Clinical anatomy of the fourth ventricle foramina

INTRODUCTION

The primary purpose of this article was to review the anatomy of the foramina of the human fourth ventricle, as well as the main clinical conditions related to pathology of these neurosurgically important structures. The existing literature regarding the gross and neurosurgical anatomy of the foramina of the human fourth ventricle was reviewed with emphasis on the clinical disorders caused by several pathological conditions affecting these structures. Neuroanatomical comments on the location of these foramina are also provided.

DISCUSSION

The author has referenced one of his own studies in this review. This referenced study has been conducted in accordance with the Declaration of Helsinki (1964) and the protocols of this study have been approved by the relevant ethics committees related to the institution in which it was performed.

ANATOMY AND MORPHOMETRY

The fourth ventricle is a broad, tent-shaped midline cavity located between cerebellum and brainstem. It is connected rostrally through the cerebral aqueduct (of Sylvius) with the third ventricle, caudally with the spinal canal and through the foramen of Magendie with vallecula cerebelli (a cleft between the cerebellar tonsils) and cisterna magna, and laterally through the foramina of Luschka with the cerebellum. Slight differences seem to exist between the two sides regarding the location of the Luschka foramen. Pathological conditions affecting the foramina of the fourth ventricle usually produce clinical manifestations due to obstruction of the cerebrospinal fluid normal flow. Microsurgical treatment of such rare but challenging lesions is nowadays feasible.

Abstract

INTRODUCTION

The three foramina of the fourth ventricle of the human brain were first described during the 19th century. The primary purpose of this article was to review the anatomy of the foramina of the human fourth ventricle, as well as the main clinical conditions related to pathology of these neurosurgically important structures. The existing literature regarding the gross and neurosurgical anatomy of the foramina of the human fourth ventricle was reviewed with emphasis on the clinical disorders caused by several pathological conditions affecting these structures. Neuroanatomical comments on the location of these foramina are also provided.

Discussion

The author has referenced one of his own studies in this review. This referenced study has been conducted in accordance with the Declaration of Helsinki (1964) and the protocols of this study have been approved by the relevant ethics committees related to the institution in which it was performed.

Anatomy and morphometry

The fourth ventricle is a broad, tent-shaped midline cavity located between cerebellum and brainstem. It is connected rostrally through the cerebral aqueduct (of Sylvius) with the third ventricle, caudally with the spinal canal and through the foramen of Magendie with vallecula cerebelli (a cleft between the cerebellar tonsils) and cisterna magna, and laterally through the foramina of Luschka with the cerebellopontine angles. It has a roof, a floor and two lateral recesses.

The roof expands laterally and posteriorly from its narrow rostral end just below the aqueduct to the level of the fastigium and lateral recess, the site of its greatest height and width, and from there it tapers to a narrow caudal apex; the floor has a rhomboid shape. Its cranial apex is at the level of the cerebral aqueduct; its caudal tip, the obex, is located at the rostral end of the remnant of the spinal canal, anterior to the foramen of Magendie and its lateral angles open through the lateral angles of the fourth ventricle. The main pathological conditions affecting the foramina of the fourth ventricle are usually associated with hydrocephalus (responsible for clinical manifestations) and include occlusion, membrane obstruction, congenital imperforation, idiopathic stenosis, arachnoid adhesions and cystic dilation.

Conclusion

The foramina of the fourth ventricle, anatomically delicate and neurosurgically crucial apertures, have close relations with several important structures of the brainstem and cerebellum. Slight differences seem to exist between the two sides regarding the location of the Luschka foramen. Pathological conditions affecting the foramina of the fourth ventricle usually produce clinical manifestations due to obstruction of the cerebrospinal fluid normal flow. Microsurgical treatment of such rare but challenging lesions is nowadays feasible.

Licensee OAPL (UK) 2014. Creative Commons Attribution License (CC-BY)

The choroid plexus of the fourth ventricle consists of several segments. Its lateral segments extend laterally through the foramina of Luschka (protruding into the cerebellopontine angle below the flocculus and behind the glossopharyngeal, vagus and accessory nerves) and its medial segments extend longitudinally through the foramen of Magendie. The medial segments stretch from the level of the nodule, anterior to the cerebellar tonsils, to the level of the foramen of Magendie. The tonsillar parts of the choroid plexus are located anterior to the tonsils and extend inferiorly through the foramen of Magendie.

Ciolkowski et al. described the median aperture (foramen) of Magendie as the largest of the three openings of the fourth ventricle and thus forming the main path for the outflow of the cerebrospinal fluid (CSF) from the ventricle. The Magendie foramen makes a natural corridor for neurosurgical approach and inspection of the fourth ventricle and its floor. According to the same authors, this foramen is limited by the following structures: obex and gracile tubercles inferiorly and tela choroidea with choroid plexus superolaterally. Obex tubercles usually have the form of a piece of neural tissue bridging two halves of the brainstem above the entrance to the central canal. Gracile tubercles together are 8.15 mm wide and the maximal width of the foramen is 6.53 mm. Tela choroidea attatches laterally at both sides to the inferior medullary velum. In most cases the right and left choroid plexuses are connected to each other with a triangular membrane of tela choroidea, which protrudes through the median foramen and attaches to the vermis at a highly variable level.

