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Case report

Use of polymethylmethacrylate plaque as a treatment of cranioschisis associated with meningocele in a Girolando heifer: A case report

Uso de placa de polimetilmetacrilato (PMMA) no tratamento de craniosquise associada à meningocele em uma bezerra girolando: relato de caso

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Abstract
Most genetic diseases affect purebred animals and are inherited as recessive genes. Cranioschisis refers to dysraphism, which occurs in the midline of the skull due to failure to close the cranial symphysis, which can lead to herniation of the meninges filled with cerebrospinal fluid (meningocele), where there is usually a projection of the meningeal tissue. Diagnosis is performed based on clinical examination, characteristic anatomopathological data, and complementary imaging tests. The surgical approach for correction of cranioschisis is the only described as a therapeutic solution and is indicated in cases in which the cranial synthesis defect does not allow for brain protrusion and there is only the occurrence of meningocele, in addition to the absence of severe signs of neurological alteration. This paper reports a case of the use of polymethylmethacrylate (PMMA) plaque to treat cranioschisis associated with meningocele in a Girolando heifer. The surgical opening of the frontonasal sacculation allowed draining a total liquid content of 488 mL, inspection, and suture of the envelope membrane. A PMMA plaque, molded to the bone surface and anchored in the adjacent soft tissue, was used to cover the evidenced frontonasal bone opening. Despite the unfavorable prognosis of the disease, the cranioplasty surgery for the treatment of cranioschisis associated with meningocele using PMMA plaque obtained satisfactory results relative to the quality and maintenance of this animal's life, evaluated at 19 months postoperatively.
Keywords: bone cement; birth defect; malformation; ruminants.

Resumo
A maioria das doenças genéticas acometem animais de raça pura e herdados como genes recessivos. A craniosquise refere-se à disrafia, que acontece na linha média do crânio pelo não fechamento da sínfise craniana, podendo levar a herniação das meninges repletas de líquido cefalorraquidiano (meningocele), onde geralmente existe projeção do tecido meningeal. O diagnóstico é realizado a partir do exame clínico, dados anatomopatológicos característicos e através da realização de exames complementares de imagem. Como solução terapêutica, a abordagem cirúrgica para correção das craniosquises é a única descrita, e é indicada em casos em que o defeito de síntese craniana não permita a protrusão encefálica e exista a ocorrência apenas da meningocele, além da inexistência de sinais graves de alteração neurológica. O artigo relata um caso de uso de placa de polimetilmetacrilato (PMMA) no tratamento de craniosquise associada à meningocele em uma bezerra Girolando. Instituiu-se a abertura cirúrgica da saculação fronto-nasal, permitindo a drenagem de conteúdo líquido total de 488 mL, inspeção e rafia de membrana envoltória. Para recobrimento da abertura óssea fronto-nasal evidenciada, utilizou-se uma placa de polimetilmetacrilato (PMMA), moldada à superfície óssea e ancorada em tecido mole adjacente. Concluiu-se que, apesar do prognóstico desfavorável da enfermidade, a cirurgia de cranioplastia para tratamento de craniosquise associada à meningocele, com a utilização de placa de PMMA, neste caso, obteve resultados satisfatórios em relação a qualidade e manutenção da vida deste animal, avaliando-se em 19 meses pós-operatório.
Palavras-chave: cimento ósseo; defeito congênito; malformação; ruminantes.

1. Introduction

Genetic diseases are rare but important in the casuistry of domestic animals. These diseases can occur as a result of environmental causes, such as infectious agents, from the ingestion of toxic plants, nutritional deficiencies, and the inheritance of recessive genes.[1–3] Cranioschisis or bifid skull refers to dysraphism of the cranial midline due to the non-closure of the cranial symphysis, with the probable consequence being the herniation of the meninges filled with cerebrospinal fluid (meningocele) due to the projection of the meningeal tissue.[1–4]

Regarding its etiology, there are no reports of occurrence and development in bovine species. However,

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these alterations are considered hereditary in pigs and cats, and the disease in cats is also believed to occur as a result of treatment with griseofulvin during the first week of pregnancy.[4] The diagnosis is made from the clinical examination and characteristic anatomopathological data in which the inspection and palpation show the lack of continuity of the skull bones.[5,6] Furthermore, complementary examinations such as image evaluation by radiography and simple and Doppler ultrasonography can also be performed.[3,6]

The surgical approach to correct cranioschises is described as the only therapeutic option and is indicated in cases in which the cranial synthesis defect is small, with only meningocele, without encephalic involvement, [3,7] as well as the absence of severe signs of neurological alteration.[6] Therefore, the study of alternative techniques for better management and treatment of this disease is necessary. This study aimed to report the use of polymethylmethacrylate (PMMA) plaque in the treatment of cranioschisis associated with meningocele in a Girolando heifer.

