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# Role of MRI CSF flowmetry in pediatric hydrocephtalus

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**Abstract**
**Objective:** is to assess intracranial CSF flow dynamics in pediatric patients with hydrocephalus suspected on morphological sequences using phase contrast MRI.
**Methods:** A prospective observational study included eighty individuals from the pediatric population, 60 patients with ventriculomegaly and suspected hydrocephalus (diagnosed by a radiological report) who referred from Pediatric department and outpatients clinics of Al-Azhar University Assiut and 20 healthy control.
**Results**: Patients were given diagnosis based on findings of conventional MR images, and were categorized into two major groups:-Group (I): Obstructive hydrocephalus (No.=31):-that subdivided into 3 sub-groups. Subgroup (Ia) Patients had aqueductal stenosis (No. =15).Subgroup (1) Patients had Arnold Chiari malformation. (No. =10).Subgroup (Ic) Patients had hydrocephalus with intracranial. SOL (No. =6).Group (II): Non Obstructive hydrocephalus (No. =29):-That subdivided into 3 sub-groups: Subgroup (2) patients had communicating hydrocephalus (no=16).Subgroup (IIb) 10 Patients had brain atrophy (No. =10).Subgroup (IIc) Patients had Dandy-Walker spectrum (No. =3).
**Conclusion:** This technique enables measuring aqueductal flow parameters in a reliable and reproducible way and enable further future understanding of the pathophysiology of abnormal CSF dynamics in cases of hydrocephalus that still appears vague. The optimal cut of value of hypodynamic CSF flow through cerebral aqueduct in comparison of all obstructive subgroups with control group is the 7.5 µl, with sensitivity 100%, specificity 64% and P value > 0.05. The optimal cut of value of hyperdynamic CSF flow through cerebral aqueduct in comparison of non-obstructive subgroups with control group is the 37.5 micro-liter with sensitivity 100%, specificity 40% and P Value > 0.05.
Cine Phase images can detect spontaneous third ventriculostomy that may occur in some cases of long standing hydrocephalus.

**Keywords:** (AS) aqueductal stenosis, (µl), microliter

## Introduction

The cerebrospinal fluid (CSF) is produced primarily in the choroid plexus on the lateral and third ventricles and then flow in the cranial and spinal subarachnoid spaces from which it is absorbed in blood circulatory system [3].
Hydrocephalus is an excessive accumulation of CSF in the cerebral CSF spaces due to imbalance of its production and resorption, the balance between production and resorption of CSF is a constant value. Hyperproduction of CSF seen in patients with papillomas of the choroid plexus. In most of the cases, hydrocephalus is usually a result of impaired resorption of CSF, or may due to blockage of CSF pathways. On the one hand, decrease of resorption may be a result of blockage of arachnoid vili [4].
MRI plays an important role in the diagnosis of hydrocephalus. Despite providing valuable anatomical data, conventional MR imaging in cases of hydrocephalus has some important limitations. Criteria for diagnosis of hydrocephalus on conventional MR images often depends on subjective evaluation by neuroradiologist and may be difficult to assess in some patients [5]. Additionally, when faced with ventriculomegaly on MR images, it sometimes may not be straight forward to determine whether this is associated with patent CSF pathways, or whether there's obstruction, or whether this obstruction, if present, is due to extra- or intra-ventricular cause. Furthermore, it lacks physiological information and is often challenging to verify the presence of complete obstruction to CSF flow at the level of the suspected anatomical obstruction, which is critical in determining surgical outcome [6].
Phase contrast MR imaging is a rapid, simple and non-invasive technique which is sensitive to even small CSF flows, and can be used to evaluate CSF flow both qualitatively and quantitatively. Cine phase contrast MR images show CSF flow in a dynamic, more easily appreciable, and in a more pleasing manner, allowing the delineation of obstruction, if present, along the portions of CSF pathway where obstruction is common (foramen of Monro, aqueduct of Sylvius) [6].
CSF flow measurement at the suspected level of obstruction gives reliable and reproducible results for more accurate diagnosis, and can be used to guide therapeutic decisions in a more reliable manner, and follow up post treatment outcome [7].
Aim of this study was assess intracranial CSF flow dynamics in pediatric patients with hydrocephalus suspected on morphological sequences using phase contrast MRI.

