Childs Nerv Syst (2017) 33:873–875
DOI 10.1007/s00381-017-3353-x

CASE REPORT

Junctional neural tube defect in a newborn: report of a fourth case

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Received: 9 November 2016 / Accepted: 30 January 2017 / Published online: 28 February 2017
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Abstract
Introduction A discontinuous, functionally disconnected spinal cord is an extremely rare finding, with only three known reports in the literature. Titled junctional neural tube defect (JNTD), this newly reported dysraphism is believed to arise from a developmental error occurring during junctional neurulation, a transitory stage of development marked by the end of primary neurulation and the beginning of secondary neurulation. Herein, we report a newborn case of JNTD.
Case report We report a newborn boy born with anorectal atresia. Physical examination revealed normal movement in the upper and lower extremities. Imaging revealed distal sacral agenesis and a spinal cord that was discontinuous at the thoracolumbar junction. Three vertebral segments inferiorly, at the L2 vertebral level, the distal end of the spinal cord (i.e., conus medullaris) were visualized. No signs of a tethered cord were identified.
Conclusions Characterized by an error in junctional neurulation in which the primary and secondary NT fail to integrate appropriately, JNTD has been recently classified. We believe the current patient to represent only the fourth reported case of JNTD in the literature.

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Keywords Junctional neurulation · Junctional neural tube defect · Malformation · Spinal dysraphism · Spinal cord · Primary and secondary neurulation · Imaging · Anatomy

Introduction

We report what is believed to represent a rare newborn case falling within the newly classified class of spinal dysraphism, called junctional neural tube defects. The patient presented with anorectal atresia, but had normal upper and lower extremity motor functions as discernable in a newborn. MRI revealed slight sacral agenesis and the spinal cord was found to be discontinuous at the thoracolumbar junction. We discuss the case and theorized embryogenesis of this new class of dysraphism within.

Case report

We report a newborn African-American boy born at 38 weeks gestation. The baby was delivered vaginally. The parents were non-consanguineous and this was the first child for this mother who did not have health issues or gestational diabetes. At birth, the baby was found to have anorectal atresia and produced urine. Physical examination revealed normal movement in the upper and lower extremities. There were no cutaneous stigmata indicative of occult spinal dysraphism. Deep tendon reflexes were normal. All major dermatomes tested were intact including T10-S4. Both testicles were within the scrotum and the cremasteric and bulbocavernosus reflexes were intact. An abdominal ultrasound revealed no signs of obstructive uropathy. Prior to surgery to treat the anorectal atresia, an MRI of the spine and pelvis was performed. Imaging demonstrated an intact bony spine superior to the

sacrum but with some degree of sacral agenesis (S1 and S2 intact). No spina bifida was seen. However, the spinal cord was found to be discontinuous at the thoracolumbar junction with a drumstick appearance of the cord at this level (Fig. 1). The last three segments of this "upper" portion of the spinal cord contained an enlarged central canal (Fig. 2). Three vertebral segments inferiorly, at the L2 vertebral level, the distal end of the spinal cord i.e., conus medullaris was visualized (Fig. 1). On axial images, the gray and white matter as well as dorsal and ventral rootlets was seen (Fig. 2). No other intradural anomalies were noted (e.g., fatty infiltrated filum terminale).

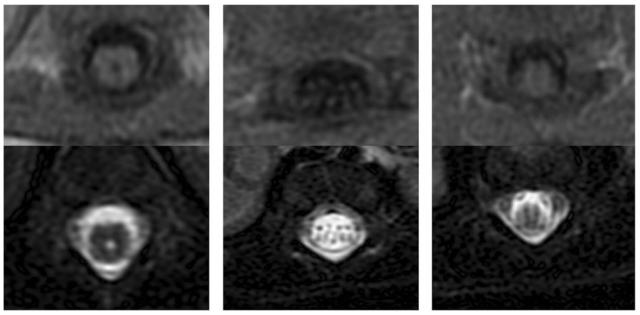

Fig. 2 MRI axial images through terminal upper cord, just inferior to this and distal lower cord. Top images are T1-weighted and lower images are T2-weighted

Discussion

Neural tube defects (NTDs) may be broadly categorized into abnormalities arising from defects in either primary or secondary neurulation [1, 2]. Primary neurulation begins with the bending of the neural plate, forming the neural groove and neural folds along the longitudinal axis of the plate. These folds meet and fuse in the midline to form the primary neural tube (NT). The edges of the neural folds are continuous with the embryonic cutaneous ectoderm and as such, errors in primary neurulation often manifest in open skin defects, or cutaneous marks indicating failed NT closure [1–3]. Secondary neurulation follows primary NT closure, specifically, its initiation is marked by the closure of the caudal neuropore of the primary NT. In contrast to primary neurulation, secondary neurulation involves a mesenchymal-epithelial transition (MET) of the caudal cell mass. Errors in secondary neurulation manifest as defects in the caudal spine, including urinary tract and conus medullaris malformations, in addition to various caudal agenesis pathologies [2–7]. The features of the currently presented case were such that classification into either of these two categories of dsyraphism proved problematic. However, recent work by Eibach et al. has provided a candidate classification for this case [3].

