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Original article

Evaluation of CSF Flow Patterns of Posterior Fossa Cystic Malformations in Pediatrics Using CSF Flow MR Imaging

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Abstract:

Background: Posterior fossa cystic malformations alter cerebral spinal fluid flow dynamics, leading to the increasing use of flow-sensitive magnetic resonance (MR) methods to evaluate both qualitative and quantitative aspects of this fluid flow. Aim: To evaluate cerebral spinal fluid flow patterns of posterior fossa cystic malformations in pediatrics utilizing cerebral spinal fluid flow magnetic resonance imaging. **Patients and methods:** This prospective cross sectional research was performed on fifty cases that were enrolled in this study with age ranged from 1-15 years old with 38 cases males and 12 cases females at Radiodiagnosis Department, Faculty of Medicine, Benha University over the period between august 2022 to august 2024. **Results:** On comparison between patient groups according to quantitative MRI CSF flowmetry findings, there was no significant difference among groups regard EDV but regard PSV (DWM+ DWV) was significantly lower than other groups with no significant difference among other groups, and regard SV: MCM & AC groups were sig lower than other groups and (DWM+ DWV) was significant higher than both groups and sig lower than PBC group. Insignificant variance or relation was observed among MRI CSF flowmetry findings and Hydrocephalus. **Conclusion:** Phase contrast MRI is a non-invasive technique used to evaluate cerebral spinal fluid flow patterns of posterior fossa cystic malformations, providing qualitative and quantitative differentiation, and serves as an essential adjunct to routine MRI diagnosis and management.

Key words: MR Imaging; posterior fossa cystic malformations; CSF

Introduction

The ventricles of the brain and the subarachnoid space surrounding the brain and spinal cord are filled with cerebrospinal fluid, watery fluid, a clear. The cerebrospinal fluid is crucial for the brain's development during evolution and protection against external trauma [(1)].

Adults typically maintain a cerebrospinal fluid pressure of five to fifteen mmHg (65–195 mm H2O). The normal CSF pressure in kids under the age of six is between ten and one hundred mm H2O [(2)].

The foramen magnum is pulsatile, with a "to and fro" nature, and cerebrospinal fluid flows through the aqueduct of Sylvius. The cerebral spinal fluid flows through foramen magnum and the aqueduct in a caudal direction during systole, but the direction changes during diastole. Phase-contrast magnetic resonance imaging detects and asses this pulsatile flow [(3)].

The cerebral aqueduct in the posterior fossa facilitates the flow of cerebrospinal fluid through the 4th ventricle and into the basal cisterns through the cisterna magna or the foramina of Luschka through the foramen of Magendie. The flow of cerebrospinal fluid is in coherence with the cardiac cycle within the posterior cervical subarachnoid space and cisterna magna [(4)].

Within the posterior fossa, cystic malformations that contain cerebrospinal fluid include persistent Blake's pouch cyst, arachnoid cyst, Dandy-Walker malformation (DWM), mega cisterna magna (MCM), and Dandy-Walker variant (DWV) [(5)].

Due to the overlapping characteristics of these entities, the differential radiologic diagnosis of cystic malformations of the PA is frequently challenging to determine using conventional imaging methods [(4)].

PA cystic malformations occupy the cerebral spinal fluid spaces, which allow them to change the dynamics of the cerebral spinal fluid flow. In the past decade, there is a growing use of flow-sensitive magnetic resonance methods to evaluate both the qualitative and quantitative dynamics of the cerebral spinal fluid flow [(6)].

Phase contrast magnetic resonance imaging is a method that is non-invasive, rapid, and simple to apply. It's sensitive to extremely small cerebral spinal fluid flows and may be utilized for assessing CSF flow in a quantitative as well as qualitative manner. At the suspected degree of obstruction, CSF flow assessment provides reproducible and accurate outcomes that facilitate a more precise diagnosis. It may additionally be utilized to inform decisions regarding therapy and to monitor the results of management after it has been administered [(7)].

