Five Cases of Cranial Duplication in Calf

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ABSTRACT. Five cases of cranial duplications in calves were morphologically reported. Each calf had a single body with duplicated heads that showed various degrees of fusion. The medial sides of individual heads were asymmetrically supplied by the branches of hemilateral common carotid or lingual artery. No marked differences in the development of the duplicated head in any of the calves were observed. Cleft palates were observed in all heads. The development and general structures of the organs in the head and neck regions appeared to depend on the degree of duplication of the cranial nerves.—KEY WORDS: calf, conjoined twin.
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Duplication of heads resulting from incomplete twinning occurs in various kinds of animals and shows varying degrees of duplication [1, 14], being a cause of severe dystocia. There are many reports on duplicated calves [2, 4, 6, 8, 10], but observations have addressed mainly the external gross features of the animals. In the present study, we examined the internal as well as external features of duplicated heads in five calves. Comparison of the features was made to study the influence of fusion on the course of the cranial nerves and blood vessels.

Five calves with cranial duplication were referred to our laboratory. Case 1 was a stillborn male calf (Japanese black); case 2 was a two-day-old male calf (Holstein); case 3 was a stillborn male (Japanese black); case 4 was a stillborn female (Japanese black); and case 5 was a one-day-old male (Japanese black). Latex (Showa Neoprene Co., Ltd.) was injected through the common carotid arteries into the vessels of each head. After solidification of the latex, the heads were removed from the bodies, and preserved in 10% formalin until examined.

The duplicated heads of each calf exhibited a V-shaped fusion. In the present study, the term "medial" was applied to indicate the organs of the opposing halves of the duplicated heads. The general features are summarized in Table 1.

Case 1 (Fig. 1): The parietal bone was duplicated. A single occipital bone was shared by the two heads. The medial temporal bones were fused together in the caudal regions of the mastoid parts. The medial submandibular and parotid glands were fused to form a large gland body between the two heads. The right common carotid artery branched into the medial and lateral rami at the level of the sixth cervical vertebra (C6). The medial ramus coursed dorsally between the mandibles and then branched into the facial and maxillar arteries. These arteries normally supplied the medial sides of both heads (Fig. 2). The lateral ramus and the left common carotid artery coursed to the lateral sides of both heads and exhibited normal branching patterns. The basilar arteries bifurcated at the site of the medulla oblongata.

Table 1. Gross findings in five calves with cranial duplication

Findings	Case 1	Case 2	Case 3	Case 4	Case 5
Eyes	4	4	4	4	3
Ears	4	3	2	4	2
Muzzle	2	2	2	2	2
Ramus of mandible	4	4	3	4	2
Tongues	2	2	2	2	2
Hyoid bone	2	1	1	2	1
Thymus	1	1	1	2	1
Thyroid gland	2	1	1	2	1
Epiglottis	1	1	1	2	1
Cerebrum	2	2	—	2	2
Cerebellum	2	1	—	2	1
Duplication of the cranial nerves	I-X	I-VIII	I-VI	I-XII	I-IV
Ventromedian fissures	2	1	2	2	1
Angle of axes of both heads	90°	75°	135°	170°	45°

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Fig. 1. Frontal view of case 1 with an incomplete duplication of the faces.

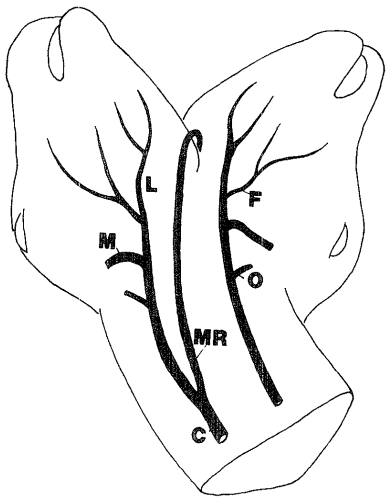

Fig. 2. Diagram of the arterial supply in case 1. Ventral view. The medial ramus of the right common carotid artery courses to the heads just like the normal common carotid artery which supplies the medial sides of both heads. C: common carotid artery, F: facial artery, L: lingual artery, M: maxillar artery, MR: medial ramus of common carotid artery, O: occipital artery.

Case 2: The rostral parts of the occipital bones were duplicated. The median zygomatic bones were fused. This calf had two tongues, but one hyoid bone. A small parotid gland was seen between the heads. The right common carotid artery coursed along the trachea, and then divided into the linguofacial and maxillar arteries in the medial side of mandibles. The linguofacial artery branched into the lingual and facial arteries. The lingual artery supplied both sides of the right tongue and the medial side of the left tongue, and coursed to the top of the head to show the same branching pattern as that of the normal facial artery which supplied the medial sides of the heads (Fig. 3). Two obvious ventral median fissures of the medulla oblongata were fused at the point of bifurcation of the basilar

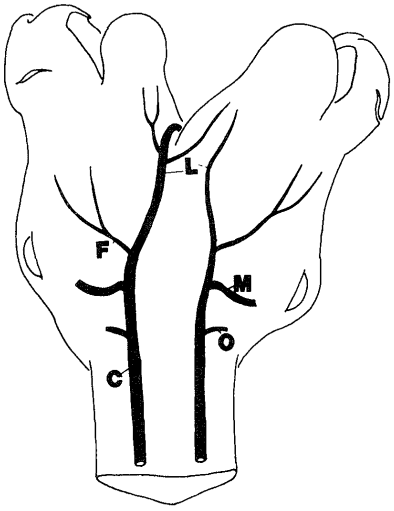

Fig. 3. Diagram of the arterial supplies of case 2. Ventral view. Lingual artery from the right common carotid artery supplies the medial sides of both heads. C: common carotid artery, F: facial artery, L: lingual artery, M: maxillar artery, O: occipital artery.

