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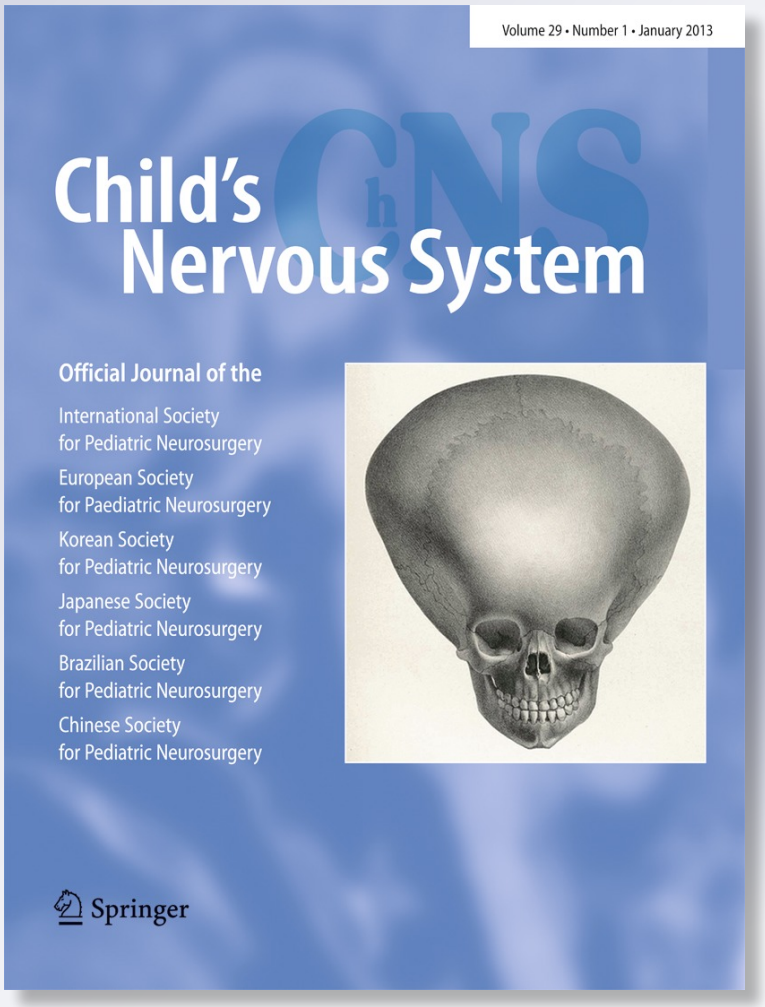
**Child's Nervous System**

ISSN 0256-7040
Volume 29
Number 1

Childs Nerv Syst (2013) 29:159-162
DOI 10.1007/s00381-012-1923-5




Springer

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CASE REPORT

# Neonatal post-hemorrhagic hydrocephalus resulting in foraminal septae—radiological technique and surgical implications

**Farhana Fadzli · Norlisah Mohamad Ramli · Kartini Rahmat · Dharmendra Ganesan**

Received: 23 July 2012 / Accepted: 5 September 2012 / Published online: 21 September 2012


**Abstract**
*Background* Intraventricular haemorrhage is the most common cause of hydrocephalus in a pre-term baby and may require surgical intervention depending on severity.
*Clinical case* This case illustrates foraminal septae as a subtle cause of progressive quadriventricular hydrocephalus in a child born pre-term with a history of grade III intraventricular haemorrhage. The septae within the fourth ventricular exits were clearly demonstrated with 3D-FIESTA (fast imaging employing steady-state acquisition) MRI acquisitions and assisted in differentiation from communicating hydrocephalus. This finding guided the decision to a successful endoscopic third ventriculostomy.
*Conclusion* 3D-FIESTA sequence is recommended for investigating children with hydrocephalus secondary to intraventricular haemorrhage due to its diagnostic potential and implications on surgical technique.