The two series of phase-contrast imaging methods have been utilized to assess the cerebral spinal fluid flow. The first one is located in the axial plane and is equipped with through-plane velocity encoding for flow quantification. The second one is located in the sagittal plane and has in-plane velocity encoding for qualitative evaluation. To perform a through-plane assessment, an axial oblique plane that is perpendicular to the long axis of the aqueduct is utilized. As a result of the reduction in partial volume impacts, this method is more accurate when it applies to quantitative assessment [(8)].

The goal of this research was to evaluate cerebral spinal fluid flow patterns of PA cystic malformations in pediatrics through the use of cerebral spinal fluid flow magnetic resonance imaging.

Patients and methods

This prospective cross sectional research was performed on fifty cases thatwere enrolled within this study with age ranged from 1-15 years old with 38 cases males and 12 cases females at Radiodiagnosis Department, Faculty of Medicine, Benha

University over the period between august 2022 to august 2024 after obtaining approval from Institutional Review Board (IRB) and explaining the study and obtaining written consent from first degree relative of children included in the study. The study was approved by the local Research Ethics Committee (Benha Faculty of Medicine Research Ethics Committee: {M.D16.8.2022}

Inclusion criteria: Patients with suspected hydrocephalus and increased intracranial pressure; clinically: headache, vomiting, gait instability and urine incontinence and radiologically: Posterior fossa cystic malformations.

Exclusion criteria: Patient with solid posterior fossa lesions, Patients who have been reported to have contraindications for magnetic resonance imaging , such as those with an pacemakers, , implanted magnetic device, cochlear implants, claustrophobia in older kids, and patients who reject to participate in the investigation.

Methods:

Our final sample size included fifty patients divided into five subgroups based on their clinical & MRI findings as follows: - mega cisterna magna, Dandy-walker variant, Dandy-walker malformation, persistent Blake pouch cyst, and Posterior fossa arachnoid cyst.

MRI and MR CSF Flowmetry examination:

Patient preparation: On arrival at the MRI unit, patients were reinterviewed to exclude any contraindications to performing the MRI examination. Irritable or uncooperative patients were referred to an attending anesthesiologist for sedation. Premedication used during sedation was Choral hydrate 250 mg orally.

MR imaging data acquisition: The research has been carried out on 1.5 tesla Siemens, GE and Philips MRI machines with placement of ECG leads for cardiac gating. The patient laid down on the MRI table in supine position following placement of the head coil.

All cases received routine magnetic resonance imaging brain imaging, which involved:

Axial T1WIs: TE =10 ms, TR = 538 ms.
Axial T2WIs: TE =120 ms, TR =4130ms.
Sagittal T2WIs; TE =120 ms, TR =4130ms.
Axial FLAIR WIs: TR= 11000 ms, TE = 140 ms, TI =2800 ms.
Axial DWI: TR = 3700 ms, TE = 108 ms.

All patients underwent a phase contrast MR imaging sequence in addition to the conventional brain magnetic resonance imaging procedure. to ensure that the frames collected contain the entire cardiac cycle, phase contrast magnetic resonance images were processed according to the cardiac cycle using ECG (electrocardiography) or PPU (peripheral pulse unit).

Axial and sagittal phase contrast magnetic resonance imaging have been conducted with the following acquisition variables:

Flip angle: ten degrees.
TR/TE: 21/6.8.
Section thickness: ten mm.
FOV: AP 190.
Matrix size: 236x182.
Encoding velocity: eight to twelve centimeters per seconds (ranged regarding expected velocity within each case).
Encoding direction: caudo-cranial or cranio-caudal.

No complications were noted during exam as it is a safe non-invasive technique. At the end of the procedure, the head coil was removed, and sedated patients stayed under the observation of the anesthesiologist until they regained consciousness.

Data collection:

The following data was collected, tabulated, analyzed, compared, and evaluated statistically.

Patient characteristic data: including age, sex and clinical status.

Descriptive data from conventional MRI as mega cisterna magna, Dandy-walker malformation, persistent Blake pouch cyst,

Dandy-walker variant and posterior fossa arachnoid cyst.