2. Case report

A female Girolando heifer, weighing 29 kg and 21 days old, was referred for hospital care due to a soft swelling in the region rostral to the head and cleft lip (Figure 1). According to the responsible for the animal, the swelling was present from birth, occurring spontaneous rupture, with the release of liquid content in the first week of life. Subsequently, there was the closure of the lesion and filling of the sacculation again, remaining the same size until the time of care.

Figure 1. Girolando heifer showing soft swelling in the rostral region of the head and cleft lip. A – Lateral view. B – Dorsal view. C – Rostral view.

Clinical examination showed that the animal was in the standing position, apathetic, with a body condition score of 2/5, uncoordinated walking, and swelling in the rostral region of the head, with a rounded appearance, measuring approximately 41.5 cm in circumference and 8.0 cm in height. There was also the presence of an alopecic area in the medial and rostrodorsal portion of the swelling and a cleft lip. The swelling showed a fluctuating and mobile consistency upon palpation. The rostral bone limit, related to the sacculation, presented probable loss of bone continuity of the frontal bone. There was no associated palatoschisis.

Physical examination also showed that the heifer was hydrated, with skin turgor < 2 seconds, heart rate at 92 bpm, respiratory rate at 28 rmpm, temperature at 40.0 °C, capillary refill time < 2 seconds, mucous membranes pink and moist, normorhythmic and normophonetic heart sounds, clear lung fields, and palpable peripheral lymph nodes of normal size, firm consistencies, mobile, and without temperature increase. The special neurological physical examination revealed an apathetic level of consciousness, absence of stereotyped behaviors, presence of tremors, and lateral deviation of the head as a change in posture. No changes were observed in cranial nerve pairs.

Locomotion examination showed grade two and three ataxia in the thoracic and pelvic limbs, respectively. The evaluation of the cervical region, trunk, limbs, tail, and anus showed a decrease in the superficial sensitivity of the pelvic limbs and the absence of tonus in the tail. Complementary imaging, radiography (Figure 2A) and skull simple and Doppler ultrasonography (Figure 2B), and hematological examinations of blood count, liver, and kidney profiles were performed.

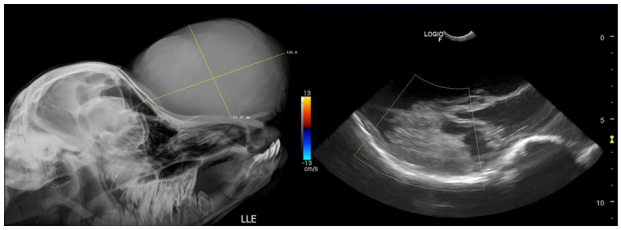

Figure 2. Complementary imaging examinations. A – Simple radiography of the skull in left latero-lateral projection, showing demarcation of the radiopaque region, with main axis measurements of approximately 12.6 and 9.2 cm. B – Doppler ultrasonography of the swelling in the region of the frontal bone of the skull. Green arrow – region of well-defined hypoechoic content. Red arrow – amorphous mass, with hyperechogenic delimitation without vascularization confirmed by Doppler.

The presence of a radiopaque area, with a rounded appearance, rostral to the frontonasal region, with regular edges and approximate measurements of 12.66 and 9.22 cm of the largest axes, were observed as radiographic findings in the left latero-lateral projection. Ultrasound examination showed a region of well-defined hypoechogenic content, with the presence of an amorphous mass inside, with hyperechogenic delimitation, without vascularization at Doppler evaluation, compatible with cystic formation. Blood count showed thrombocytosis (1,048,000 x 10^3/µL), neutrophilia by segmented neutrophils (7.275 x 10^3/mm^3), and lymphopenia (2.134 x 10^3/mm^3). The serum biochemical analysis showed a decrease in plasma proteins (5.8 g/dL) and urea (76.5 mg/dL). Cranioplasty was indicated as a diagnostic and therapeutic approach.

