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A sudden death, an aortic rupture, and an unexpected cause: A report about suspected child abuse

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Abstract

All unexpected deaths of children require an autopsy to determine the cause of death. In cases of aortic rupture, the immediate cause of death is easily identified at autopsy. Although the majority of aortic ruptures are caused by high-energy trauma, other causes should not be missed.

We present and discuss the case of a 29-month-old child who died suddenly at home. Her recent medical history and the ecchymotic lesions observed on external examination of the body appeared potentially suspicious of physical abuse. The autopsy concluded that death was due to complete rupture of the abdominal aorta with associated vertebral disjunction. At first glance, the overall forensic picture could suggest a traumatic death. However, careful inspection of the retroperitoneum revealed a discrete atypical mass of infiltrative tissue within the hematoma. Histopathological examinations confirmed tumor proliferation of the soft tissues, triggering vascular and spinal injuries. Other paraneoplastic elements or metastasis were ultimately revealed (orbital and subcutaneous). Overall, this was a rare and fatal case of abdominal aortic rupture induced by tumors.

Due to the mechanisms and the forces needed to cause vertebral dislocations and aortic rupture, the combination of the two is highly suggestive of child abuse when an accidental traumatic history is absent or inconsistent with the injuries. Nevertheless, this case illustrates the importance of a systematic and rigorous forensic examination, rather than ignoring other possible diagnoses.

Introduction

Forensic and clinical pathologists are regularly confronted with sudden unexpected death. A thorough autopsy must be performed for all cases to determine the cause of death. In the case of an aortic rupture, the immediate cause of death is usually easily recognized at autopsy [1]. However, the distinction between natural or unnatural deaths due to

aortic rupture can be difficult. An apparent unnatural death (e.g., a traffic accident) may be initiated by a natural cause (e.g., a hereditary connective tissue disease or an aneurysm) [1].

Vertebral fractures constitute less than 3% of skeletal injuries in abused children [2, 3]. A comprehensive review of the literature revealed a limited number of references to pediatric aortic rupture [4].

All of the reports of pediatric aortic disruption described the injuries (often lethal injuries) as being secondary to severe accidental or nonaccidental trauma. The purpose of this report is to describe a case of fatal aortic disruption whose cause was not traumatic. We discuss the forensic diagnostic approach and the differential diagnosis of child abuse.

Case presentation

A 29-month-old girl died suddenly at home. The mother explained to investigators that she had discovered her daughter in respiratory distress during her nap. She was noticeably pale. She would have immediately contacted the emergency services, but the death occurred quickly after their arrival. Her recent medical history (<2 months) included several pediatric consultations in a hospital (primary and secondary care). Ten days before the death, during hospitalization, doctors observed bilateral blepharitis associated with pseudomembranes, keratoconjunctivitis and periorbital ecchymotic swellings. A few falls with mild head trauma were alleged by the parents. Small bruises were rarely reported in the medical history. Clinical and paraclinical examinations did not identify any systemic pathology or coagulation/hemostasis disorder. A brain scan showed right posterior ethmoiditis

and left mastoiditis. An abdominal ultrasound did not show any organomegaly or solid organ tumor lesions. The vascular system was not described by the radiologist.

Autopsy performed by the coroners revealed a normally developed and well-nourished child who weighed 13 kg (50th percentile) and was 95 cm long (75th percentile). External examination revealed a bilateral yellowish periorbital halo and two bluish bruises under the left mandible. Known bilateral keratitis was present. Cutaneous-muscular incisions made on the upper limbs revealed three centimetric lesions distributed over both limbs. Dark dermo-hypodermic infiltration, first suggesting bruising was observed (see Fig. S1). After cutting the scalp, blood infiltrations were seen on its inner side. There was no skull fracture. There was no intracranial bleeding. The opening of the petrous pyramids showed left mastoiditis with a hemotympanum and a small perforation. The opening of both orbital roofs did not reveal evident tumor, infectious disorders or hemorrhagic disorders. No lesions were observed in the cervical region. Regarding the thorax, a right hemothorax (40 mL) and a tear of the right crura of the diaphragm were found (see Fig. S2). Opening of the abdominal cavity revealed 150 mL of

