Case Report

Multiple neural tube defects in a child: A rare developmental anomaly

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Abstract

Background: The presence of multiple neural tube defects (NTDs) is a rare entity. Published literature shows not more than 10 case reports. Such cases contradict the well-established “zipper model” of neural tube closure and support “multi-site closure model.”

Case Description: We are reporting a unique case of multiple NTDs in a 5-month-old female child. Occipital encephalocele, dorsal meningomyelocele, Split cord malformation (SCM), and tethered cord were present in this case.

Conclusion: This case report further substantiate the “multisite closure model,” however, more research work on human neuro-embryology is needed to overcome the controversies of neural tube closure.

Key Words: Meningocele, multiple neural tube defects, multisite closure, neural tube, Zipper model

INTRODUCTION

Neural tube defects (NTDs) refer to the congenital deformities involving the coverings of nervous system. These can be classified on the basis of embryological considerations and the presence or absence of exposed neural tissue, as open or closed types. Open NTDs (ONTDs) occur due to failure of primary neurulation and the neural tissue is exposed with associated cerebrospinal fluid (CSF) leakage.4 Closed NTDs (CNDTs) result from a defect in secondary neurulation and neural tissue is not exposed as the defect is fully epithelialized although the skin covering the defect may be dysplastic.5 Since the anterior and posterior neuropores close last, they are the most vulnerable to defects. The simultaneous occurrence of meningomyelocele and/or encephaloceles at multiple sites along the vertebral axis is extremely rare and accounts for <1% of cases. Published literature shows not more than 10 case reports. The largest series so far on these rare anomalies is of seven cases of multiple NTDs.3 The occurrence of multiple NTDs contradicts the traditional “Zipper model” of neural tube closure and favors Van Allen’s “Multi-site closure model.” Herein, we report a case of occipital encephalocele with dorsal meningomyelocele which is another evidence in favor of the later. An additional NTD detected was split cord malformation. The synchronous presence of such anomalies has never been reported in the published literature.

CASE REPORT

A 5-month-old female patient, first child of healthy parents, presented with two cystic swellings since birth, one in the suboccipital area and the other in
the mid-thoracic region [Figure 1]. Parents had a nonconsanguineous marriage. Her perinatal history was uneventful.

The swellings were covered with skin and 10 × 9 × 7 cm and 7 × 6 × 4 cm in dimensions, respectively. The swellings were translucent and increased in tension when the child cried. The child was moving all four limbs normally and sphincter functions were unimpaired. Developmental assessment revealed normal milestones and growth parameters were within normal range.

Brain MRI revealed herniation of meninges, CSF, and brain parenchyma through a midline defect in occipital bone consistent with meningoencephalocele. Hydrocephalus and features of Chiari malformation were also present.

MRI thoracic spine demonstrated spina bifida from mid thoracic to upper lumbar spine with herniation of meninges, CSF, and neural elements at D7/8 levels diagnostic of meningomyelocele (MMC). The cord was low lying and tethered posteriorly with the intact posterior elements of D6. Syrinx was present in the cord proximal to the site of defect [Figure 2].

Axial T2- and T1-weighted MR images revealed a longitudinally split lower thoracic spinal cord with one dural tube and CSF intervening between the two hemicords [Figure 3]. No bony, cartilaginous or fibrous spur was identified along the course of the split cord consistent with Pang type 2- SCM.

DISCUSSION

Reports of multiple NTDs in the same patient are very rare in the published literature. Potter (1962) described two cases and Bertan (1968) described one case of dorsal and lumbar meningomyelocele.[2] Fahrenkurg and Hojgaard (1963) described a case of multiple paravertebral lumbar meningocele.[3] Tekkok reported a case with three distinct NTDs (a parietooccipital encephalocele, a small cervical MMC, and a thoracolumbar MMC). The largest series so far on these rare anomalies is of seven cases of multiple NTDs.[1] We are reporting a unique case of such type. Occipital meningoencephalocele, dorsal meningomyelocele, SCM, and low lying tethered cord were present in this case.

Over the past few years, in-depth descriptive research has been conducted on brain and spinal cord development in human embryos to know the embryological basis of such complex anomalies. Most important are the studies conducted by O’ Rahilly and Muller who concentrated their efforts on expanding several stages (8 through 23) related to CNS development.[7] The NTDs are classified as neurulation defects, which occur by stage 12 and postneurulation defects.[5] Neural tube formation and closure involve complex cellular, extracellular,
and intercellular processes. Formation begins with primary neurulation and is completed by the process of canalization, which occurs during secondary neurulation.

Two primary theories exist regarding the neural tube closure. The widely accepted theory is that neural tube closure is a continuous, bidirectional process which begins in the mid cervical region and progresses in a zipper-like fashion both rostrally and caudally, with the cranial and caudal neuropores being the last to close (at Days 24 and 26, respectively). Thus, the neural tube forms up to S-2, and the areas caudal to S-2 form through secondary neurulation. The embryogenesis of myelomeningocele has been attributed to the defects in primary neurulation. There are many fallacies of this rather simplistic “zipper model.” According to this theory, the most common site of MMC is at the most cranial or most caudal ends, but it fails to explain the occurrence of encephaloceles, cervical MMCs and multiple NTDs.

In 1993, Van Allen et al. proposed the second theory “multisite closure model,” in which they hypothesized that there are five sites of initiation of neural tube closure and the NTDs occur at the “collision sites” of neural tube closure with opposing closure directions. According to this theory, the initial site of closure (closure 1) is in the midcervical region which proceeds bidirectionally, closing over the area of the future spine at the level of L2. Closure 2 begins at the prosencephalon/mesencephalon boundary which also proceeds bidirectionally and meets site 3 rostrally and terminates caudally at superior part of rhombencephalon. Closure 3 proceeds rostrally from the stomatodeum and meets the cranial end of closure site 2. Closure 4 takes origin at the caudal end of the rhombencephalon and proceeds rostrally to meet the caudal aspect of site 2. Lastly, closure 5 originates at the caudal end of neural tube and proceeds rostrally to close the caudal end of the neural tube from the level of future S2 through L2 [Figure 4]. The majority of NTDs could be explained by failure of fusion of one of the closures or their contiguous neuropores, with spina bifida resulting from incomplete fusion of closure 5 or of rostral or caudal closure 1.

Thus, the multisite closure theory is more inclusive than the zipper model but has the shortcomings that the double or multiple NTDs should have been more commonly seen but in reality only a few case reports are available. It may be explained by the hypothesis given by some and supported by Nakatsu et al., that such malformations, particularly the multiple NTDs, are usually incompatible with life. The other drawback has been the etiogenesis of cervical MMC.

Martinez-Frias et al. conducted an epidemiological study of 774 live-born infants with NTDs based on the multisite closure theory. They found that isolated closure failure is the most prevalent and the most commonly effected site is closure site 1 followed by sites 4 and 2, respectively. They also found that multiple closure defects are rare.

Split cord malformation, though a common association of meningomyelecele, has never been reported in the published literature with double meningocele.

Our case report further substantiate the “multisite closure model,” however, more research work on human neuro-embryology is needed to overcome the controversies of neural tube closure.

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