Fasting was discarded due to the age of the animal. A reduced amount of milk was given two hours before the procedure, totaling one liter, in the pre-anesthetic period.

The anesthetic protocol consisted of using meperidine 2 mg/kg intramuscularly as pre-anesthetic medication. The animal was then positioned in sternal decubitus after 20 minutes for anesthetic induction with propofol 2 mg/kg associated with midazolam 0.05 mg/kg and ketamine 1 mg/kg, all intravenously. Subsequently, an orotracheal examination was performed with an endotracheal probe number 7.5. Anesthetic maintenance was performed with isoflurane through a universal vaporizer at a dose sufficient to maintain the animal at the Guedel's third stage and second plan, in addition to fentanyl 2 µg/bolus, followed by continuous infusion of fentanyl at a dose of 2.5 µg/kg/h. A bilateral infraorbital block was also used with 2% lidocaine without vasoconstrictor in a total of 2.0 ml.

The sacculation was measured again after shaving and cleaning the swelling area. After antisepsis of the frontonasal region, an elliptical skin incision was made using a No. 23 scalpel, approximately 16 cm long, rostral to the swelling, located over the frontal and nasal bones. Then, the divulsion of the skin was started, which allowed visualizing a membrane, composing the envelope of the sacculation. Centesis was performed and 38.0 ml of the content was initially collected for analysis of the cavity fluid and cytopathology. Subsequently, the remaining 450.0 ml of reddish liquid content was taken using a surgical fluid aspirator. The membrane was opened along its median axis, allowing the visualization of a mass (Figure 3A) similar to a clot, which was loose inside the cavitation, lodged in the ventral portion. It was collected and preserved in formalin for histopathological examination. The presence of an opening in the frontal bone, with measurements of the main axes of 5.0 and 3.5 cm, and the presence of a non-protruded encephalic mass were also observed.

The envelope membrane was submitted to partial resection, using the bone defect as a limit, and, subsequently, sutured in a simple continuous pattern with 2-0 polydioxanone thread (Figure 3B). A plaque made of polymethylmethacrylate bone cement (C-MAXX®) was applied to the skull opening region at the time of surgery, with sufficient dimensions to cover the skull opening, superimposed on the bone edge, with an approximate thickness of 0.4 cm. It was molded on the bone surface during the transoperative period by applying sterile saline solution until the material hardened, when it was removed and transferred outside the operative field for cooling, limiting local exposure to heat. After polymerization and hardening of the material, four cross holes were made to anchor the plate, fixing it with simple stitches in the adjacent subcutaneous tissue, using No. 0 polydioxanone thread (Figure 3C). The procedure was concluded by resecting the excess skin and suturing it, in a continuous scalloped pattern, with N° 0 nylon thread.

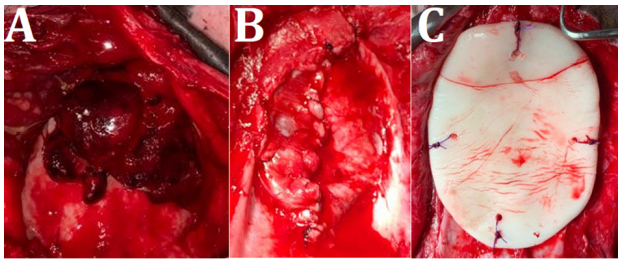

Figure 3. Surgical procedure for cranioplasty using a polymethylmethacrylate plaque to correct cranioschisis in a Girolando heifer. A – Frontonasal opening after incision of the envelope membrane on the median axis. White arrow – Mass similar to a clot, lodged inside the sacculation. Green arrow – Envelope membrane. B – Frontonasal opening (dotted line) after suture of the envelope membrane in a simple continuous pattern and partial resection at the level of the bone edge. C – Polymethylmethacrylate plaque positioned next to the frontonasal opening and fixed using No. 0 polydioxanone thread.