hemoperitoneum and a large bilateral retroperitoneal hematoma (see Fig. 1). The

origin of the bleeding was a complete rupture of the

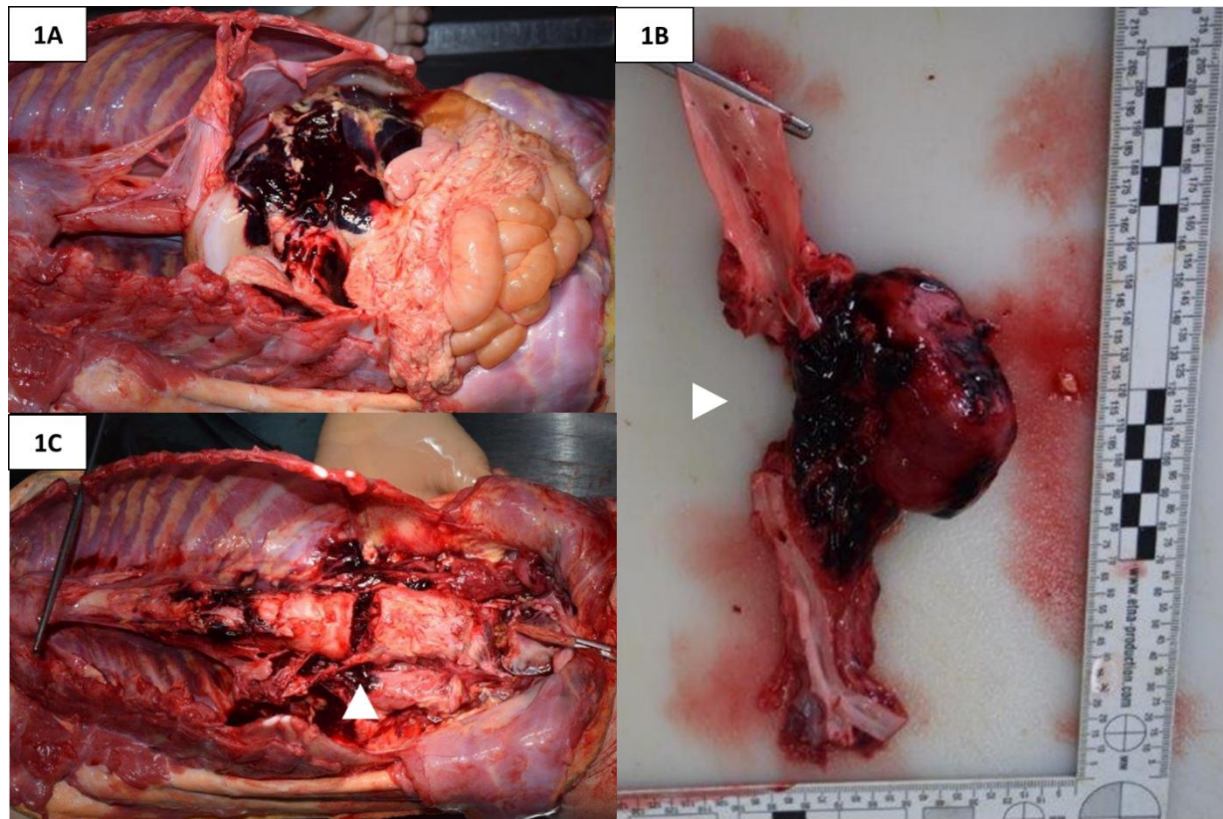


Figure 1. Pictures during the autopsy. **1A** Large bilateral retroperitoneal hematoma. **1B** Complete rupture of the infrarenal aorta and the left renal artery (▶). Bleeding around the left kidney. **1C** Disjunction between the L2-L3 vertebrae (▶) after removal of the hematoma and the intervertebral mass.

infrarenal aorta associated with a rupture of the left renal artery. The aortic rupture was clear, without dissection. The kidneys and adrenal glands had no visible lesions. In the hematoma, the medical examiners suspected a mass of infiltrative tissue that was slightly indurated. The aortic wall had a discrete inflammatory aspect opposite the aortic rupture zone and in contact with the lumbar spine. Second, the removal of the retroperitoneum showed a disjunction between the L2-L3 vertebrae. There was

also a hemorrhage in contact with the dura mater. The autopsy did not reveal any other macroscopic abnormalities.