From the phase contrast magnetic resonance images

Qualitatively images: were analyzed for abnormal flow patterns, including simultaneous bidirectional flow, attenuated flow, signal inhomogeneity, and the connection among posterior fossa cysts and subarachnoid spaces.

Quantitative images: were analyzed for the subsequent variables attained at variant concentrations of flow quantification: end diastolic velocity (EDV in cm/sec), stroke volume (SV in microliter (µL) /cycle), & peak systolic velocity (PSV in cm/sec), the results were compared with different types of posterior fossa cysts.

The stroke volume value: was semi-automatically calculated according to parameters provided by each MRI machine as follows

In Phillips MR Machine:

- The following parameters were automatically provided:
- Forward flow volume in milliliter per second.
- Backward flow volume in milliliter per second.
- Manual calculation of stroke volume (in µL /cycle) was performed as follows: forward flow volume (in milliliter per second) x 1000 + backward flow volume (in milliliter per second) x 1000 / 2.

In GE MR Machine:

- The following parameters were automatically provided:
- Peak positive velocity in centimeters per second.
- Peak negative velocity in centimeters per second.
- Sum flow values (Flux) in ml/min.
- Manual calculation of the stroke volume (in µL /cycle) was performed as follows: Mean systolic flow (calculated as sum of flux values/number of phases) x duration of cardiac cycle.

In Siemens MR Machine:

Manual calculation of the stroke volume (in µL /cycle) was performed as follows: mean systolic flow (calculated as sum of flux values/number of phases) x duration of cardiac cycle.

Statistical analysis

Microsoft Excel was used to code, enter, & analyze historical data as well as basic clinical examination, laboratory tests, & outcome measurements. After that, data were loaded into statistical package for social sciences (SPSS version 20.0) program in order to be analyzed. Qualitative data was represented as a number & percentage, while quantitative data was represented as a mean ± standard deviation. Chi square test (X2) was utilized to assess for significance in differences between qualitative & quantitative variables. Variations between many groups by ANOVA & LSD & between quantitative independent groups using t test. For significant results, P value was set at <0.05, & for highly significant results, at <0.001.

Results

This prospective cross sectional study includes 50 patients presented by clinically suspected posterior fossa cystic malformations to assess role of MRI CSF-flowmetry in evaluation of various types of posterior fossa cystic malformations.

50 patients with clinically suspected posterior fossa cystic malformations with ages varied between one to fifteen years with mean 6.62+/-3.8 years were included, of the patient's population, 38 were male (76%) and twelve have been female (twenty-four percent) with men to women ratio =3.1; 1. Concerning the hydrocephalic changes, 90% of the patients had Hydrocephalus and 10% with no Hydrocephalus **(Table 1).**

There was no significant difference or association between Hydrocephalus distribution and different types of cystic malformation (**Table 2)**

Table 1: Sex and Age Distribution, and Hydrocephalus Distribution in the Examined Group (N=50)

Age (years)	**Mean± Standard Deviation**	**6.62±3.8**	
	Median (Range)	**5.0 (1-15)**	
		N	**%**
Sex	**Male**	**38**	**76.0**
	Female	**12**	**24.0**
	Total	**50**	**100.0**
		Number	**%**
Hydrocephalus	**-VE**	**5**	**10.0**
	+VE	**45**	**90.0**
	Total	**50**	**100.0**

Table 2: The relation between different cystic malformations and hydrocephalus.

			Malformation				**X^2**	**P**
			AC	**DWM&DWV**	**MCM**	**PBC**		
Hydrocephalus	**-VE**	**N**	2	1	1	1		
		%	16.7%	5.9%	50.0%	5.3%		
	+VE	**N**	10	16	1	18	4.92	0.17
		%	83.3%	94.1%	50.0%	94.7%		
Total		**N**	12	17	2	19		
		%	100.0%	100.0%	100.0%	100.0%		

Table 3: Conventional magnetic resonance imaging results within every patient group.