## Patients and Methods

Between September 2017 and December 2019, Eighty patients aged between 1 day -18 years from the pediatric population were included in this study, 60 patients with ventriculomegaly and suspected hydrocephalus (diagnosed by a radiological report) A control group included 20 individuals, age & sex matched, who showed normal ventricular size on conventional MR images and without any clinical complaint at the radiology Department, Faculty of Medicine, Al Azhar University at Assiut, Egypt.

Inclusion criteria:

- Patients with range of age between 1 day -18 years old who diagnosed with ventriculomegaly and suspected hydrocephalus (clinically and radiologically)
- No gender predilection.

**Exclusion criteria**

- Patients known to have contraindications for MRI, e.g. an implanted magnetic device, pacemakers or claustrophobia.
- Patients above 18 years old
- Patients with V-P shunts to avoid fallacies in the measurements that might be caused by the shunts.

**All patients were subjected to**

- History taking and Clinical examinations.
- Conventional MRI, All patients underwent routine MR brain imaging, including, Axial T1, FLAIR, T2 WI AND Diffusion WI, sagittal T2 WI. Mid line-sagittal FIESTA image. All MRI scans were performed by a 1.5 Tesla Philips MACHINE& 1.5 Tesla using a head coil at MRI unit at Radio diagnosis and medical imaging department, AL-Azhar University Assiut Hospital.

**Cine Phase contrast MR technique**

- Cine Phase contrast MR technique, in all cases, cardiac gating was performed with MR compatible electrodes. Phase contrast MR images were gated to the cardiac cycle by ECG, so that the frames obtained covers the entire cardiac cycle and Sagittal and axial phase contrast MR imaging was performed Sagittal and axial phase contrast MR imaging was performed with the following acquisition parameters, Flip angle: 10 degrees, TR/TE: 21/6.8 Section thickness: 10 mm, FOV: AP 190, Matrix size: 236x182, Velocity Encoding (VENC): ranged between 5- up to 25 cm/s(average 15 cm/s), and if aliasing was observed, we decreased the encoding velocity in increments of 5-cm/sec until aliasing resolved and Encoding direction: cranio-caudal or caudo-cranial.
- For sagittal phase contrast MR imaging, the midline sagittal plane which clearly shows the aqueduct of Sylvius, and the anterior and posterior CSF spaces at the cranio-cervical junction will be chosen from regular imaging.
- Quantitative CSF flow measurements were obtained by performing axial phase contrast MR imaging. Traditionally, axial images are acquired in a plane perpendicular to the presumed direction of CSF flow at the level of aqueduct of Sylvius.

**Velocity Parameters**

- Peak systolic velocity (cm/sec) highest CSF velocity of the obtained measurement during the systole.
- End diastolic velocity (cm/sec) highest CSF velocity of the obtained measurement during the diastole.
- Mean (average) velocity (cm/sec) during both systole and diastole.

**Volumetric Flow Parameters**

- Mean Flow rate (ml/min)= Summation Of Flow Values /Their Numbers)
- Stroke volume (microliter) defined the mean volume of CSF passing the aqueduct during the systole =mean systolic flow X CSF duration during the systole.

**Statistical analysis**

Data were analyzed and expressed in tables using Statistical Package for Social Science (SPSS). Statistical methods included descriptive methods (mean, standard deviation, frequency distribution) and significance tests (t-test for quantitative data, correlation coefficient test and analysis of variance (ANOVA) tests). The significance will be adjusted when P equal 0.05 or less.

**Results**

The patients' age ranged from 3 years to 26 years &divided into 3 groups from 3-10 years which is the commonest age group, from 11-15 years which is the 2nd common age group and above 15 years which is the 3rd common age group. Male and female patients were almost equal.