Sharifi et al. studied 40 human cerebella and distinguished two compartments of the foramen of Luschka, namely the choroidal and patent part. Interestingly, 7.5% of the foramina were closed. The mean distance between the foramen of Luschka and the anterior inferior cerebellar artery was 3.9 mm. The distance from the posterior inferior cerebellar artery was 7.08 and 5.81 mm to the left and right foramina of Luschka, respectively. In ten cases, tortuous vertebral artery was occupying the left cerebellopontine angle space and the foramen of Luschka.

The Magendie foramen is, to the author’s gross anatomical experience, located 12 mm (9-15 mm) inferior to the pontomedullary junction, while the Luschka foramen is located 1.4 mm (0-11 mm) superior to this junction. The fourth ventricle extends ≥ 9 mm inferior and the Luschka foramina are located superior to this junction (37% placed exactly at this level). The Magendie foramen is located 0.3 mm (0-2 mm) posterior to the fourth ventricle floor, while the Luschka foramen is located 1.3 mm (0-4 mm) posterior to this floor (16% of the Luschka and 83% of the Magendie foramina were found at the level of this floor). Interestingly, the right Luschka foramen seems to be located 1.5 mm more superior from the pontomedullary junction and 0.7 mm more posterior from the fourth ventricle floor as compared to the left.

Longatti et al. examined the access to the fourth ventricle achieved by the endoscopic transaqueductal approach, to enumerate and describe the anatomically identifiable landmarks and to compare them with those described during microsurgery. Twenty anatomic structures could consistently be identified by exploring the fourth ventricle with a fiberscope, including the foramina of Luschka and Magendie. Neuroendoscopy offers a quite different outlook on the anatomy of the fourth ventricle, and compared with the microsurgical descriptions it seems to provide a superior and detailed visualisation, particularly of the structures located in the inferior triangle.

Clinical conditions
There are several pathological conditions of the fourth ventricle foramina, congenital or acquired, which usually cause hydrocephalus (principally responsible for clinical manifestations), mainly due to obstruction of the normal CSF flow.

Occlusion of the foramen of Magendie (e.g. by a plexus ependymal cyst) can cause hydrocephalus. In children, occlusion of the foramen of Magendie is usually the consequence of Dandy-Walker cysts or Arnold-Chiari type I malformation. In adults, the occlusion is rather acquired than congenital, linked to infection, head trauma, intraventricular haemorrhage, tumours or Arnold-Chiari malformation. In rare cases, in children as well as in adults, obstructive hydrocephalus has been reported due to the occlusion of the foramen of Magendie by a membrane, likely to be an extension of the inferior medullary velum and the tela choroidea. Until now, the diagnosis was suggested on indirect data, confirmed by invasive procedures such as ventriculography or direct surgical exploration.

Cystic malformations in the posterior cranial fossa result from developmental failure in the paleocerebellum and meninges. Takami et al. reported a case of an infant with hydrocephalus associated with cystic dilation of the foramina of Magendie and Luschka. This 7-month-old female infant presented with sudden onset of tonic-clonic seizures. Computed tomography (CT) scan revealed quadri-ventricular hydrocephalus. Magnetic resonance imaging (MRI) demonstrated a cyst communicating with the fourth ventricle.
ventricle and projecting to the cisterna magna and the cerebellopontine cisterns through the foramina of Magendie and Luschka. A suboccipital craniotomy was performed for removal of the cyst wall and the transparent membrane covering the foramen of Magendie. However, the hydrocephalus was removed under a microscope. After the surgery, the patient’s hydrocephalus improved and a phase contrast cine MRI study showed evidence of normal CSF flow at the level of the third and fourth ventricles.

Three weeks later, however, the hydrocephalus recurred. An endoscopic third ventriculocisternostomy was performed to address the possibility of stagnant CSF flow in the posterior cranial fossa, but the hydrocephalus continued. Finally, the patient underwent placement of a ventriculoperitoneal shunt, resulting in resolution of the hydrocephalus. The authors speculated that the cystic malformation in their patient could be classified in a continuum of persistent Blake pouch cysts. Hydrocephalus was caused by a combination of obstruction of CSF flow at the outlets of the fourth ventricle and disequilibrium between CSF production and absorption capacity.

A membrane obstruction of the foramina of Magendie and Luschka is an uncommon origin of hydrocephalus characterised by unusual clinical symptoms of rhomboid fossa hypertension. Various surgical approaches have been proposed to alleviate this obstruction, including opening the obstructed foramen of Magendie using suboccipital craniectomy, shunting procedures and more recently, endoscopic third ventriculostomy (ETV). In some cases, however, reshaping of the posterior fossa due to the collapse of the preponitone cistern could make ETV difficult for the surgeon and dangerous to the patient. In these cases, endoscopic opening of the foramen of Magendie by transaqueductal navigation of the fourth ventricle is a suitable and feasible therapeutic option.