Histopathological examinations showed in the retroperitoneal hematoma a tumoral proliferation composed of spindle cells, which had invaded and ruptured the aortic wall (see Fig. 2). The proliferation invaded the paravertebral muscular structures (e.g. right crura of diaphragm) and the intervertebral disc up to the dura without passing through it (see Fig. S3). Samples

on skin (lesions of the upper limbs and those of the scalp) showed proliferative

conjunctival spindle cells, capillaries with thickened

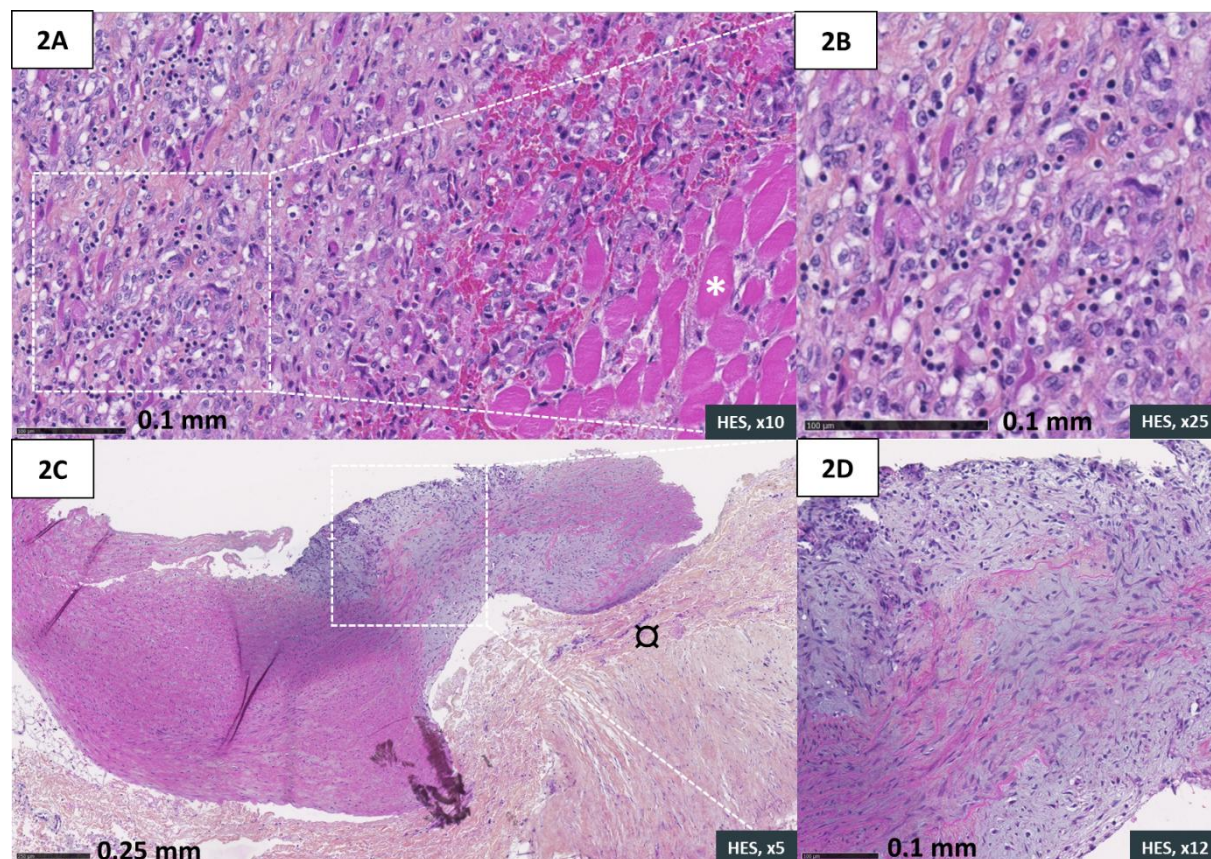


Figure 2. Histopathology of the retroperitoneum. Tumor proliferation (**2A** & **2B**), composed of diffuse spindle cells that infiltrate the muscle (■). Spindle cells have a sparse cytoplasm and a large oblong nucleus, which is sometimes nucleolated. The collagenous stroma is the site of inflammatory cells, mainly lymphocytes. This proliferation infiltrates the 3 tunics of the aorta (**2C** & **2D**), causing a clear rupture of the aorta (□).
HES = hematoxylin-eosin-safran staining

walls, sometimes not only with recent bleeding but also with siderophages in hypodermatitis (see Fig. 3). The epidermis and dermis were normal (see Fig. 3). In the periorbital fat and muscles, no recent hemorrhage was observed. A fibroblastic and collagenous infiltration with capillaries with thickened walls, cytosteatonecrosis lesions and siderophages were seen. Retinas and optic nerves were normal.

Therefore, these elements were not in favor of a traumatic origin but suggestive of a paraneoplastic syndrome. Several immunohistochemical stains were negative (anti-ALK, anti-desmin, anti-myoD1, anti-S100, anti-MDM2, anti-nTRK3, anti-beta-catenin, anti-CD31, and anti-CD34). Immunohistochemistry did not allow us to formally conclude the type of abdominal tumor. The toxicological expert did not

detect any xenobiotics in the samples taken during the autopsy. Overall, the child died

from an abdominal hemorrhage caused by a neoplastic rupture of the aorta.