According to patient`s age that ranged from 15 days to 18 years, they divided them in to 3 groups with age group from 1 to 10 years found to be the most common (35 patients 58.3%), with mean age 4.2±4.8 years

**Table 1:** distribution of the cases among patient’s age groups.

| Age group (years) | No. of Pat. | Percentage % | Chi-square $\chi 2$ | P |
|---|---|---|---|---|
| < 1 year | 16 | 26.6% | 0.794 | 0.986 |
| 1-10 year | 35 | 58.3% | | |
| 10-18 year | 9 | 15% | | |
| Total | 60 | 100% | | |

In the present study, most common diagnosis was communicating hydrocephalus 16 patients (26.6%), then aqueductal stenosis 15 patients (25 %), Chiari malformation and brain atrophy were 10 patients for each diagnosis

**Table 2:** Distribution of patients according to diagnosis.

| Diagnosis | No. of patients | Percentage % |
|---|---|---|
| Communicating hydrocephalus | 16 | 26.6% |
| Aqueduct stenosis | 15 | 25 % |
| Brain atrophy | 10 | 16.6 % |
| Arnold Chiari Malformation | 10 | 16.6 % |
| Hydrocephalus with SOL | 6 | 10 % |
| Dandy walker spectrum | 3 | 5 % |
| Total | 60 | 100% |

There is marked decrease in CSF flow measurements through the aqueduct of Sylvius in comparison between control and all obstructive group from PSV, PDV to MPV through SSV and the difference was statistically significant.

**Table 3:** Comparison between the control and obstructive groups regarding PSV, PDV, MPV and SSV.

| Value by group Mean± SD | Control | Obstructive Group | F | P value |
|---|---|---|---|---|
| PSV | 4.81±1.33 | 2.99± 1.47 | 21 | 0.001* |
| PDV | 4.78±1.02 | 2.76±1.34 | 32 | 0.001* |
| MPV | 4.76±10.7 | 2.88±1.53 | 21 | 0.001* |
| SV | 21.5±4.81 | 7.2±4.85 | 105 | 0.001* |

The optimal cutoff value for hypodynamic CSF flow through cerebral aqueduct, Regarding SSV, for hypo dynamic CSF through cerebral aqueduct, the mean was 4.04± SD 0.2 and for control individuals 21.5 ± SD 4.81

(Mann Whitney test P). There is statistical significance for differentiation between hypodynamic CSF flows from control individuals. At a cut off value (7.5 microliter), lower values were suggested to hypodynamic CSF flow across cerebral aqueduct

**Table 4:** Comparison between the control and all obstructive subgroups regarding predilection of the optimal cutoff value for hypo dynamic circulation.

| Value by Group Mean± SD | AUC | Optimal Cut Off | P Value | Sensitivity | Specificity |
|---|---|---|---|---|---|
| SSV | 0.978 | 7.50 | 0.001* | 100% | 64% |

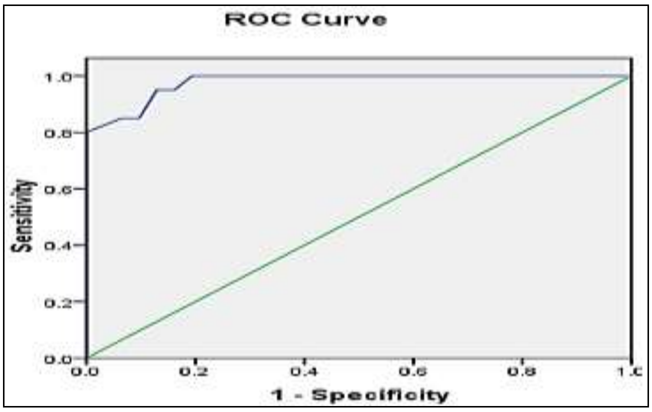


**Fig 1:** ROC curve for predilection of the optimal cutoff value for hypodynamic circulation

There is relative no difference in velocity measurements among flow through the aqueduct of Sylvius from PSV,PDV to MPV as well as there is relative decreased in SSV and the diff was statistically significant.Also there is interaction between control and brain atrophy subgroup.

