation and diagnostic exploration to laboratory confirmation—providing valuable insight into the diagnostic and management approach for bovine thoracic sarcomas.

**Acknowledgments:** None

**Conflict of Interest:** None

**Financial Support:** None

**Ethics Statement:** None

## References

1. Maxie MG. Jubb, Kennedy & Palmer's Pathology of Domestic Animals, 6th ed. Philadelphia, PA: Elsevier; 2016. Vol. 3, 957 p.

2. Vidal E, Tolosa E, Espinar S, de Val BP, Nofrarías M, Alba A, et al. Six-Year Follow-up of Slaughterhouse Surveillance (2008–2013): The Catalan Slaughterhouse Support Network (SESC). Vet Pathol. 2016;53:532–44.
3. Babkine M, Blond L. Ultrasonography of the bovine respiratory system and its practical application. Vet Clin North Am Food Anim Pract. 2009;25:633–49.
4. Misdorp W. Tumours in calves: Comparative aspects. J Comp Pathol. 2002;127:96–105.
5. Cappelleri A, Minoli L, Pigoli C, Costa A, Zaghini L, Bassanini L, et al. Retrospective study of tumors from cattle slaughtered in Lombardy (Italy): Preliminary evaluation on the establishment of a bovine cancer registry. Vet Ital. 2022;58:67–75.
6. Sousa DZ, Rivera LC, Quevedo DC, Gorino AC, Biagio S, Laufer R. Pulmonary adenocarcinoma in cattle. Rev MVZ Córdoba. 2014;19:4358–63.
7. Gorig A. Sarkomatose bei einem drei Wochen alten Kalbe. Dtsch Tierarztl Wochenschr. 1893;1:321.
8. Jacinto JGP, Bolcato M, Gentile A, Benazzi C, Muscatello LV. Congenital suborbital undifferentiated sarcoma in a crossbred calf. Animals. 2021;11:534.
9. Schwartz I, Levy D. Pathobiology of bovine leukemia virus. Vet Res. 1994;25:521–536.
10. Seluanov A, Gladyshev VN, Vijg J, Gorbunova V. Mechanisms of cancer resistance in long-lived mammals. Nat Rev Cancer. 2018;18:433–41.
11. Bertone AL. Neoplasms of the bovine gastrointestinal tract. Vet Clin North Am Food Anim Pract. 1990;6:515–24.
12. Lucena RB, Rissi DR, Kommers GD, Pierezan F, Oliveira-Filho JC, Macedo JTSA, et al. A retrospective study of 586 tumours in Brazilian cattle. J Comp Pathol. 2011;145:20–4.
13. Jourquin S, Lowie T, Debruyne F, Chantillon L, Vereecke N, Boyen F, et al. Dynamics of subclinical pneumonia in male dairy calves in relation to antimicrobial therapy and production outcomes. J Dairy Sci. 2023;106:676–89.
14. Rhodes V, Ryan EG, Hayes CJ, Mcaloon C, O'Grady L, Hoey S, et al. Diagnosis of respiratory disease in preweaned dairy calves using sequential thoracic ultrasonography and clinical respiratory scoring: Temporal transitions and association with growth rates. J Dairy Sci. 2021;104:11165–75.
15. Cramer MC, Ollivett TL. Growth of preweaned, group-housed dairy calves diagnosed with respiratory disease using clinical respiratory scoring and thoracic ultrasound—A cohort study. J Dairy Sci. 2019;102:4322–31.
16. Andrade Neto AQ, Souto RJC, de Paula Cajueiro JF, De Mendonça CL, Driemeier D, De Almeida Souza JC, et al. Primary pulmonary adenocarcinoma in a cow. Acta Sci Vet. 2019;47:6.
17. Barley JP. Pulmonary papillary adenocarcinoma in an adult cow. Vet Ir J. 2011;1:674–5.
18. Carminato A, Bozzato E, Trevisan L, Vascellari M, Catania S, De Palma D, et al. Blastoma polmonare del bovino—Bovine pulmonary blastoma. Large Anim Rev. 2008;14:3–5.
19. Roth L, Bradley GA. Pulmonary hamartoma in a calf. J Comp Pathol. 1991;105:471–4.
20. Üzum N, Özcay N, Ataoglu Ö. Benign multicystic peritoneal mesothelioma. Turk J Gastroenterol. 2009;20:138–41.
21. Hollington P. Benign multicystic mesothelioma. ANZ J Surg. 2010;80:186–7.
22. Magnusson RA, Veit HP. Mesothelioma in a calf. J Am Vet Med Assoc. 1987;191:233–4.
23. Wolfe DF, Carson RL, Hudson RS, Boosinger TR, Mysinger PW, Powe TA Jr, et al. Mesothelioma in cattle: Eight cases (1970–1988). J Am Vet Med Assoc. 1991;199:486–91.
24. Pizarro M, Brandau C, Sanchez MA, Flores JM. Immunocytochemical identification of a bovine peritoneal mesothelioma. Zentralbl Veterinarmed A. 1992;39:476–80.
25. Girard CA, Cecyre A. Diffuse abdominal epithelioid mesothelioma in a cow. Can Vet J. 1995;36:440–1.
26. Braun U, Rutten M, Bleul U, Previtali M, Kruger S, Gerspach C, et al. Biphasisches Mesotheliom bei einer Braunviehkuh: Klinische, histomorphologische, immunhistochemische und elektronenmikroskopische Befunde [Biphasic mesothelioma in a Swiss Braunvieh cow: Clinical, histological, immunohistochemical and electron microscopical findings]. Schweiz Arch Tierheilkd. 2012;154:33–8.
27. Gerbaudo VH, Sugarbaker DJ, Britz-Cunningham S, Di Carli MF, Mauceri C, Treves ST. Assessment of malignant pleural mesothelioma with (18)F-FDG dual-head gamma-camera coincidence imaging: Comparison with histopathology. J Nucl Med. 2002;43:1144–9.