Group	**Magnetic resonance imaging findings**
1-Dandy Walker malformation (**N.=16**)	– Cerebellar vermis agenesis/hypoplasia with large posterior fossa cyst communicated with dilated 4th ventricle. – Elevated tentorial insertion (torcula). – Supratentorial ventricular dilatation. – other brain congenital anomalies (e.g. corpus callosum agenesis, heterotopia., lissencephaly)
2- Dandy Walker Variant (**DWV**) (**N.=1**)	– Cerebellar vermis hypoplasia. – Retro cerebellar cyst communicated with 4th ventricle. – Moderate supratentorial hydrocephalus.
3-Black pouch cyst (BPC) (**N.=19**)	– Posterior fossa cyst anteroinferior to the cerebellar vermis displaying CSF signal on all pulse sequences. – Associated with hydrocephalic changes in most cases.
4- posterior fossa arachnoid cysts (PFAC) (**N.=12**)	– Retro-cerebellar cyst displaying CSF signal on all pulse sequences. – Associated with hydrocephalic changes if large enough compressing the cerebellum and fourth ventricle.
5- Mega cisterna magna (MVM) (**N.=2**)	– Retro cerebellar CSF signal intensity with normal cerebellar hemispheres, normal 4th ventricle and normal vermis. – One case showed mildly dilated supratentorial ventricles 2nd to atrophic changes.

Table 4: Comparison of Patient Groups Based on Quantitative MRI CSF Flowmetry Findings and Their Distribution in Relation to Hydrocephalus

	AC	**DWM+DWV**	**MCM**	**PBC**	**F**	**P**
PSV	-9.46±1.87	-3.88±1.36*	-11.95±0.49	-10.99±3.38	17.99	0.00**
EDV	7.73±1.23	6.07±2.11	9.0±0.84	6.77±2.39	1.509	0.22
SV	33.50±1.90	50.72±13.37	21.7±8.91	83.40±26.66	22.36	0.00**
	Hydrocephalus		**No**		**t**	**P**
PSV	-8.18±2.85		-8.77±3.01		0.280	0.781
EDV	6.86±2.16		6.76±2.48		0.089	0.930
SV	61.22±23.6		60.78±21.9		0.033	0.974

The following table summarizes the conventional MRI findings of the studied groups **(Table 3)**

On comparison between patient groups according to quantitative MRI CSF flowmetry findings, there was no significant difference among groups regard EDV but regard PSV (DWM+ DWV) was significantly lower than other groups with no significant difference among other groups, and regard SV: MCM & AC groups were sig lower than other groups and (DWM+ DWV) was significant higher than both groups and sig lower than PBC group. Insignificant variance or relation was discovered among MRI cerebrospinal fluid flowmetry findings and Hydrocephalus (**Table 4**).

Case (1)

A 1-year-old female patient presented clinically with macrocephaly, on neurological examination, she suffers epilepsy and signs of increased intracranial tension with clinically suspected hydrocephalus.

Conventional MRI findings:

Base line MRI study including fig (A) axial T1, fig (B) Axial T2, fig (C) sagittal T2 -CISS-3D show:

Hypoplasia of the cerebellar hemispheres, agenesis of the cerebellar vermis, cystic dilatation of the posterior fossa connected with dilated 4th ventricle and rotated, elevated tentorial insertion.

Marked dilatation of the supra-tentorial ventricular system with patent sylvian aqueduct. **show (Case (1).**

CSF Flowmetry study:

Qualitative assessment: Sagittal phase contrast images fig (D, E) show bidirectional aqueductal flow into the posterior fossa cyst. No connection among the posterior subarachnoid and space posterior fossa cysts.

Quantitative measurements: Velocity-time curve fig (F) shows cerebrospinal fluid in both systole (below the base line) and diastole (above the base line curve) with PSV=-1.2cm/sec, EDV=1.4cm/sec, SV=27.5 microliter/cycle.