**Table 5:** Comparison between the control and different subgroups regarding PSV, PDV, MPV and SSV.

| Value by group Mean± SD | PSV | PDV | MPV | SSV |
|---|---|---|---|---|
| Comm. Hydrocephlus | 8.82±2.49 | 4.95±0.48 | 11.7±0.97 | 51±14.3 |
| Aqueduct Stenosis | 1.67± 0.41 | 1.75±0.57 | 1.85±0.31 | 4.04±2 |
| Brain Atrophy | 4.75± 1.25 | 3.94±0.57 | 5.1±0.5 | 11.8±2.29 |
| Chiari Mal. | 4.7± 0.58 | 4.54±0.34 | 5.01±0.23 | 13.2±3.01 |
| Hydrocephlus with SOL | 3.45± 0.76 | 2.34±0.35 | 1.9±0.48 | 5.43±2.86 |
| DW Spectrum | 5.4± 0.90 | 5.07±0.68 | 5.06±0.41 | 14±2.08 |
| Control | 4.81±1.33 | 4.78±1.02 | 4.76±1.07 | 21.5±4.81 |
| F | 31 | 30 | 46 | 26 |
| $P_{LSD}$ | 0.001* | 0.001* | 0.001* | 0.001* |

In the current study, there is significant difference in velocity measurements among CSF flow through the aqueduct of Sylvius from PSV, PDV to MPV and SSV, in comparison between control and non-obstructive groups. No statistical significance as regard PDV.

**Table 6:** Comparison between the control and non-obstructive group regarding PSV, PDV, MPV and SSV.

| Value by group Mean± SD | Control | Non-Obstructive Group | F | P value |
|---|---|---|---|---|
| PSV | 4.81±1.33 | 7.06± 2.80 | 12 | 0.01* |
| PDV | 4.78±1.02 | 4.6±0.71 | 0.44 | 0.50 |
| MPV | 4.76±10.7 | 8.76±3.45 | 23.5 | 0.001* |
| SV | 21.5±4.81 | 33.6±22.2 | 5.7 | 0.02* |

There is relative increased difference in measurements among CSF flow parameters through the aqueduct of Sylvius from PSV, to MPV, marked increased in SSV. As well as there is no activity in PDV and the diff was statistically significant.also there is interaction between subgroups

**Table 7:** Comparison between the obstructive and non-obstructive group regarding PSV, PDV, MPV and SSV.

| Value by group Mean±SD | Obstructive Group | Non-Obstructive Group | F | P value |
|---|---|---|---|---|
| PSV | 2.99± 1.47 | 7.06± 2.80 | 50 | 0.001* |
| PDV | 2.76±1.34 | 4.6±0.71 | 43 | 0.001* |
| MPV | 2.88±1.53 | 8.76±3.45 | 74 | 0.001* |
| SSV | 7.2±4.85 | 33.6±22.2 | 41 | 0.001* |

The optimal cutoff value for hyperdynamic CSF circulation. Regarding SSV, for hyper dynamic circulation the mean was 33.6±22.2 and control individual 21.5 ± SD 4.81 (Mann Whitney test P). There is statistical significance for differentiation between SSV from non-obstructive lesions. At a cut off value (37.5 microliter) lesions higher value were suggested to hyperdynamic CSF flow across cerebral aqueduct

**Table 8:** Comparison between the control and all non–obstructive group regarding predilection of the optimal cutoff value for hyper dynamic circulation.

| Value by group Mean±SD | AUC | Optimal Cut Off | P value | Sensitivity | Spicificity |
|---|---|---|---|---|---|
| SSV | 0.998 | 37.5 | 0.001* | 100% | 40% |

