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Gross Anatomical Study of Congenital Meningoencephalocoele and Craniofacial Deformities in A Kid

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ABSTRACT

Background: Occurrence of congenital anomalies are less common in small ruminants, especially in goats compared to sheep. Most common cause for the congenital deformities in new born ruminants is due to the ingestion of toxic plants during gestation. Congenital meningoencephalocoele with associated craniofacial deformities is a rare occurrence in goats.

Methods: A day old crossbred kid was presented with cranial defects and protrusion of brain through the defect. Detailed examination of the animal revealed cranioschisis in the frontal and parietal region along with presence of cleft lip, cleft palate and accessory ear lobe on the right side. Herniation of meninges and brain was exposed directly and was not covered by skin. There were two parietal cranial defects separated by a plate of bone.

Result: Postmortem examination of the animal showed bilateral cleft lip and cleft palate with lateral deviation of nasal septum and deformation of premaxillary region. On reflection of skin over the frontal region, revealed frontal cranioschisis and the brain was situated subcutaneously. There were total of three cranial defects (two in the parietal and one in the frontal region) separated by small plates of bone in between them. This present study explains the anatomical aspects of cranioschisis, meningoencephalocoele, cleft lip, cleft palate and associated craniofacial abnormalities in a day old kid.

Key words: Cranioschisis, Cleft lip, Cleft palate, Congenital, Deformities, Goat, Meningoencephalocoele.

INTRODUCTION

The domestic goat (*Capra hircus*) shares some of the congenital abnormalities generally seen in other domesticated ruminant animals (Dennis, 1993). Congenital defects are structural or functional abnormalities that are present at birth and may affect a single structure or function, parts of various systems or an entire system (Rahul *et al.,* 2017). Definitive etiology of congenital anomalies in small ruminants is unknown. However, various genetic, environmental (toxic, infectious and nutritional) or inherited factors were suggested to be the causes for congenital anomalies (Radostitis *et al*., 2000).

Congenital defects of the central nervous system (CNS) can affect only the CNS or the craniofacial skeleton and the CNS. Meningoencephalocele is the exposure or protrusion of the meninges and brain through a defect in the cranium (cranium bifidum or cranioschisis) (Di Muro *et al.,* 2020). Regarding the occurrence of congenital abnormalities, carnivores are mostly affected by hereditary anomalies whereas herbivores are affected by natural or synthetic teratogens producing congenital deformations (Camon *et al.,* 1990).

The morphogenesis of meningocoele is not simply a problem of defective ossification of the skull with secondary herniation of preformed intracranial tissue but instead, depends on a primary defect of the neural tube, by which there is focal failure of dehiscence of the neural tube from the embryonic ectoderm and in consequence, a focal failure of development of the skeletal encasement (Jubb and Huxtable, 1993).

Clefts of the face are developmental disorders due to failure of closure in facial processes such as the frontonasal, maxillary and mandibular processes. The defects appear in the lateral or median site of the rostral face as cleft lip, jaw and palate (Moritomo *et al*., 1999).

A neonate with a congenital defect is an adapted survivor from a disruptive event of a genetic or environmental nature or of a genetic-environmental interaction at one or more of the stages in the sequences of embryonic and fetal development (Radostits *et al*., 2000). Hence the present clinical case was examined thoroughly to rule out the congenital defects involving the craniofacial skeleton and neural tube in the crossbred kid.

MATERIALS AND METHODS

A day-old non-descript male kid was presented to Veterinary Clinical Complex, Veterinary College and Research Institute, Salem during February 2021, with the history of inability to stand and suckle since birth and presence of cranial defect.

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The dam of the kid gave birth to two male kids earlier in the morning of that day. The co-twin of the presented animal was normal, able to walk and suckle.

The animal had visible cranial defect in the parietal region with a portion of meninges and brain protruding through the defect. The animal also had conditions such as bilateral cleft lip and cleft palate. Hence, the animal could not be hand-fed and eventually died due to starvation on the end of the day. Postmortem examination of the animal was performed to study the extent of deformity involving the cranium and face. On reflecting the skin over the frontal region there was loss of bone on both the sides in the frontal area but the frontal process of the orbital rim was complete. Cornual process was not developed except for small projection of frontal nuchal crest. Lips were examined for the bilateral cleft condition. The upper and lower jaws were also separated to study the extent of cleft palate. The thorax and abdomen was dissected to rule out any developmental defect in the viscera.

RESULTS AND DISCUSSION

The kid was presented with inability to stand and presence of cranial defects (Fig 1). On physical examination, the animal was unable to stand even with assistance and proprioception was absent. Similarly, Yaman *et al.* (2013) reported that a brown Swiss calf with congenital meningoencephalocoele and other craniofacial deformities was never able to stand up and walk.