**Keywords** Hydrocephalus · Magnetic resonance imaging · Infant · Premature · Ventriculostomy

## Introduction

The most common cause of hydrocephalus in a pre-term baby is intraventricular haemorrhage of prematurity [1]. There are numerous postulations of the pathophysiology of this condition [2]. Cases are being increasingly diagnosed with the help of imaging modalities especially ultrasound and magnetic resonance imaging (MRI). This report illustrates a case of hydrocephalus during infancy in a baby who had grade III germinal matrix intraventricular haemorrhage of prematurity. High-resolution 3D-FIESTA (fast imaging employing steady-state acquisition) images from MRI acquisition played a crucial role in the accurate diagnosis of septations within the foramen Magendie and Luschka and eventual choice of the best treatment.

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## Case report

The patient was born prematurely at 26 weeks as the second twin. She was born with low Apgar scores and intubated soon after delivery. Her 3-month stay at the Special Care Nursery was complicated by grade III intraventricular haemorrhage with hydrocephalus, chronic lung disease, sepsis and retinopathy of prematurity. Ultrasound cranium during the prolonged admission showed intraventricular blood with bilateral hydrocephalus. The patient's head circumference continued to increase from 34.5 cm at day 2 of life (between the 95th to 97th percentile) to 45 cm at 4 months of age (above the 97th percentile) based on corrected age. However, the anterior fontanelle was full but not tense and the baby was managed expectantly at this stage.

An MRI (using 1.5-T GE scanner (GE Medical Systems, Milwaukee, WI)) done at 7 month of age under general anaesthesia demonstrated quadriventricular hydrocephalus and an impression was made of communicating hydrocephalus. The aqueduct of Sylvius appeared narrow but patent. No transependymal seepage was seen. At this point, ventriculoperitoneal (VP) shunt insertion was considered as the treatment of choice if the head circumference and serial MRI showed progression of ventricular dilatation.

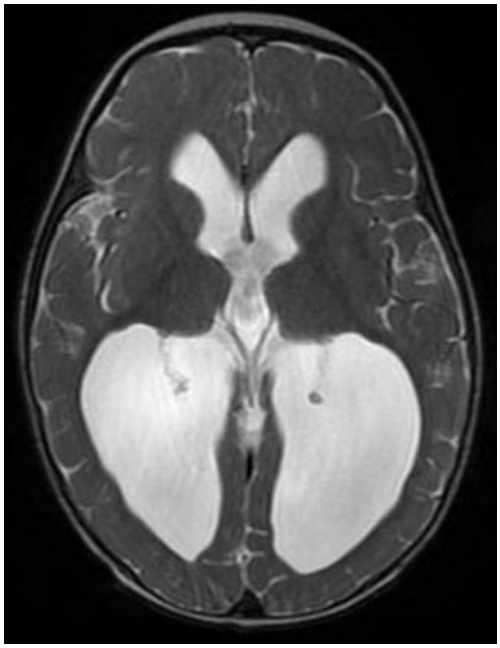

**Fig. 1** Axial T2-weighted image shows grossly dilated third and both lateral ventricles

Subsequent assessments showed a gradual increase in the head circumference from 46 cm at 8 months of age (corrected age of 5 months) to 49 cm at 11 months of age (corrected age of 8 months). The anterior fontanelle became progressively more tense over this period. The patient was however, asymptomatic. A repeat MRI showed an increase in the degree of dilatation of the third and lateral ventricles with effacement of the subarachnoid spaces. However, there was no evidence of cerebrospinal fluid (CSF) seepage (Fig. 1). 3D-FIESTA images were performed in the sagittal plane with the following parameters: TR=4.8 ms, TE=1.8 ms, number of excitations=1, acquisition time=43.34 min, Flip angle=65°, FOV=190×190 mm, slice thickness=2.0 mm, matrix=320×256, bandwidth=62.5 Hz/pixels and partition number=72. 3D reconstruction of the FIESTA images performed during this examination revealed the presence of septae at the foramen of Magendie and Luschka (Figs. 2 and 3). As a consequence of the clear demonstration of an obstructive nature of the hydrocephalus, an endoscopic third ventriculostomy (ETV) was performed instead of a VP shunt. A stoma at the floor of the third ventricle could permit a 2.9-mm endoscope through and the basilar artery was visualised. The patient was discharged the next day. Three months later, it was discovered the patient was asymptomatic with an anterior fontanelle that was soft and sunken with a stable head circumference. MRI brain repeated 3 months later showed no significant change in the size of the ventricles (Fig. 4).