The conventional MRI, and CSF flowmetry studies findings consistent with Dandy Walker malformation with marked supra-tentorial hydrocephalus. Hypodynamic CSF flow along the Sylvian aqueduct. Negative cerebrospinal fluid flow among the cervical subarachnoid spaces and the retro-cerebellar cyst **show (Case (1).**

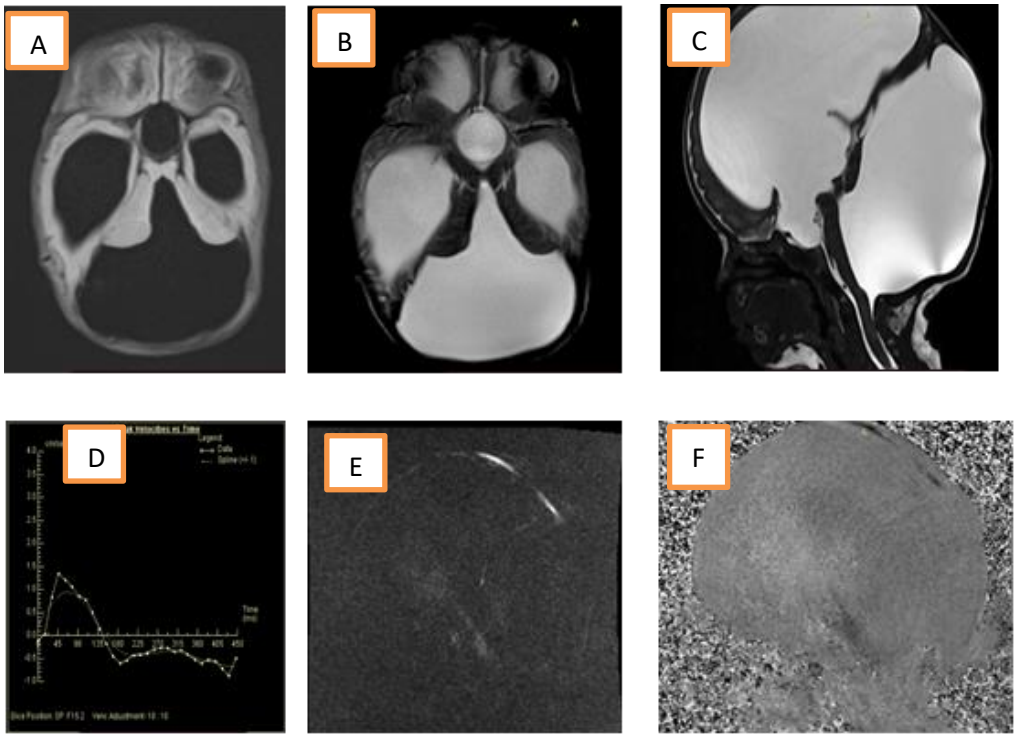

Fig 1 (cases (1) shwing: (A) axial T1, (B) Axial T2, (C) sagittal T2, (D, E) show bidirectional aqueductal flow into the posterior fossa cyst. No connection among the posterior subarachnoid and space posterior fossa cysts and **(F)** shows cerebrospinal fluid in both systole (below the base line) and diastole (above the base line curve) with PSV=-1.2cm/sec, EDV=1.4cm/sec, SV=27.5 microliter/cycle.

Case (2)

A 11-year-old female patient presented clinically with headache and mild epileptic fits, on neurological examination, she suffers signs of increased intracranial pressure with gait instability.

Conventional MRI findings:

Base line MRI study including **fig (A)** axial T1, **fig (B)** Axial T2, **fig (C)** sagittal T2 - CISS-3D show:

Infra-vermian cyst seen continuous with dilated 4th ventricle, indenting the inferior aspect of the cerebellum. Moderate dilatation of the supra and infratentorial ventricular system with patent sylvian aqueduct. Normal posterior fossa size. Normal cerebellum and brain stem. **show (Case (2).**

CSF Flowmetry study:

Qualitative assessment: Sagittal phase contrast images **fig (D, E, F)**

Free aqueductal cerebrospinal fluid flow during cerebrospinal fluid systole (hypointense signal), and during diastole (hyperintense signal).