Bilateral asymmetrical cleft lip condition was observed and the face of the animal itself appeared deformed with a mild lateral deviation towards the right side (Fig 2). Examination of the oral cavity revealed bilateral cleft palate involving both hard palate and soft palate. Vijayanand *et al.* (2009) reported cleft lip along with hydrocephalus and arthrogryposis in a newborn calf, while Sumena and Lucy (2015) reported presence of cleft lip and cleft palate in a Malabari kid. The nasal cavity was exposed completely. A small accessory ear lobe was observed on the right side, below the base of the right ear (Fig 3). A fold of serous membrane-like structure was observed around the lower jaw region, which is attached only at the base of the ears of both sides. The purpose of this membrane-like structure was not clear. It was hypothesized that a sac-like structure would have been enclosing the head, which may have ruptured during birth exposing the cranial defects. Presence of fluid-filled sac-like structure was reported in the case of meningoencephalocoele in calves (Yaman *et al.,* 2013 and Di Muro *et al.,* 2020). The posterior part of the head was not covered by skin and showed two separate cranial defects in the parietal region.

Potential anomalies that accompanied with meningoencephalocoele were bilateral cryptorchidism (Lapointe *et al*., 2000), cranioschisis, spina bifida (Ohba *et al*., 2008), kyphoscoliosis (Zani *et al*., 2010), anopthalmia (Manjunath *et al*., 2015) and agenesis of nasal septum, prognathia, dermoid cyst (Yaman *et al.,* 2013).

On postmortem examination of the animal, no abnormalities were observed in the organs of respiratory, digestive, circulatory and urogenital systems. The large intestine consisted of unexpelled meconium and bladder contained small amount of urine. The orbits and eyeballs appeared to be developed completely. Meningoencephalocele can form separately or can be accompanied with certain other malformations within the same site or in other part of the body (Yaman *et al*., 2013).

Bilateral asymmetrical cleft lip was evident with left side cleft being larger. Deformity of the premaxillary region with right lateral deviation was noticed. Bilateral cleft palate resulted due to incomplete closure of palatine process of maxilla and horizontal plate of palatine bone was observed. Right lateral deviation of the nasal septum could be evidenced through the defect in the palate (Fig 4).

In the head, two circular shaped openings in the cranium were noticed in the parietal region. A median circular opening of 3.2 cm length and 3.0 cm width was situated



P1- Anterior defect, P2 - Posterior defect, B- Plate of bone separating the two parietal defects

Fig 1: Photograph of the head of day-old kid showing two separate cranial defects in the parietal region.



Fig 2: Photograph of the head of day-old kid showing bilateral cleft lip and deformed premaxillary region (Arrows).

anterior to the posterior margin of the squamous occipital bone. Anterior to this defect, a thin plate of bone about 1 cm width was observed. In front of the plate of bone, another oval opening of 2.0 cm length and 3.4 cm width was observed. The two parietals and interparietal were not fully developed and failed to fuse, forming large openings in the cranium. Meninges and portion of brain were herniated outside through both defects. In meningocele and meningo-encephalocele cases, the herniated pouch may or may not be covered with the skin (Yaman *et al*., 2013). In the present study, the meningoencephalocoele was not covered by skin and there was no accumulation of cerebrospinal fluid. The parietal region of the skull measured about 6.2 cm length and 6.5 cm width, out of which the two cranial defects occupied 3.2 cm and 2.0 cm length with an intervening 1.0 cm wide plate of bone (Fig 5 and 6).

On further examination of head region, the frontal region was covered only by skin, where the brain was situated subcutaneously. A large opening in the frontal area was identified behind the nasal bones. The frontal region was about 3.9 cm long, in which 2.5 cm long and 3.0 cm wide opening was observed. A thin bone of 0.5 cm width incompletely separating the parietal and frontal defects was noticed (Fig 5 and 6). The supra orbital process of frontal bone forming the posterior rim of the orbits appeared normal.

There were reports of cranioschisis in frontal region only in a calf (Yaman *et al*., 2013) and in parietal region only in a lamb (Raoofi *et al*., 2004). In this study, the cranioschisis was observed in both the parietal and frontal regions.

Camon *et al*. (1990) observed that occipito-parietal cranioschisis resulted in meningocoele along with palatoschisis of maxilla and palatine bones in a piglet. Similarly Senna *et al*. (2003) reported a case of cranioschisis in the parietal region with exposed brain in a three day old kid which might be due to non-closure of the cranial portion of the neural tube and failure of cranial development resulted in defective cranium. Lahunta *et al.* (2014) reported hereditary conditions of meningoencephalocoele with combinations of facial malformations such as cleft lip, deformed nasal cavity and malformation of cerebrum in Burmese kittens.

Dreyer and Preston, (1974) observed thirteen dogs with complete bilateral cleft lip and cleft palate out of total number of thirty five cases of various forms of cleft lip and palate. Di Muro *et al.* (2020) reported a crossbred calf with meningoceole through the cranioschisis at frontal region along with median cleft lip, cleft palate, hypertelorism and prognathism.