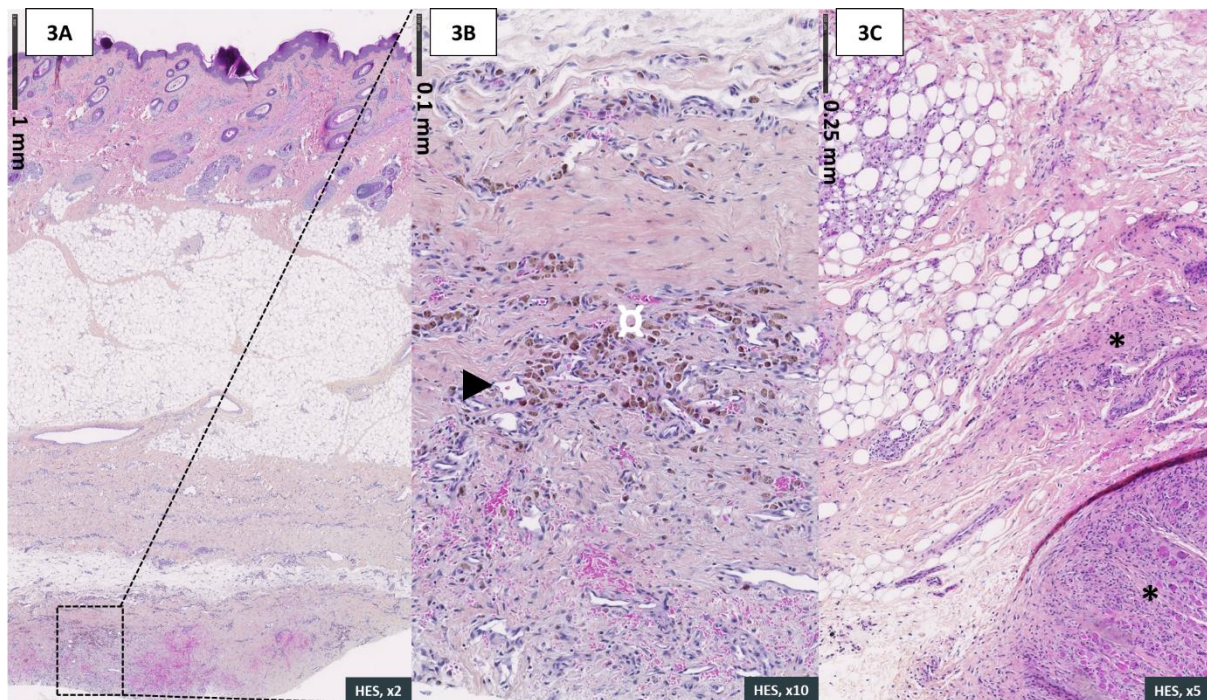


Figure 3. Histopathology of the subcutaneous lesion on the posterior side of the right forearm (3A & 3B) and the periorbital fat (3C). In the hypodermis, proliferative conjunctival spindle cells are seen (□), among which capillaries with thickened walls are present (▶). The epidermis and dermis are normal. In the periorbital fat, no recent hemorrhage is observed but again increased connective tissue (*) with capillaries with thickened walls, cytosteatonecrosis lesions and siderophages are seen.

HES = hematoxylin-eosin-safran

staining

Methods

Samples taken at the autopsy were fixed in buffered formaldehyde diluted 10% for 6 weeks. Systematic samples were taken according to French recommendations [5] as well as targeted samples on macroscopic lesions. Then, they were paraffin-embedded. Slides 5 µm thick stained with hematoxylin eosin saffron were prepared for routine optic microscopy. Hemorrhagic areas were stained with Perls Prussian

blue. Faced to fusiform proliferation with fibrous stroma at the peritoneal level in children, the immunohistochemistry panel to be performed should include at least desmin, myogenin, caldesmon, smooth muscle actin, CD34 associated with the S100 protein and possibly ALK, ROS, and panTRK. We also have done anti-myoD1, anti-MDM2, anti-beta-catenin, and anti-CD34. Histopathological examination was carried out by a forensic pathologist. The

tumor slides have been reviewed with a member of the RREPS network (French Reference Network in Pathology of Sarcomas).