No evidence of cerebrospinal fluid flow found in the infra-vermian cyst.

The flow is not present between infra-vermian cyst and cervical subarachnoid spaces.

Quantitative measurements: Velocity-time curve **fig (G, H)** shows cerebrospinal fluid in both systole (below the base line) and diastole (above the base line curve) with SV= 70 microliter/cycle.

The conventional MRI and CSF flowmetry study's findings of Supra and infra-tentorial ventricular moderate (communicating) hydrocephalus with hyperdynamic cerebrospinal fluid flow across patent aqueduct and no flow within the infra-vermian cyst, Persistent Blake's pouch cyst is indicated by negative cerebrospinal fluid flow among the posterior cervical subarachnoid spaces and the PFAC. **show (Case (2).**

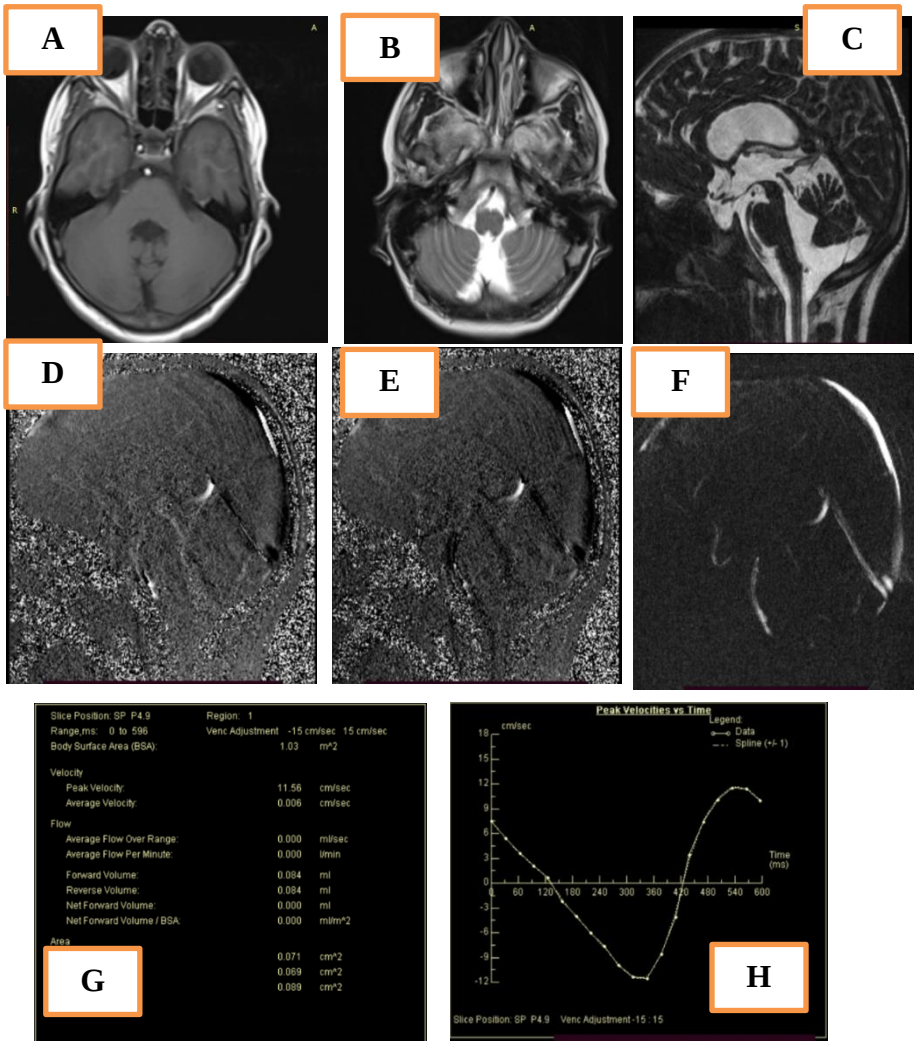

Fig 2 (cases (2) shwing: (A) axial T1, **(B)** Axial T2, **(C)** sagittal T2, **(D, E, F)** free aqueductal cerebrospinal fluid flow during cerebrospinal fluid systole (hypointense signal), and during diastole (hyperintense signal) and **(G, H)** shows cerebrospinal fluid in both systole (below the base line) and diastole (above the base line curve) with SV= 70 microliter/cycle.