Rougier and Ménégon reported a case of a 61-year-old man who developed headaches for several months and more recently an unsteady gait. The CT scans showed quadri-ventricular hydrocephalus involving mainly the fourth ventricle with dilated lateral recesses but without an Arnold-Chiari malformation. A membrane occluding the foramen of Magendie was demonstrated on the MRI. At operation, the tonsils appeared normal and were easily separated to expose the vallecula. In the area of the foramen of Magendie the fourth ventricle was hermetically sealed by a strong membrane in continuation with the tela choroidea. The membrane was excised resulting in free flow of CSF. After surgery, the headaches resolved immediately whereas the gait returned to normal within one month. At six months following operation, the ventricular size was normal on the controlled CT scan.

Congenital membranous obstruction of the foramen of Magendie is a rare entity. Hashish et al. reported two cases (35 and 68 year-old) with chronic hydrocephalus due to congenital membranous obstruction of the foramen of Magendie. Both these patients presented with headaches, nausea, and impairment of gait and memory. CT and MRI examination showed a communicating hydrocephalus, with particular enlargement of the fourth ventricle. Both patients were operated on for microsurgical exploration of the outlet of the fourth ventricle, which demonstrated membranous obstruction of the foramen of Magendie. Microsurgical perforation of the foramen of Magendie was performed, and a ventriculo-cisternal shunt was left in place. The two patients were cured.

Despite its rare occurrence, congenital imperforation or membranous obstruction of the foramen of Magendie must be considered as a possible etiology of chronic hydrocephalus in adult, especially in case of non-proportioned enlargement of the fourth ventricle, associated to signs of increased intracranial pressure. According to Hashish et al., the best curative surgical procedure consists in a microsurgical exploration of the foramen of Magendie associated to a ventriculo-cisternal shunting (from the fourth ventricle to the cisterna magna) and has more advantages than a simple ventriculo-peritoneal shunting.

Tubbs reported a young girl who presented with headache and back pain. Dynamic MRI revealed no cerebrospinal egress from the median aperture (foramen of Magendie) of the fourth ventricle and syringomyelia. A posterior cranial fossa exploration was performed and agenesis of the median aperture was observed. Following surgical penetration of the posterior aspect of the fourth ventricle and at the most recent follow-up examination, this patient’s syringomyelia had resolved, as had her symptoms. Agenesis of the foramen of Magendie may be a rare cause of inhibition of normal CSF egress from the fourth ventricle with resultant syringomyelia.

Idiopathic stenosis of the foramina of Magendie and Luschka is a rare cause of obstructive hydrocephalus involving the fourth ventricles. Like other causes of non-communicating hydrocephalus, it can be treated with ETV. Karachi et al. reported three patients (21, 53 and 68 years of age) presenting with either headaches (with or without raised intracranial pressure) or vertigo, or a combination of gait disorders, sphincter disorders and disorders of higher functions. In each case, MRI demonstrated hydrocephalus involving the fourth ventricles with no signs of an Arnold-Chiari type I malformation. The diagnosis of obstruction was confirmed using ventriculography and/or MR flow images. All patients presented with marked dilatation of the foramen of Luschka that herniated into the cisterna pontis. All patients were
Clinical anatomy of the fourth ventricle foramina

Critical review

Occlusion (e.g. infection, head trauma, intraventricular haemorrhage, space-occupying lesions, congenital anomalies)
Membrane obstruction
Congenital imperforation (agenesis)
Idiopathic stenosis
Arachnoid adhesions
Cystic dilation

Table 1: Main pathological conditions affecting the foramina of the fourth ventricle

Conclusion

The foramina of the fourth ventricle (Figure 1) are anatomically delicate and neurosurgically (neuroendoscopically) crucial parts of the ventricular system of the brain. They have close relations with several important structures of the brainstem and cerebellum. Slight differences seem to exist between the two sides regarding the location of the Luschka foramen. Pathological conditions affecting the foramina of the fourth ventricle (congenital or acquired) usually produce clinical manifestations due to obstruction of the normal flow of the CSF. Microsurgical treatment of such rare but challenging lesions is nowadays feasible.

Table 1: Main pathological conditions affecting the foramina of the fourth ventricle

1. Occlusion (e.g. infection, head trauma, intraventricular haemorrhage, space-occupying lesions, congenital anomalies)
2. Membrane obstruction
3. Congenital imperforation (agenesis)
4. Idiopathic stenosis
5. Arachnoid adhesions
6. Cystic dilation

References

Critical review

Competing interests: None declared.

All authors contributed to conception and design, manuscript preparation, read and approved the final manuscript. All authors abide by the Association for Medical Ethics (AME) ethical rules of disclosure.

Licensee OAPL (UK) 2014. Creative Commons Attribution License (CC-BY)