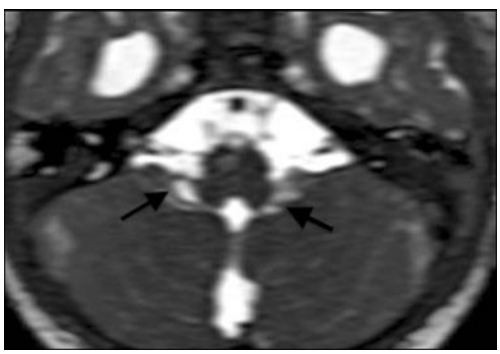

**Fig. 2** Reconstructed axial image in 3D-FIESTA shows septa within both foramen of Luschka (*arrows*)

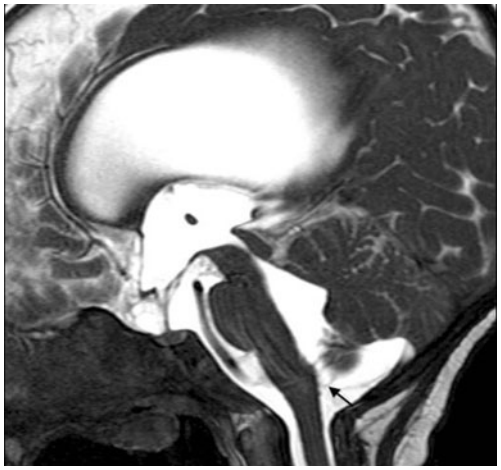

**Fig. 3** Sagittal 3D-FIESTA image demonstrates dilated lateral and fourth ventricles with septa within foramen of Magendie (*arrow*)

## Discussion

An epidemiological study done in the early 1970s to the early 1990s showed that intraventricular haemorrhage was the most common cause of hydrocephalus in pre-term

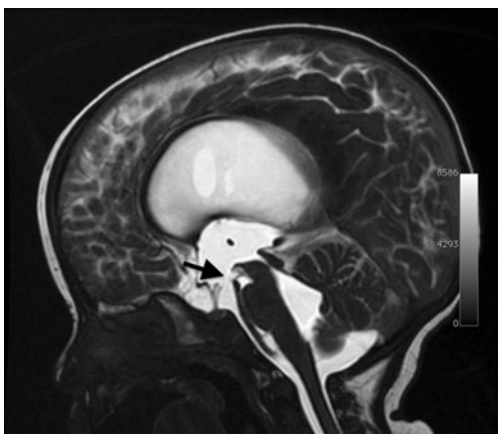

**Fig. 4** Sagittal 3D-FIESTA image post ETV shows patent ventriculostomy site (*arrow*)

babies [1]. Several other studies have demonstrated that patients with higher grades of pre-term intraventricular haemorrhage (grades III–IV) were predisposed to developing post-hemorrhagic hydrocephalus [2, 3]. In our case, the child had grade III intraventricular haemorrhage and ran a high risk of requiring permanent CSF diversion. Though in the initial stages there were no clinical and radiological signs of progression of hydrocephalus, at later stages there were clear evidence that the child needed a permanent CSF diversion surgery.

Several theories on the pathophysiology of hydrocephalus secondary to intraventricular haemorrhage have been postulated, including physical obstuction of CSF outflow by blood clots [4] or extracellular matrix proteins, reactive subependymal gliosis [5], obliterative fibrosing arachnoiditis and meningeal fibrosis [6], which likely results in septations within the foramen. In a recent study of 134 patients with communicating hydrocephalus aged 2 days to 18 years, the most common cause found was membranes within the intraventricular system [5].