Discussion

Regarding children, there have been very few autopsy reports of aortic and spinal injuries. Moreover, the cause is often obvious because the most common cause in children is motor vehicle collisions [4, 6]. Very high velocity accidents can cause dissection, intramural hematomas, penetrating wounds or free rupture of the aorta [7]. On the other hand, blunt abdominal aortic disruption remains an uncommon injury, especially in children [6–8]. Although rare, coexisting aortic and vertebral injuries are highly suggestive of child abuse. Lieberman et al. [4] and Callanan and McClain [9] described an L2-L3 intervertebral dislocation with transection of the adjacent aorta, similar to the injuries found in the current case. The mechanism of injury proposed was hyperextension of the spine. Because the aorta is adherent to the anterior vertebral body, hyperextension of the spine would exert distraction forces on the abdominal aorta, causing aortic disruption. Due to the mechanisms and the forces needed to cause vertebral dislocations and aortic rupture, they are highly suggestive of child abuse when a traumatic history is absent or inconsistent with the injuries [10]. In our case, the observation of bruise-like lesions on the limbs and head was an additional suspicious element. Therefore, during

abdominal dissection, with the discovery of a ruptured aorta coexisting with a spinal disjunction, the main hypothesis was child abuse. Nevertheless, reservations were expressed. A rigorous observation of lesions during autopsy is important. A meticulous macroscopic examination may suggest a suspicious mass in a retroperitoneal hematoma or an inflammatory aspect of the aortic wall. But it was not a clearly delineated tumor. Microscopic examinations are then necessary to search for a connective-tissue disorder, a prior intimal or medial mural injury, or another inherent aortic disease. In our case, we were able to formally eliminate blunt trauma in view of the very important tumor infiltration within the rupture of the aorta and the adjacent structures. Careful analysis showed infiltration of the full thickness of the aortic wall by neoplastic cells. Thus, the fragility of the aorta was extreme and no "trauma" was necessary for its rupture, but a common movement or a slight increase in blood pressure was sufficient. We also recall that there were no typical lesions for grasping, no alopecia and no lumbar skin lesions. In addition, histological analysis of the peripheral skin lesions excluded bruises. The histology of the orbital tissues was also against blunt trauma. The child had a paraneoplastic syndrome: like Hutchinson syndrome. Orbital metastasis is

known in several cases of malignant tumors, of which neuroblastoma is the most described (but it is also known for cases of soft tissue tumors) [11–13]. It usually manifests as periorbital ecchymosis (raccoon eyes) and proptosis. Periorbital lesions may initially be misinterpreted as child abuse [14]. Our case report shows the importance of a careful and rigorous forensic diagnostic approach by examining the macroscopic and microscopic, atypical elements together, in order not to make a hasty conclusion.

Here, given the extensive nature of the tumor, which completely infiltrated the aortic wall, the traumatic intervention of a person in the child's mechanism of death could be formally eliminated. The infiltrative character suggested a malignant tumor such as a sarcoma. Nevertheless, immunohistochemical analyses did not allow us to formally determine the family of the tumor. The tumor in our case remained atypical. The classification of soft tissue tumors is very complex and evolving [15]. Due to their rarity and their great diversity, tumor entities need a global analysis of the transcriptome by high-throughput sequencing technique (RNA-seq) to perform diagnostic and prognostic purposes. This type of global molecular analysis, initially possible only on fresh frozen material, is now completely feasible

on a routine basis on material fixed in formalin and embedded in paraffin, including archives [16]. Many advances in cytogenetics and molecular biology have been made in recent years [17]. They have often led to new diagnostic tools that are routinely used in clinical practice. Unfortunately, as a death of traumatic origin was ruled out, the magistrate in charge of the investigation did not consider it appropriate to pursue investigations, despite the recommendations of the forensic doctors. This is regrettable because in the long run, a more precise cancer diagnosis could be useful for the child's siblings. This problem is linked to a specific organizational feature of the French criminal procedure.

The hypothesis of symptoms caused by a neoplastic pathology was explored during the previous hospitalization, especially because of the eye symptoms. Despite investigations, the cancer had not been identified. The abdominal ultrasound report did not describe the abdominal aorta. We do not know if the aorta was not examined, or if the tumor was not detected due to lack of echogenicity. It is also possible that this very aggressive tumor has progressed very quickly after the abdominal ultrasound. We do not know whether criminal or civil proceedings were subsequently initiated against the hospital.

Conclusion

In children, motor vehicle accidents are the most common cause of closed abdominal aortic trauma. However, the combination of aortic and spinal injuries is sometimes the consequence of violence, particularly by hyperextension of the spine. In this case, a complete forensic approach allowed

the identification of a rare cause of aortic rupture and spinal dislocation. This case illustrates the importance of a systematic and rigorous forensic examination. Hasty lesion interpretations or conclusions can have serious consequences.