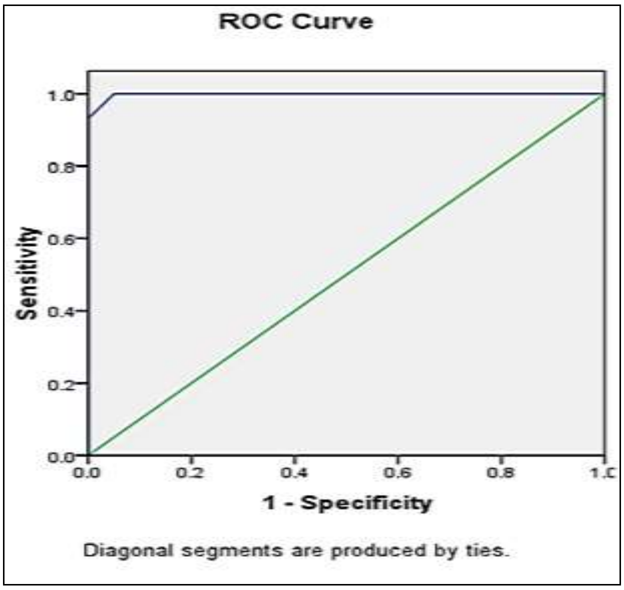


**Fig 2:** ROC curve for predilection of the optimal cutoff value for hyperdynamic circulation.

In this study one case with long standing supra-tentorial hydrocephalus due to aqueduct stenosis, shows turbulence of CSF flow at the base of the third ventricle. Cine phase images was done the site of turbulence, and shows unidirectional flow with PSV 12 cm/sec, PDV 0.5 cm/, MPV 8.75cm/sec, systolic duration 500 ms, SSV 41 µl, and absolute stroke volume (ASV) 41 µl..Denoting spontaneous third ventriculostomy.

**Table 9:** Findings of CSF flowmetry in one case with Spontaneous third ventriculostomy.

| Parameters | PSV | PDV | MPV | Systolic Duration | SSV | ASV |
|---|---|---|---|---|---|---|
| Value | 12 | 0.5 | 8.75 | 500 | 41 | 41 |

**Discussion**

CSF is present in all ventricles, CSF subarachnoid spaces, such as cisterns and sulci, and the central canal of the spinal cord. The rate of CSF formation in humans is about 0.3-0.4 ml min (about 500 ml day). Total CSF volume is 90-150 ml in adults and 10-60 ml in neonates and it undergoes resorption and reformation of its entire volume at least three times a day. Potential sites of CSF origin include the choroid plexus, parenchyma of the brain and the spinal cord, and ependymal lining of the ventricles [9].

During systole, arterial blood flows into the fixed cranial vault and the brain at a faster rate than venous blood exits these structures, yielding a net gain in parenchymal and intracranial blood volume. CSF flows caudally from the ventricles and the subarachnoid space into the spinal canal, with the distal spinal canal acting as a capacitor that accommodates the excess CSF. During CSF diastole, venous blood exits the cranial vault at a faster rate than arterial blood enters it, with a resultant net loss in intracranial blood volume and a reversal of CSF flow [10, 11].

The phase contrast technique is extremely sensitive even to slow flow and provides the potential for noninvasive flow quantification. The results of these measurements have yielded considerable information on the physiology of the normal CSF circulation and were applied and analyzed in pathological conditions such as aqueductal stenosis, Chiari malformation and normal pressure hydrocephalus [12].

Cardiac-gated phase-contrast MRI has emerged as a fascinating technique for dynamic imaging of the CSF flow and evaluating different parameters of CSF dynamics, both qualitatively and attempted quantitatively [13].

In this study, we attempted to characterize patterns of CSF flow in pediatric patients presented with ventriculomegaly and suspected hydrocephalus.

Among the sixty (60) patients included in the study males representing 55% & females representing 45%. (33 males, 27 females), the age ranged between (15 day to 18 years); with mean age: 4.2 ± 4.8 years. No gender predilection was noted as reported in the literature Greitz 2006 [14].

While in Abdelhameed *et al.* 2017 [15], that included 20 hydrocephalus patients of age range of 2 months to 12 years, they found female predominance 12 females and 8 males

In our study Quantitative assessment of our 15 patients showed moderate to marked reduction of the systolic peak and mean velocity as well as stroke volume in comparison with non-hydrocephalic individuals in the control group, with average peak systolic velocity of 1.67 ± 0.41 cm/s, average PDV 1.75 ± 0.57 cm /sec, MPV 1.85 cm ± 0.31 and average SSV of 4.04 ± 2 µl, compared to normal PSV of 5.06 cm/s and SSV of 21.5± 4.81 µl, obtained from non-hydrocephalic individuals in the control group. In Parkkola *et al.* 2001 [16]. Study of the CSF dynamics of normal individuals and hydrocephalic patients, he found that, two patients of his hydrocephalic patients were diagnosed with aqueductal stenosis by conventional MR images. On phase contrast study, one patient showed hypodynamic flow through the aqueduct of Sylvius, which was consistent with our study. Our study was also consistent with Lucic *et al.* 2013 (89) who conducted a study to evaluate the CSF dynamics in 30 patients with aqueductal stenosis and compared them to normal control group. Similarly, he found that qualitative assessment of CSF flow at the aqueduct of Sylvius in AS patients showed significantly impaired flow compared to normal control group. It's important to note that the study done by Lucic *et al.* 2013 [17], on adult patients, as mentioned before, his paper was used for comparison since there's sparsity in studies done on CSF at the aqueduct of pediatric patients suffering from AS.