The surgical procedure took a total of five hours, during which the patient remained stable and monitored using ECG, pulse, oximetry, capnography, invasive blood pressure, and temperature. Post-anesthetic recovery was without complications. The postoperative period was instituted with meloxicam 0.5 mg/kg intravenously once a day for three days, in addition to tramadol 2.0 mg/kg intramuscularly twice a day for three days, and ranitidine 1.5 mg/kg intravenously twice a day for three days. Ceftriaxone 10.0 mg/kg intravenously twice a day associated with amikacin 22.0 mg/kg intravenously once a day, both for 15 days, and vitamin B1 5.0 mg/kg intramuscularly once a day, totaling three applications, were also administered.

A daily local dressing was applied, consisting of cleaning with aqueous chlorhexidine, antibiotic and healing ointment (Vetaglós®), and application of elastic bandage (Surgifix®). The collected cavity fluid samples were sent for CSF biochemical and cytological analysis, together with samples of the envelope membrane and the mass found inside the cavity, for histopathological examination. The biochemical evaluation of the fluid showed important alterations in its composition from the physical analysis, such as reddish coloration, cloudy appearance, coagulation, density and increased protein, and the presence of occult blood.

The cytological analysis of the fluid showed the presence of macrophages with bacteria in their vacuoles, suggesting late infection. A high amount of intact neutrophils, degenerated red blood cells, and rare active macrophages were also observed. Amorphous, weakly basophilic material was observed in the background, suggestive of hemorrhagic inflammatory exudate. The

histopathological analysis of the mass showed a tissue fragment showing a focally extensive area composed of fibrillar material (fibrin), a high amount of red blood cells, a moderate amount of platelet groups, and formed blood elements. High cellularity composed of neutrophils and lymphocytes and a slight presence of eosinophils and plasmocytes, suggestive of fibrin and clot formation, were observed in between (Figure 4A). The evaluation of the envelope membrane evidenced a small filament of connective tissue, with a histological pattern of the meninges observed in this age and species.

No intercurrences were observed in the surgical wound ten days after the operation, and the stitches were removed after this period. The animal remained in a hospital environment for observation and monitoring. The nervous system was evaluated 15 days after the operation (Figure 4B). The patient was alert, but the inspection of movement in a straight line showed a behavior of walking in circles to the left side for a few seconds after walking approximately 30 meters. The animal did not present alteration in posture or cranial nerve pairs. The locomotion evaluation also revealed that incoordination (ataxia) was reduced at this moment to grade one in all limbs compared to the preoperative condition. The other clinical parameters were within normal limits. A new assessment of the nervous system was carried out after two months, with the maintenance of the results obtained previously.

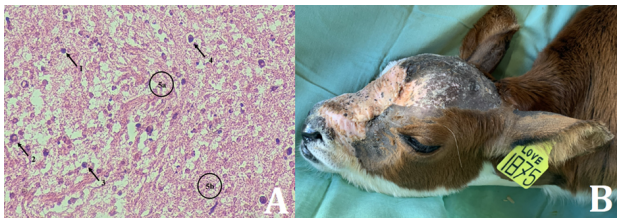

Figure 4. A – Histological examination of the mass. Tissue with a soft, friable consistency, measuring 3.2 cm x 2.0 cm x 0.5 cm, with color ranging from white to blackish. 4x magnification. 1 – Lymphocyte; 2 – Eosinophil; 3 – Neutrophil; 4 – Plasma cell; 5a and 5b – Fibrin. B – Heifer at 15 days after surgery.

The patient had an excellent surgical recovery, without manifestation of changes in the frontonasal region of the skull, being followed up in a hospital environment until the present moment, nineteen months after the surgical procedure. Surgical correction of the cleft lip was not chosen, as it did not interfere with its development or food holding.

3. Discussion

The presented clinical findings corroborate the presentation of similar reports of meningocele in cattle, where there was the presence of motor incoordination, ataxia, difficulty in feeding and standing still, and ration in cranial nerve pairs, in addition to macroscopic alterations, such as the increase in saccular volume, floating and filled with fluid in the frontal region of the skull.[6,7] Although congenital anomalies are generally easily recognized based on a broad clinical approach,[8] performing imaging exams for complementation and indication of surgical conduct was necessary.