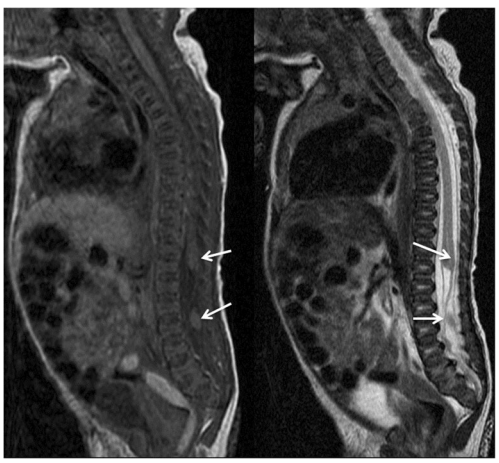

Fig. 1 T1- (*left*) and T2-weighted (*right*) midsagittal MRI of the spine. The *upper arrows* mark the termination of the "upper" cord and the lower images mark the "lower" cord

In 2014, Dady et al. published on a little described and poorly understood transitional process occurring in the interlude between primary neurulation's termination and the initiation of secondary neurulation, called junctional neurulation [8]. The junctional region represents the location where the primary NT shifts to the secondary NT [9]. While the continuity of primary and secondary NT cavities has been previous described, it was Dady et al. who characterized the complex underlying mechanisms by which topological continuity is maintained and asserted this process as distinct from either primary or secondary neurulation [8, 9]. The authors theorized that errors in this process may underlie a multitude of anomalies occurring in the thoracolumbar region which may not necessarily strictly accord with primary or secondary NTDs.

In 2016, Eibach et al. presented three cases in which imaging, and subsequent surgical findings, revealed two physically separated, functionally disconnected spinal cord segments in each patient [3]. Of interest, surgical investigation found each segment of spinal cord to be fully functional and connected by a thin, non-neural band. Building on the work of Dady et al., the authors posited that this anomaly may have arisen from an error in junctional neurulation in which the primary and secondary NTs became separated, forming two functional, but physically and neurologically distinct spinal cord segments. The authors hypothesized a derangement of critical cell adhesion molecules may underlie the failed association between the primary and secondary NTs. The three cases were classified as a new class of dysraphism called junctional neural tube defect (JNTD).

In their series, Eibach et al. reported that two of their three cases presented with club feet and all three showed atrophy and paralysis of foot muscles, diminished sensation, and a delayed ability to walk [3]. In addition, all three patients were found to have a hypertonic external anal sphincter; however, all had complete urinary and fecal incontinence. In contrast, our presently reported case showed normal movement in the upper and lower extremities, with no foot deformity or

discernable muscle paralysis. As this case is a newborn, no comment can be made about the potential of delayed walking abilities. While the embryological errors associated with the anorectal atresia and sacral agenesis observed in our case are abnormalities of the caudal cell mass (secondary neurulation), the physical dissociation of the primary and secondary neural tube seen via MRI, in addition to the seemingly functional nature of both spinal cord segments, leads us to believe that the presently reported case falls under the new classification of JNTD.

Options for surgical correction depend upon the nature and extent of presenting deficits. The rationale behind surgical correction in newborns hinges on the supposition that uncorrected deficits will lead to progressive deterioration. Following surgical correction of the patient's anorectal atresia, the lack of further neurological deficits or imaging signs of a tethered cord resulted in the decision to opt for close observation in the patient's management. Assuming that this is a case of JNTD and the lower spinal cord segment was functional and operating independently of true CNS input, it is likely the infant will develop total bladder and bowel incontinence. Additionally, the presence of a syrinx should alert the clinician to follow such a patient closely. Further neurological degeneration is possible during maturation and it will be of interest to monitor the neurological progression of this case.

Conclusions

We have herein reported a fourth case of the newly classified spinal dysraphism termed junctional neural tube defect. Characterized by what is thought to be an error in junctional neurulation in which the primary and secondary parts of the NT fail to integrate appropriately, patients with JNTD are found to harbor two functional, but physically independent spinal cord segments. While the case reported here differed in symptomology compared to the three earlier reported cases, MRI findings were similar.

Compliance with ethical standards

Conflict of interest The authors declare no conflicts of interest.

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