Also our study in agreement with Elsafty *et al.* 2018 [18], study results that concluded :In the four patients of the aqueduct stenosis group, no flow was detected in the aqueduct by cine PC-MRI and mean values of peak velocities were found significantly lower compared with the normal control group.

Communicating hydrocephalus implies cases with no obstruction in the ventricles or the cisterns. Aqueductal CSF flow void is increased in communicating hydrocephalus plausibly because of decreased intracranial compliance Raybaud *et al.* 2016 [19].

All 16 patients, with suspected communicating hydrocephalus, diagnosis was suspected by tetra-ventricular dilatation and increased T2 flow void on conventional MR images. Phase contrast MRI is performed to confirm the diagnosis by assessing the flow of CSF at the aqueduct of Sylvius, which is expected to be hyperdynamic. Our study included 16 patients with suspecting communicating hydrocephalus; their CSF flow study showed significant increase in their aqueductal CSF flow velocity; average PSV 8.8 ± 2.49 cm/s, PDV 4.95 ± 0.48 cm/s, MPV 11.74 ± 0.99 cm/s and SSV in the patients were 51 ± 14.3 µl, respectively compared to that of the control group. Also there is strong statistical significance was documented as regard PSV, MPV and SSV, with P value > 0.001 and no significance as regard PDV with P value 0.549. Qualitatively, the patients showed prominent flow through the aqueduct of Sylvius. Our study was consistent with Lucic *et al.* 2013 [17], who conducted a study on 100 patients (52 with communicating hydrocephalus and 48 healthy individuals' adults) and compared the CSF velocity at the aqueduct of Sylvius in both groups. As mentioned before, since there's sparsity in the papers that studied CSF dynamics in pediatric patients in different pathologies, we used this paper as a reference to compare their results with Lucic *et al.* 2013 [17]. Found that intra-aqueductal CSF flow velocity to be significantly higher than that of the healthy group, which was similar to our finding. This is thought to be due to decreased arterial compliance, leading to increased capillary pulse pressure and increased brain parenchymal expansion, which is directed inwards towards the ventricular system. This causes increased intraventricular pulse pressure and increased systolic CSF flow through the aqueduct. In study by Bateman *et al.* 2012 [20]. Aqueductal flow was found to be 0.56 ± 0.55 ml/min in children with communicating hydrocephalus below the age of 2 years And 5.56 ± 4.73 ml/min in older children.

This study quiet in different with study done by Senger *et al.* 2017 [21]. That stats, the mean value of ASV was 152 µl, with SD 49 µl and for control was 32 µl, with SD 12 µl an. P value of 0.0001 is highly significant establishing a strong statistical correlation. SSV value of this study is in close agreement with the study done by Schroeder *et al.* 2000 [22] and Bradley *et al.* 2000 [23], the mean value of PSV for the cases was 8.12 cm/s standard deviation of 2.53 cm/s.

Also the current study was consistent with (Abdelhameed *et al.* 2017) [15] that examined two patients who showed hyperdynamic flow through the aqueduct of Sylvius compared to that of non-hydrocephalic individuals, with PSV 15.01 cm/s, PDV 4.8 cm/sec, MPV 10.34 cm /sec in these patients compared to that of non-hydrocephalic individuals, showing strong statistical significance as regard PVS and MPV with P value 0.002, and no statistical significance as reared PDV, with P value 0.2173.

On the current study the ROC curve for prediction of the optimal cutoff value for hyper dynamic circulation was done as Regarding SSV, for hyper dynamic circulation with the mean was 33.6 ± 22.2 µl and for control individual 21.5 ± SD 4.81 µl (Mann Whitney test P). There is statistical significance for differentiation between SSV from non-hydrocephalic individuals. At a cut off value (37.5 µl), the higher value were suggested to hyperdynamic CSF flow across cerebral aqueduct.