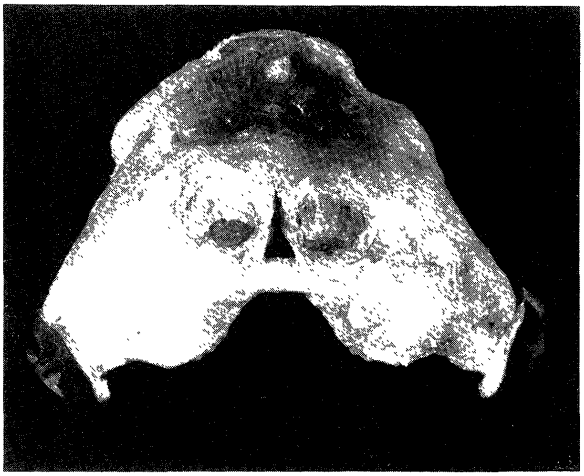

Fig. 4. Cranial bones of case 3 which lack skull caps. The base of the skull is seen directly from the top of the heads.

arteries. Rudimentary facial and vestibulocochlear nerves were observed between the two heads.

Case 3: This case had neither a skull cap (calvaria) nor brain (Fig. 4). Therefore the base of the skull and the posterior part of the atrophied medulla oblongata were directly observed from the top of the head. The heads were fused at the region of the medial sphenoidal bones. The right lobe of the thyroid gland was absent and the left one was smaller than usual. Left common carotid artery bifurcated into the lateral and medial rami at the level of C6. The medial aspects of the heads were supplied by this medial ramus. The median rami of the mandibles were fused and had single condylar and coronoid processes.

Case 4: Two heads were fused together in the posterior region of the parietal bones. The basilar parts of the occipital bones were fused along their ventral sides. The

Fig. 5. Frontal view of case 5. This case has one skull cap, two maxillae and one mandible.

foramen magnum was smaller than usual, and the occipital condyle was poorly developed. The right common carotid artery bifurcated into the lateral and medial rami at the level of C6. The lateral ramus and left common carotid artery supplied the lateral aspects of both heads. The medial ramus coursed rostrally in the same fashion as the normal common carotid artery which supplied the medial sides of both heads. Both brains were fused along the caudal portion of the medulla oblongata. The lateral ventricles were distended due to hydrocephalus.

Case 5: This case had one skull cap, two maxillae and one mandible. It showed the lowest degree of duplication among the present five cases. A vestigial eye was present on the fusion line of the two faces (Fig. 5). The ocular muscles of the medial sides passed through a large pore at the base of the skull and ended at the median maxillae. The optic chiasma was not evident. The oral cavity consisted of two maxillae and one mandible. The tongue bifurcated at the apex. The lingual artery which was a branch of the left linguofacial artery was well developed and coursed to the anterior parts of both tongues. It branched to the bifurcated apexes of the tongues and went to the basal part of the skull via the muscular collum and supplied the ocular muscles of the medial sides of the heads. The arteries which supplied the medial side of heads were not observed.

Cleft palates are commonly associated with conjoined twins [6, 8, 9, 15]. This was true in the present study; that is, all the heads exhibited identical cleft palates. In our cases, as the cranial nervous systems became singular caudally, the organs which were innervated by these nerves became singular as well.

Hiraga *et al.* [6] classified the duplication of heads into 5 types based on the number of eyes and ears. The present cases 2 and 3 belong to type 3, and cases 1 and 4 belong to type 5; these two types have a high frequency in the cranial duplication [6]. The case 5 belongs to type 1.

The branching patterns of the arteries in the duplicated head have been described in some reports [4, 5, 7, 14], but their asymmetry has not been discussed. In the cases which had a small angle of the head's axes (cases 2 and 5), the arteries that supplied the medial side branched off more anteriorly than in other cases. In 3 of the present cases the medial sides of the heads were supplied by the arteries which came from the right common carotid artery, and the other 2 cases were supplied by the left common carotid artery. Thus the branching of the artery was asymmetrical, but we could not find any differences in the morphological development between paired heads.

There are two hypotheses for the etiology of conjoined twins: the fission concept of imperfect twinning, and the collision concept of two embryonic masses. The symmetrical (mirror image) distribution of the organs observed in the present study supports the hypothesis that conjoined twins are originally monozygotic (from a single body axis) and are caused by an imperfect separation [12]. There are also some hypotheses about the etiologies of embryonic fission in conjoined twins [3, 11, 13]. A partial twinning of bovine embryos may occur sometime after the eighth day of development [12]. In the present case, as McGirr *et al.* [13] described, the splitting of the embryo is likely to arise later in development since the viscera are not duplicated.

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