Obstruction due to septation at foramen Magendie and Luschka would cause quadriventricular hydrocephalus leading to an erroneous diagnosis of communicating hydrocephalus if made solely on the basis of T1W and T2W, which is the more conventional MRI imaging. It is known that conventional imaging is less sensitive at detecting fine membranes at these cisterns . The reasons include CSF flow artefacts and the higher slice thickness with T2W images, which produce poor spatial resolution [7] as well as partial volume averaging [8]. 3D fast imaging employing steady-state acquisition images are acquired by combining two image sets produced by steady-state free precession and applying maximum intensity projection [9]. The 3D-FIESTA sequence is analogous to 3D-CISS (constructive interference steady state) images produced by Siemens MRI scanners. This sequence accentuates T2 values between CSF and adjacent structures, as well as improving the resolution with submillimeter slices [8]. Another benefit is the reduction of intrinsic signal loss from CSF pulsatile flow by acquiring FISP (free induction with steady-state precession) with flow compensation over each TR cycle instead of each TE cycle [8]. This sequence has been described as excellent in assessing cranial nerves as they traverse CSF [10–12]. Clear delineation of microsurgical anatomy allows detailed planning of surgical technique and approach, which is beneficial to the surgeon [5, 10]. Apart from demonstrating the presence of septa within the foramen, this sequence has the potential to define the number, location and extent of the septations. The significance of this lies in the surgical method, in which endoscopic fenestration may be the only intervention required in a case of isolated membrane within cisterns [5]. Therefore, 3D-FIESTA (or CISS sequences in Siemens scanners) has been recommended in the assessment imaging of hydrocephalus in the pre-operative setting and also post-operative evaluation [5, 7, 13–16]. Disadvantages of the 3D-FIESTA sequence include relatively long scan times and poor differentiation of the brain parenchyma [5]. In our centre, the addition of FIESTA images results in additional 5–7 min to conventional MRI study. In this patient, assessment of the FIESTA data which was reformatted into 3D images helped to elucidate the presence of the septae within foramen Magendie and both foramen Luschka.

Conventionally, infants who develop hydrocephalus as a result of post-intraventricular haemorrhage of pre-term would require permanent diversion in the form of a ventriculoperitoneal shunt, particularly, if the imaging suggests a communicating type of hydrocephalus. ETV is believed to be less effective in such cases due to diminished absorptive capacity of the arachnoid granulation. Moreover, ETV in the infancy period has been reported to have a higher chances of failure [17].

In our case, the membranes visualised within the foramen Magendie and Luschka were regarded as the cause of quadriventricular hydrocephalus. Therefore, it would be reasonable to attribute the build up of the CSF to obstruction at that level rather than diminished absorption. Therefore, the success of ETV even in infancy is higher once an obstructive element in the ventricular system can be demonstrated for example, aqueduct stenosis in infancy [17]. This benefits the child in the avoidance of a VP shunt which would be a long-term implant with inherent risks of shunt dependency, infection, skin erosion, shunt failure, ventricular isolation, over-drainage of CSF and intra-abdominal complications [16].

Resolution of hydrocephalus is often not as readily visible in ETV cases as compared to shunts, with successful results only visible after days, weeks [16] or a year later [18]. Even so, the reduction in ventricular size may be only slight, negligible or unchanged [16]. In our patient, there was no further exaggerated increase in head circumference and fontanelle remained soft after the ETV. The MRI brain 6 months after the ETV showed no significant reduction in ventricle size. She has been closely monitored for 9 months, the fontanelle is soft and partially sunken with a head growth following the normal curve and achieving milestones of the corrected age.

In conclusion, septations within the foramen Magendie and Luschka are known complications of germinal matrix intraventricular haemorrhage with subtle findings which may be easily missed during routine imaging. The 3D-FIESTA sequence during the MRI brain clearly showed the septae at this location. As a result , ETV was chosen as the surgical procedure of choice as opposed to a VP shunt which has its own short and long term sequelae. We recommend this sequence or the equivalent 3D-CISS in investigating children with hydrocephalus secondary to intraventricular haemorrhage, as findings of intraventricular septations determine the choice of surgical treatment.