Discussion

Our study included 50 patients with clinically suspected hydrocephalus and elevated intracranial pressure, regarding the demographic data of our patients, their ages varied between one to fifteen years with average age 6.62±3.8, 38 males (76%) and 12 females (24%) with men to women ratio =3.1;1**.**

This was in keep with Yildiz and colleagues [(9)] who within the research, there were forty cases (eighteen females and twenty-two males; mean age 23.5 years; range, three months to sixty-three years).

In our study we had 45 cases (90%) with hydrocephalus and 5 cases (10%) with no hydrocephalus, cases with hydrocephalus distributed as the following 10 cases (22.2%) with arachnoid cysts, 16 cases (35.6%) with DWM, and 18 cases (40%) with PBC and one case (2.22%) with MCM. BPC most common cases with hydrocephalus.

This was unlike Yildiz and colleagues [(9)] who had 2 cases with Blake's pouch cyst, seven cases with non-communicating arachnoid cysts, and one patient with DWM associated with hydrocephalus with

Arachnoid cysts most common cases with hydrocephalus.

Within the current research, insignificant variance or association was observed among Symptoms distribution and different types of cystic malformation, also there was no significant difference or association between hydrocephalus and symptom distribution.

The subarachnoid space surrounding the spinal cord and brain, as well as the ventricles of the brain, is filled with cerebrospinal fluid, watery fluid, a clear. The foramen magnum is pulsatile, with a "to and fro" nature, and cerebrospinal fluid flows through the aqueduct of Sylvius. PC magnetic resonance imaging gating is synchronized with the cardiac cycle. During systole, cerebrospinal fluid flows through the aqueduct and foramen magnum in a caudal direction those changes during diastole. Phase-contrast magnetic resonance imaging identifies and calculates this pulsatile flow **(10, 11)**.

Magnitude and phase images comprise phase-contrast magnetic resonance imaging. The magnitude image shows the visualization of flowing cerebrospinal fluid as a bright signal, whereas stationary tissues are suppressed and represented as a black background. The phase image is phase-shifted, with white and black signals indicating forward and backward flows, respectively. It contains velocity information that may be quantitatively calculated, as it's phase-dependent. Both types of images may show pulsatile cerebral spinal fluid flow **(12)**.

In patients with DWM, away from one case with DWM that shows connection between posterior fossa cyst and the posterior cervical subarachnoid space, all other cases with DWM showed no flow between cyst and the posterior cervical subarachnoid space. The posterior fossa cyst is the site of flow through the aqueduct, and a cerebrospinal fluid flow signal has been observed in the cyst. All of the cases that involved hydrocephalus had hyperdynamic aqueductal flow, with the exception of one case, which presented hypodynamic flow.

The cerebrospinal fluid did not flow through the posterior cervical subarachnoid space and the prominent retro-cerebellar cerebrospinal fluid space in children with the Dandy-Walker variant. There was hypodynamic aqueductal flow onto the 4^{th} ventricle and the retro-cerebellar cyst. The cerebrospinal fluid flow signal didn't include the entire cyst, and it could be seen throughout the cardiac cycle.

In patients with black pouch cyst, there was no cerebrospinal fluid flow signal within the infra-vermian cyst. There was no flow between the cyst and the posterior cervical subarachnoid space. The aqueductal flow was hyperdynamic within the case with hydrocephalus except two cases showed hypodynamic aqueductal flow**.**

The clinician is able to select the most appropriate therapy method for a case with a posterior fossa arachnoid cyst by observing the communication between the arachnoid cyst and subarachnoid cerebrospinal fluid spaces. The imaging plane is adjusted regarding to the expected point of communication; it could be in the sagittal, coronal or axial, planes to identify pulsatile flow (white and black shades) at the neck of the cyst in phase images as evidence of communication with the subarachnoid spaces. This is due to the fact that the pulsatile movement of the cerebrospinal fluid in the subarachnoid spaces is transmitted to the neck of the cyst through the point of communication. The absence of such a signal is indicative of non-communication **(13)**.