The morphogenesis of these defects was not simply a problem of defective ossification of the skull with secondary herniation of preformed intracranial tissue but instead, depends on a primary neural tube defect by which there was focal failure of dehiscence of the neural tube from the



LE- Left ear, RE- Right ear,
AE- Accessory ear lobe

Fig 3: Photograph of the head of day-old kid showing presence of accessory ear lobe on the right side.

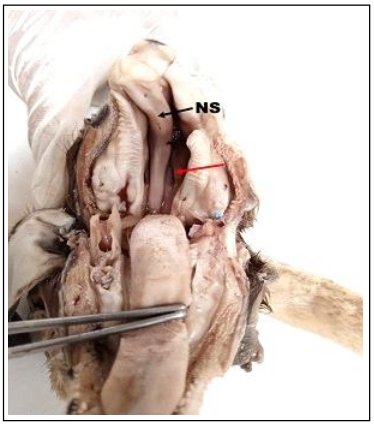


Fig 4: Photograph of the dissected oral cavity of day-old kid showing bilateral cleft palate (arrow) and lateral deviation of nasal septum (NS).

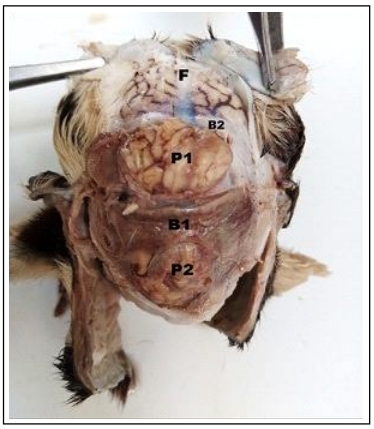


Fig 5: Photograph of the head of day-old kid showing two openings of parietal bone defect (P1 and P2) and one opening of frontal bone defect (F) with skin in the frontal region reflected. Two plates of bones separating the three openings (B1 and B2).

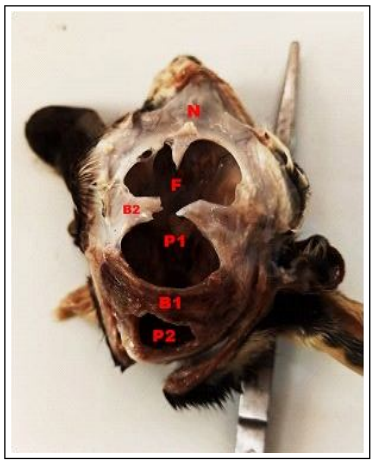


Fig 6: Photograph of the head of day-old kid after removal of brain substance showing two openings of parietal bone (P1 and P2) and one opening in the frontal bone (F) with skin in the frontal region removed. Two plates of bones separating the three defects (B1 and B2). Nasal bones (N) developed normally.

embryonic ectoderm and in consequence, focal failure of development of the axial skeletal encasement and the herniation was related to suture lines which occured almost always median (Rahul *et al*., 2017).

After the examination of surface bones, the brain substance was removed and examined. There were no gross abnormalities in the brain could be identified. Inside the cranial vault, normal development of ethmoid, sphenoid and occipital bones were observed.

The relation between median facial skeletal defects and brain anomalies may be because of the patterning error of the frontonasal mesenchyme and inductive error of the precordal mesoderm, which leads to some type of facial and neuronal malformation (Moritomo *et al*., 1999).

Congenital abnormalities in animals resulted from either due to genetic factors such as recessive genes, chromosomal aberrations; environmental causes like teratogenic viruses, phytoteratogens, drugs, nutritional deficiencies and physical causes such as hypothermia, radiation and hypoxia during foetal development (Dennis, 1993).

Panter *et al*. (1990) conducted a feeding trial and reported that the ingestion of *Conium maculatum* (poison-hemlock), *Nicotiana glauca* (tree tobacco) and *Lupines formosus* (lunara lupine) plants during gestation in goats caused high occurrence of cleft palate with multiple congenital contractures in the young ones. Even though the etiology for the occurrence of craniofacial deformities in the present case could not be elucidated by the history of the clinical case, it might be considered that major cause of the congenital cranioschisis with bilateral cleft lip and cleft palate is due to environmental factors involved during the gestation period such as plant teratogens, physical stress or drugs.

CONCLUSION

The presented animal had combination of many craniofacial congenital deformities including cranioschisis of parietal and frontal bones, bilateral cleft lip and cleft palate, presence of accessory ear lobe and lateral deviation of premaxilla and nasal septum. These conditions may occur due to defect in the neural tube development. These deformities may also be attributed to genetic and environmental factors causing teratological effect on the foetus. This anatomical study will illuminate on the further studies on congenital anomalies and teratology in animals.

Conflict of interest

All authors declared that there is no conflict of interest.

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