**Acknowledgment** The authors gratefully acknowledge support from University Malaya Research Grant (RG178/09HTM).

## References


1. Fernell E, Hagberg G, Hagberg B (1994) Infantile hydrocephalus epidemiology: an indicator of enhanced survival. Arch Dis Child-Fetal Neonatal Ed 70(2):F123–F128
2. Tsitouras V, Sgouros S (2011) Infantile posthemorrhagic hydrocephalus. Child's Nerv Syst 27(10):1595–1608
3. Murphy B, Inder T, Rooks V, Taylor G, Anderson N, Mogridge N, Horwood L, Volpe J (2002) Posthaemorrhagic ventricular dilatation in the premature infant: natural history and predictors of outcome. Arch Dis Child Fetal Neonatal Ed 87(1):F37–F41
4. Whitelaw A (1997) We need a new understanding of the reabsorption of cerebrospinal fluid. Acta Paediatr 86(2):133–134
5. Dinçer A, Kohan S, Özek M (2009) Is all "communicating" hydrocephalus really communicating? Prospective study on the value of 3D-constructive interference in steady state sequence at 3 T. Am J Neuroradiol 30(10):1898–1906
6. Muszinski C (2010) Posthemorrhagic hydrocephalus. Cerebrospinal fluid disorders Informa Healthcare USA, Inc, New York, pp 141–153
7. Aleman J, Jokura H, Higano S, Akabane A, Shirane R, Yoshimoto T (2001) Value of constructive interference in steady-state, three-dimensional, Fourier transformation magnetic resonance imaging for the neuroendoscopic treatment of hydrocephalus and intracranial cysts. Neurosurgery 48(6):1291
8. Ramli N, Cooper A, Jaspan T (2001) High resolution CISS imaging of the spine. Br J Radiol 74(885):862–873
9. Chavhan GB, Babyn PS, Jankharia BG, Cheng HLM, Shroff MM (2008) Steady-state MR imaging sequences: physics, classification, and clinical applications1. Radiographics 28(4):1147–1160
10. Everton K, Rassner U, Osborn A, Harnsberger H (2008) The oculomotor cistern: anatomy and high-resolution imaging. Am J Neuroradiol 29(7):1344–1348
11. Seitz J, Held P, Strotzer M, Völk M, Nitz W, Dorenbeck U, Stamato S, Feuerbach S (2002) MR imaging of cranial nerve lesions using six different high–resolution T1–and T2(*)–weighted 3D and 2D sequences. Acta Radiologica 43 (4):349–353
12. Yagi A, Sato N, Taketomi A, Nakajima T, Morita H, Koyama Y, Aoki J, Endo K (2005) Normal cranial nerves in the cavernous sinuses: contrast-enhanced three-dimensional constructive interference in the steady state MR imaging. Am J Neuroradiol 26(4):946–950
13. Buxton N, Turner B, Ramli N, Vloeberghs M (2002) Changes in third ventricular size with neuroendoscopic third ventriculostomy: a blinded study. J Neurol Neurosurg Psychiatry 72(3):385–387
14. Kurihara N, Takahashi S, Tamura H, Higano S, Furuta S, Jokura H, Umetsu A (2000) Investigation of hydrocephalus with three-dimensional constructive interference in steady state MRI. Neuroradiology 42(9):634–638
15. Laitt R, Mallucci C, Jaspan T, McConachie N, Vloeberghs M, Punt J (1999) Constructive interference in steady-state 3D Fourier-transform MRI in the management of hydrocephalus and third ventriculostomy. Neuroradiology 41(2):117–123
16. van Lindert EJ, Beems T, Grotenhuis JA (2006) The role of different imaging modalities: is MRI a conditio sine qua non for ETV? Child's Nerv Syst 22(12):1529–1536
17. Javadpour M, Mallucci C, Brodbelt A, Golash A, May P (2001) The impact of endoscopic third ventriculostomy on the management of newly diagnosed hydrocephalus in infants. Pediatr Neurosurg 35(3):131–135
18. Fukuhara T, Vorster SJ, Luciano MG (2000) Risk factors for failure of endoscopic third ventriculostomy for obstructive hydrocephalus. Neurosurgery 46(5):1100