Throughout the entire cardiac cycle, pulsatile cerebrospinal fluid flow has been noticed in the entry zone of the cysts adjacent to the foramen magnum in our cases with communicating arachnoid cysts. This flow was more pronounced during early systole, and there wasn’t flow signal in the remaining parts of the cysts.

Within patient with non-communicating AC, there was no flow among the upper cervical subarachnoid space and the cysts at the foramen magnum level.

In cases with arachnoid cysts, the cerebrospinal fluid flow pattern of the central cerebrospinal fluid spaces was consistent; however, different flow patterns were observed in the aqueduct and the 4th ventricle of cases that were diagnosed with hydrocephalus. These variations were attributed to the increased mass impact of the cyst.

One case of mega cisterna magna (MCM) cases demonstrated homogeneous hypointense cerebrospinal fluid flow throughout the large retro-cerebellar cistern during early cardiac systole, while the other case observed flow in the inferior part of the cyst throughout the cardiac cycle. The MRI cerebrospinal fluid Flowmetry investigation through the aqueduct of Sylvius, 4th ventricle, and cervical subarachnoid space had been normal in all cases.

This was in a line with [9] who stated that; the PF cyst was the site of aqueductal flow in all Dandy-Walker malformation cases, and the pulsatile signal of cerebrospinal fluid flow has been observed in the cyst. In any case, there wasn't flow between the posterior cervical subarachnoid space and the cisterna magna. The case with hydrocephalus observed hyperdynamic aqueductal flow**.**

The prominent retro-cerebellar cerebrospinal fluid space and the posterior cervical subarachnoid space were the sites of cerebrospinal fluid flow in cases with DWV. During the cardiac cycle, this flow signal has been noticed. Flow wasn't noticed from the 4th ventricle into the retro-cerebellar space. Furthermore, the cardiac cycle wasn't synchronized with the aqueductal flow, which was extremely slow.

Within the cysts of all three cases with Blake's pouch cyst, there wasn't cerebrospinal fluid flow signal. There wasn't flow among the cyst and the posterior cervical subarachnoid space**.** The aqueduct, 4th ventricle, and 3rd ventricle all showed hyperdynamic pulsatile flow, despite the fact that 2 of the cases had hydrocephalus**.**

Pulsatile cerebrospinal fluid flow has been found in the entry zone of the cysts adjacent to the foramen magnum in all cases with communicating arachnoid cysts. This flow was evident throughout the entire cardiac cycle, however it was more pronounced in early systole. In cases where arachnoid cysts were non-communicating, none of the cases with retro-cerebellar non-communicating arachnoid cysts showed any flow between the upper cervical subarachnoid space and the cysts at the foramen magnum. 4 of the cysts showed hydrocephalus, and there was no pulsatile cerebrospinal fluid flow among them.

The large retro-cerebellar cistern in early cardiac systole showed homogeneous hypointense cerebrospinal fluid flow in all cases with mega cisterna magna. The flow in cervical subarachnoid space, the aqueduct, 4th ventricle, and prepontine cistern had been normal.

Insignificant variance or relation was observed among MRI CSF flowmetry findings and hydrocephalus, also there was no significant difference or association between hydrocephalus distribution and different types of cystic malformation.

In study done by [7] they found that in patients with obstructed hydrocephalus, quantitative analysis through the aqueduct discovered irregular cerebrospinal fluid flow curve.

Conclusion

Phase contrast MRI is non-invasive technique used to assess cerebrospinal fluid flow patterns of different PA cystic malformation both qualitatively and quantitatively to differentiate between them so used as useful adjunct to routine MRI in diagnosis and management.

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