This study was correlated with previous studies done on communicating hydrocephalus patients, by Bradley *et al.* 1996 [13] Performed CSF velocity MR imaging before ventriculo-peritoneal shunting on eighteen patients with communicating hydrocephalus. They reported that 12 of these patients had a hyperdynamic circulation with a stroke volume ranging from 42 to 352 µl. Also all these 12 patients responded favorably to CSF shunting so that the relationship between CSF stroke volume greater than 42 µl and favorable response to shunting.

The vigorous pulsatile motion of CSF flow could be viewed in sagittal cine-loop which is highly reliable for demonstrate patency of the endoscopic third ventriculostomy stoma and for detecting of any fluid obstruction by membrane or cyst. etc., so used it for qualitative assessment of endoscopic third ventriculostomy stoma while the axial acquisitions perpendicular to the ventriculostomy takes advantage of through-plane flow, so it was more accurate for quantitative analysis Hassanien *et al.* 2018 [24].

On the other hand in the present study one patient with chronic hydrocephalus, diagnosed as marked cerebral aqueducts stenosis, shows turbulence flow at the base of the third ventricle with no massive hydrocephalus. Cine phase was done the site of turbulence, showing unidirectional flow with PSV 12 cm/sec, PDV 0.5 cm/, MPV 8.cm/sec, systolic duration 500 ms, SSV 41 µl, diastolic stroke volume, zero µl and absolute stroke volume 41 µl. Denoting spontaneous third ventriculostomy.

This in agreement with study done by Hassanien *et al.* 2018 [24] that, demonstrated the patency of the ETV stoma qualitatively assessed by observing the pulsatile CSF flow at mid-sagittal image and quantitatively by measuring CSF flow at regions of interest (ROI) over ventriculostomy orifice at the 3rd ventricular floor

## Conclusion

Phase contrast MR imaging is a rapid, simple and non-invasive technique which is sensitive to even small CSF flows, and can be used to evaluate CSF flow both qualitatively and quantitatively. Cine phase contrast MR images show CSF flow in a dynamic, more easily appreciable, and in a more pleasing manner, allowing the delineation of obstruction, if present, along the portions of CSF pathway. Several quantitative parameters of CSF flow have been investigated, including temporal, velocity and volumetric flow parameters.

The studied patients had ventriculomegaly with suspected hydrocephalus were finally diagnosed as obstructive and non-obstructive groups. The obstructive group sub divided to three subgroup,subgroup $I^A$ aqueduct stenosis and include 15 patients, show statistically significant hypodynamic CSF flow measurements through cerebral aqueduct in comparison to control individuals with average PSV 1.67±0.41 cm/sec and SSV 4.04 ± 2.01 µl, subgroup $I^B$, patients with Arnold Chiari malformation and include 10 patients with non-statistically significant in CSF flow dynamic in comparison with the control individual as regard PSV, PDV and MPV and statistically significant as regard SSV with P value > 0.05. Statistically significant difference in comparison of patients hydrocephalus with intracranial SOL subgroup $I^C$ with control individuals as regard PSV PDV, MPV and SSV, with P value >0.05.

The optimal cut of value of hypodynamic CSF flow through cerebral aqueduct in comparison of all obstructive subgroups with control group is the 7.5 µl, with sensitivity 100%, specificity 64% and P value > 0.05.

The non-obstructive group, include three subgroups, 16 patients with communicating hydrocephalus (subgroup $II^A$ ) show statistically significant hyperdynamic CSF flow through cerebral aqueduct in comparison to control individuals with average PSV 8.82± 2.49 cm/sec and SSV 51± 14.3 µl. In brain atrophy patients ( subgroup $II^B$ ), which included 10 patients show non-statistically significant in CSF flow dynamic in comparison with the control individual as regard PSV, PDV, and MPV, with statistical significant as regard SSV. Non-statistically significant difference in CSF flow dynamic in comparison of patients Dandy Walker spectrum (subgroup $II^C$) with control individuals.

The optimal cut of value of hyperdynamic CSF flow through cerebral aqueduct in comparison of non-obstructive subgroups with control group is the 37.5 micro-liter with sensitivity 100%, specificity 40% and P Value > 0.05.

On the other hand one patient with chronic hydrocephalus, diagnosed as marked cerebral aqueduct stenosis showing moderate hydrocephalus on conventional MRI images. On Cine Phase images show turbulence flow at the base of the third ventricle, denoting spontaneous third ventriculostomy.

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