The radiographic findings were compatible with those found by Boscarato et al.[6] in an animal with the same symptoms. The observation of the area of bone discontinuity in the frontal bone through ultrasound evaluation has been reported in similar cases of cranioschisis[6] but this image delimitation was not possible in this report. The literature shows some reports of cranioschisis and meningocele in calves, with surgical repair as a treatment method. In this context, the reports by Back et al.[9] and Kohli and Naddaf[10] stand out. The former described the case of a two-and-a-half-month-old heifer that presented a protuberance located caudally to the intercornual region. The latter reported the case of a five-day-old heifer that showed an increase in volume in the frontal region, more specifically in the supraorbital region. However, the animals died in a short postoperative period despite the viability of the surgical therapy presented by the authors.

Although surgical reduction of the meningocele without the use of grafts is used in some cases, we decided to apply a plaque made of polymethylmethacrylate (C-MAXX®) in the region of the cranioschisis aiming at closing the gap and protecting the region. It was fixed using four stitches forming a cross in the adjacent subcutaneous tissue to guarantee the permanence of the plaque at the site, next to the posterior tegumentary juxtaposition, with no postoperative alterations associated with local healing or occurrence of recurrence, as reported by Nogueira et al.[3] The fixation of polymethylmethacrylate implants with screws is indicated in cranioplasties[11] and the application, in this case, was performed only by anchoring with suture and tegumentary overlap, keeping the plaque stable and without mobility throughout the postoperative period and follow-up of the animal. The choice of this plaque fixation method without the use of screws followed that used in grafts for closing bone defects[7] and aimed to avoid possible restrictions or alterations in cranial growth,[12–15] as it is a newborn animal.

The use of autogenous bone grafts is considered the gold standard to repair bone defects[16] but we opted for the use of bone cement due to the better capacity of molding this material to the recipient bed. Oliveira-Filho et al.[7] also used the placement of a graft for the occlusion of a bone defect in the skull, but the author

opted for using auricular cartilage, with the indication in previous studies of efficacy in repairing defective bones in humans.[17] However, the result consisted of the death of the studied animal fifteen days after surgery. The cytological evaluation allowed observing the presence of a high amount of degenerated and intact neutrophils, degenerated red blood cells, and rare active macrophages, in addition to bacteria in their vacuoles, which are compatible and complementary with those found in the leukogram. These findings suggested late infection and may be related to the spontaneous rupture of the sacculation that occurred on the property.

Wronski et al.[8] and Oliveira et al.[5] have observed lung tissue consisting of bronchi, bronchioles, and alveoli compatible with choristoma in subcutaneous tissue adjacent to meningocele but similar structures were not found in this report despite the presence of a reddish mass that was found loose inside of sacculation. However, this one had a composition compatible with the initial formation of a clot. Ceftriaxone was prescribed as an antibacterial therapy due to its ability to cross the blood-brain membrane, antibacterial activity under conditions commonly observed in meningitis, and few adverse effects.[18,19] The association with amikacin was justified by the synergism between aminoglycosides to cephalosporins, increasing the power of action.[20] No intercurrences were observed 19 months after the surgical procedure. The heifer was in good general condition, managing to live in a relatively normal way, without prejudice to its vital functions. This satisfactory result differs from those found in the literature, which has reported spontaneous death or euthanasia of treated animals.[6,7]

4. Conclusion

Despite the unfavorable prognosis of the disease, the cranioplasty surgery for the treatment of cranioschisis associated with meningocele using polymethylmethacrylate plaque obtained satisfactory results relative to the quality and maintenance of this animal's life until the evaluated moment.

Conflict of interests

The authors declare that there is no conflict of interest of any kind.

Author contributions

Conceptualization: N. V. da Silva, D. J. Z. Delfiol, M. Horr, J. P. E. Saut, G. M. Nogueira. *Writing (original draft):* N. V. da Silva, D. J. Z. Delfiol, M. Horr, J. P. E. Saut, G. M. Nogueira. *Writing (review & editing):* N. V. da Silva, D. J. Z. Delfiol, M. Horr, J. P. E. Saut, G. M. Nogueira

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