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Contributors' Statement Page

Dr. Quentin Scanvion conceptualized and designed the study, drafted the initial manuscript, and reviewed and revised the manuscript.

Dr. Clémence Delteil, Dr. Erwan Le Garff, and Dr. Raphaël Cornez collected data, carried out the initial analyses, and reviewed and revised the manuscript for important intellectual content.

Prof. Valéry Hédouin coordinated and supervised the drafting of the initial manuscript and data collection and critically reviewed the manuscript.

All authors approved the final manuscript as submitted and agree to be accountable for all aspects of the work.

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Supplementary information

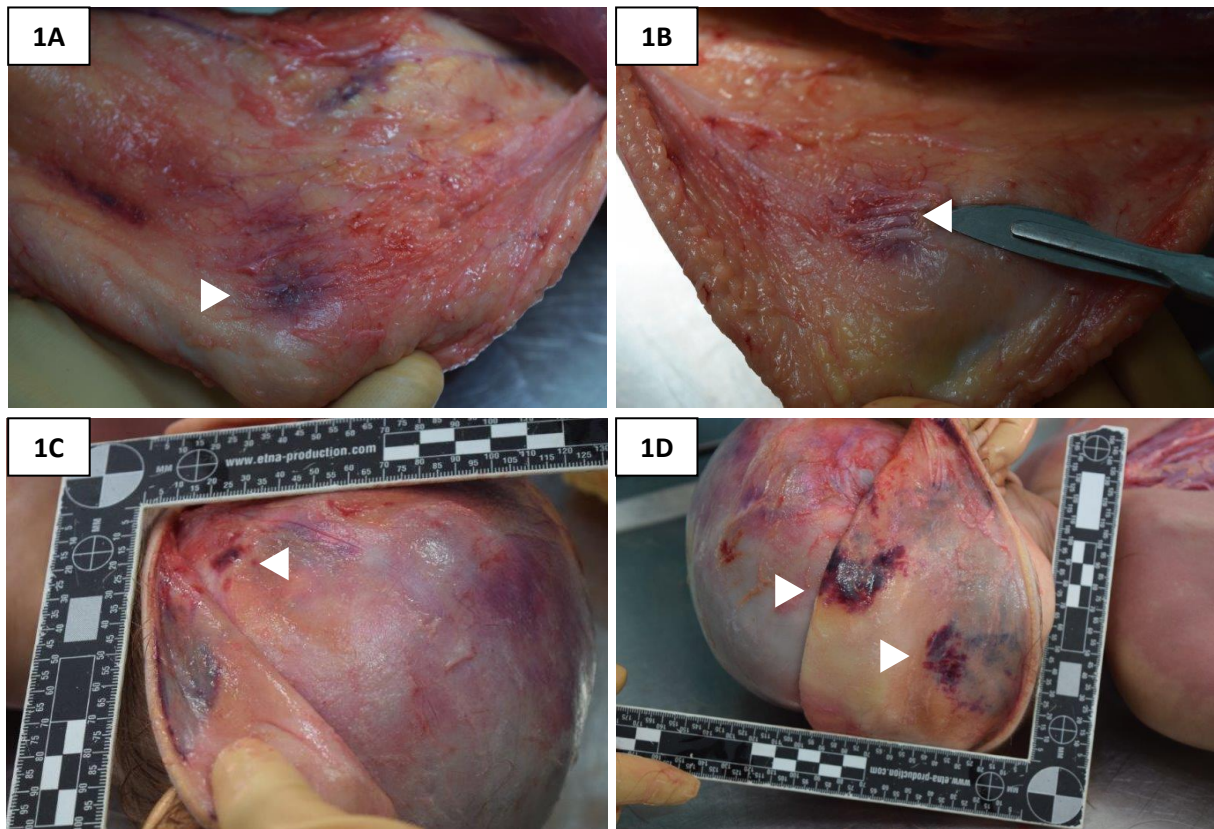


Figure S1: 1A Subcutaneous lesion (1x2 cm) on the posterior side of the right forearm. 1B Subcutaneous lesion (0.5 cm in diameter) on the medial side of the left arm. 1C Inner side of the scalp, left temporal area. 1D Inner side of the scalp, left frontoparietal area.