28. Takasu M, Shirota K, Uchida N, Iguchi T, Nishii N, Ohba Y, et al. Pericardial mesothelioma in a neonatal calf. J Vet Med Sci. 2006;68:519–21.
29. Thomson RG, McGavin MD, Carlton W, Zachary JF. Thomson's Special Veterinary Pathology, 3rd ed. Boston, MA: Mosby; 2000. 755 p.
30. Peli A, Bolcato M, Roccaro M, Gentile A, Militerno G. Mesothelioma in cattle: Two case reports. Large Anim Rev. 2018;24:89–92.
31. Kawashima Y, Fujimoto A, Saito M, Mikami O, Ishikawa Y, Kadota K. Histological comparison of malignant epithelioid mesothelioma in young and adult cattle. J Vet Med Sci. 2021;83:968–72.
32. Bengston JS. Primary reticulum cell sarcoma of the lymph nodes of a cow with widespread metastases. Am J Pathol. 1938;14:365–76.
33. Devbhandari MP, Meraj S, Jones MT, Kadir I, Bridgewater B. Primary cardiac sarcoma: Reports of two cases and a review of current literature. J Cardiothorac Surg. 2007;2:34.
34. Marlowe KW, Robat CS, Clarke DM, Taylor A, Touret M, Husbands BD, et al. Primary pulmonary histiocytic sarcoma in dogs: A retrospective analysis of 37 cases (2000–2015). Vet Comp Oncol. 2018;16:658–63.
35. Armbrust LJ, Biller DS, Bamford A, Chun R, Garrett LD, Sanderson MW. Comparison of three-view thoracic radiography and computed tomography for detection of pulmonary nodules in dogs with neoplasia. J Am Vet Med Assoc. 2012;240:1088–94.
36. Merritt RM, Williams MF, James TH, Porubsky ES. Detection of cervical metastasis. A meta-analysis comparing computed tomography with physical examination. Arch Otolaryngol Head Neck Surg. 1997;123:149–52.
37. Dernell WS, Withrow SJ, Kuntz CA, Powers BE. Principles of treatment for soft tissue sarcoma. Clin Tech Small Anim Pract. 1998;13:59–64.
38. MacEwen EG, Powers BE, Macy D. Soft tissue sarcomas. In: Withrow SJ, MacEwen EG, editors. Small Animal Clinical Oncology, 3rd ed. Philadelphia, PA: WB Saunders; 2001. p. 283–304.
39. Ehrhart N. Soft-tissue sarcomas in dogs: A review. J Am Anim Hosp Assoc. 2005;41:241–6.
40. Guardado FJ, Gabadage K, Allen AL. Presumptive metastatic leiomyosarcoma in a feedlot steer. Can Vet J. 2022;63:819–24.
41. Ikeda N, Yoshida T, Seki A, Nakamura M, Tanaka T, Ichikawa R, et al. Extraskeletal chondrosarcoma in the abdominal cavity of a cow. J Vet Med Sci. 2019;81:1749–52.
42. Fujimoto A, Wada Y, Kanada T, Ishikawa Y, Kadota K. Mast cell sarcoma with megakaryocytic differentiation in a calf. J Vet Med Sci. 2012;74:1643–6.