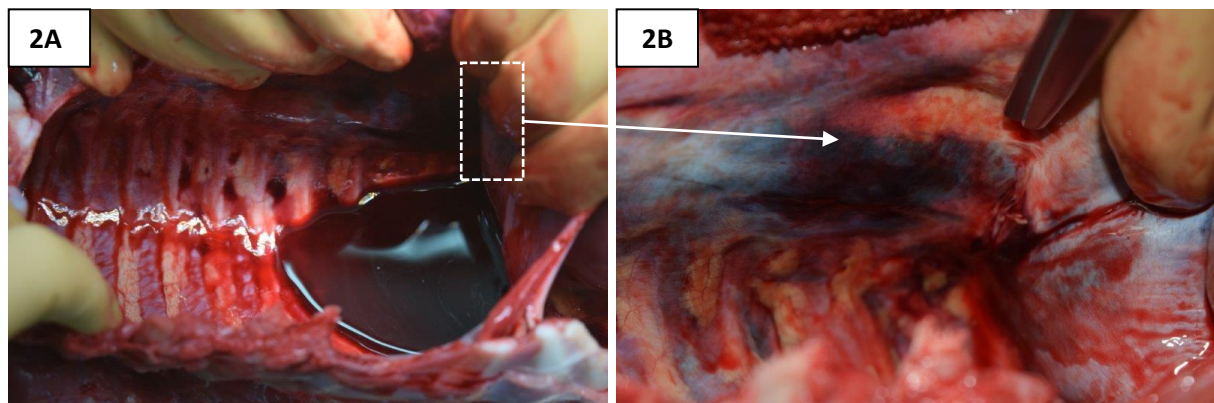


Figure S2: 2A Right hemothorax (40 mL). 2B Tear of the right crura of the diaphragm.

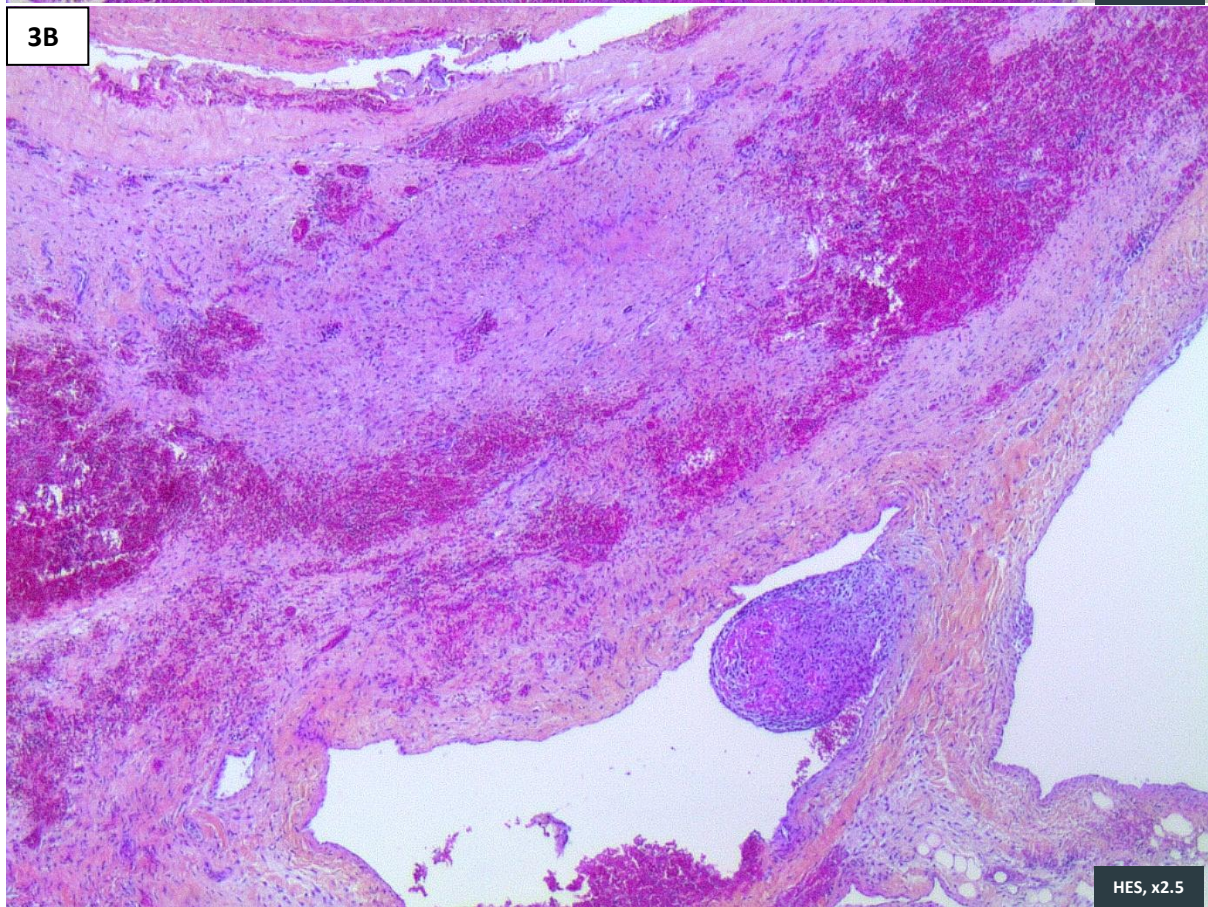
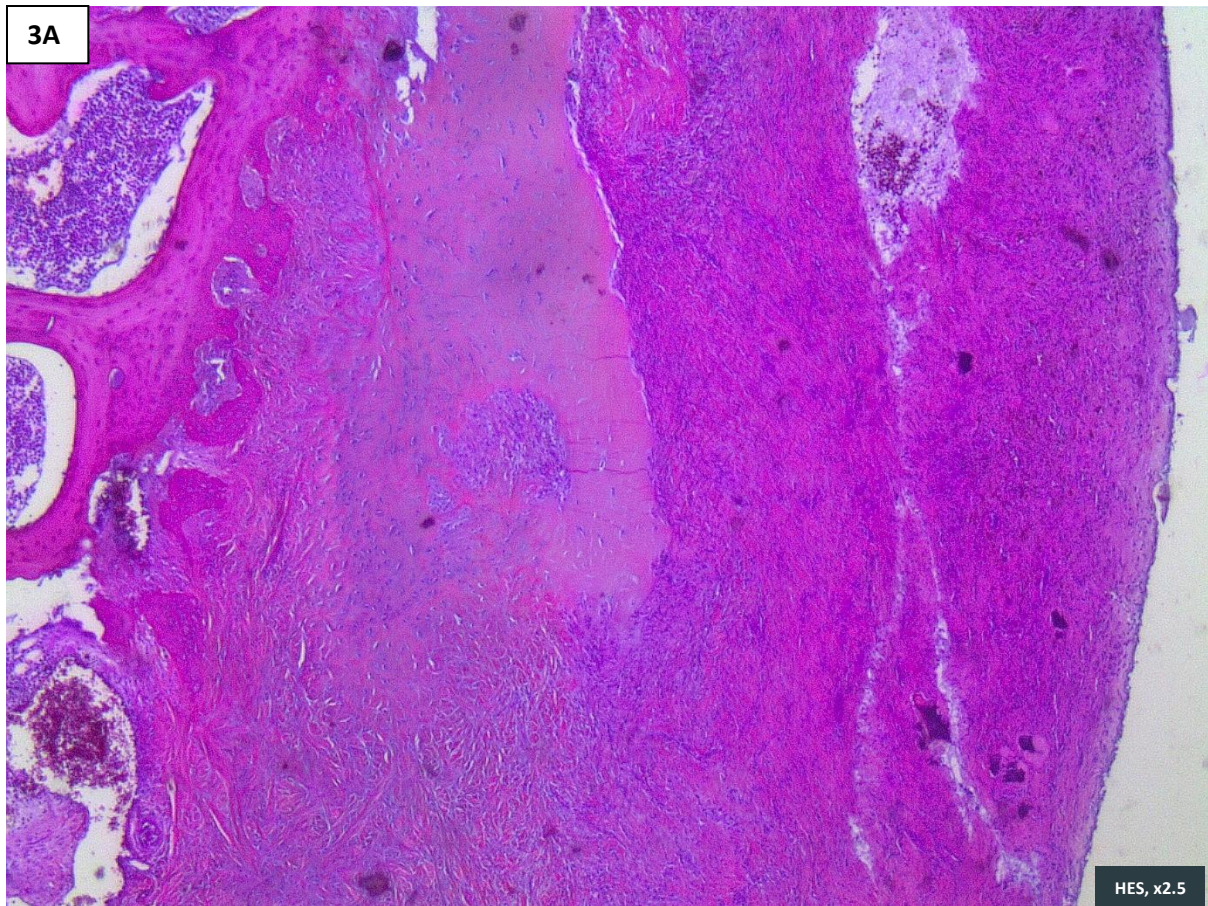


Figure S3: Tumor proliferation (**3A** on the right) composed of diffuse spindle cells that infiltrate the muscle and reach the periosteum (**3A** on the left) and the dura mater (**3B**) without involving the spinal cord. Numerous siderophages in the dura mater. The spindle cells have a sparse cytoplasm and a large oblong nucleus, which is sometimes nucleolated. HES = hematoxylin-eosin-safran staining