Diagnostic Value of MRI and MRV in Migraine indicating Intracranial Hypertension

Ghada M. Abd-elrazek[a], Islam Elmalky[b] , Abeer Mohamed Saddiq[a*], Saeda Mohamed Abd-el Wahab[a]
[a]Department of Radio-diagnosis, Faculty of Medicine, South Valley University, Qena, Egypt
[b]Department of Neurology, Head of Neurovascular Unit, Faculty of Medicine, South Valley University, Qena, Egypt .

Abstract

Background: Migraine is one of the most common causes of headaches. Its mechanism and pathophysiology are complex and linked to environmental and genetic factors. and it is more prevalent in women post-pubertal. Sometimes migraine is associated with intracranial hypertension. MRI and MRV are non-invasive techniques to detect intracranial hypertension rather than opening CSF pressure.

Objectives: This study is to investigate the role of MRI and MRV in detecting increased intracranial tension in patients suffering from migraine.

Patients and methods: This cross-sectional study was conducted in Qena University Hospital (Radiology & Neuropsychiatry departments). South valley university between March 2022 till March 2023. This study was conducted on 50 cases of migraine patients by detecting signs of increase intracranial pressure by MRI and MRV and comparing results with opening CSF pressure.

Results: The migraine patients were divided into two groups regarding C.S.F pressure. There was a statistically significant difference between the two groups regarding papilledema ($P < 0.001$) and transverse sinus stenosis grades ($P = 0.032$). By logistic regression analysis, the significant predictors of high C.S.F were papilledema and grade II transverse sinus stenosis ($P = 0.014$, and 0.033, respectively).

Conclusion: MRI and MR venography can be used in detecting intracranial hypertension in migraine patients. The most contributing factors for intracranial hypertension among migraine patients were papilledema and grade II TSS.

Keywords: Magnetic resonance venography (MRV); Magnetic resonance imaging (MRI); Migraine.

***Correspondence**: abirmohmed662@gmail.com

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Introduction

Migraine is a frequent, chronic condition that is characterized by recurrent, incapacitating headache attacks and related symptoms, such as aura, with multifactorial etiology (**Ferrari et al., 2022).** Headache may start suddenly and end with sleep in some cases. In other instances, the headache may be preceded by a prodromal phase with symptoms such as exhaustion, euphoria, irritability, depression, constipation, food cravings, neck stiffness, increased yawning, and/or abnormal sensitivity to light, sound, and smell, as well as an aura phase with several focal cortically mediated neurological symptoms that manifest just before and/or during the headache phase **(Burstein et al., 2015).**

According to the most recent Global Burden Disease study, migraine remains the leading cause of disability among young women and ranks second overall. Depending on whether an aura appears or not, as well as the frequency of the headaches, there are different types of migraine. The patient's migraine types episodic or chronic is determined by the number of headache days (**Aguilar-Shea et al., 2022).** Clinically, chronic migraine (CM) and idiopathic intracranial hypertension without papilledema (IIHWOP) frequently look the same. Chronic migraine (CM), a condition with a predicted prevalence of 2–3%, is characterized by 15 or more headache days per month, 8 of which have migraine-like symptoms. A portion of episodic migraine sufferers may develop CM, which is caused by a progressive worsening of attack frequency that can lead to daily or nearly daily pain **(De Simone and Ranieri, 2015).** In the vast majority of cases, MRI is normal. In hemiplegic migraines, venous dilatation can be seen on SWI MIP images contralateral to the hemiparesis, although this is not typical. Changes in cerebral perfusion have also been described.

MRI may demonstrate T2 hyperintensities in the white matter of the centrum semiovale, not dissimilar to small vessel deep white matter ischemic change. These are distinguished predominantly on history, although recent 3 T work 1 suggest that there is increased T2 signal in the cortex overlying white matter abnormalities as well as in the brainstem. (**Bell and Gaillard, 2008).**

In the current work we aimed to investigate the role of MRI and MRV in detecting increased intracranial tension in patients suffer from migraine.

Patients and Methods

A cross-sectional study was performed to assess the role of MRV and MRI in detecting intracranial hypertension among migraine patients attending Diagnostic radiology department at Qena University Hospital. The following formula was used to calculate adequate sample size:

$$n = \frac{Z^2 p(1-p)}{d^2}$$

n: sample size, **Z**: standard normal variant (at 5% type 1 error (P <0.05) it is 1.96, **P:** expected proportion in population based on previous studies = 3.3%, **d**: absolute error or precision = 0.05, the level of confidence is usually 95%. The probable sample size was 50. About 50 cases of chronic migraine patients more than 1 year presented to neuropsychiatric disease clinic and referred to diagnostic radiology department.

Inclusion criteria

Patients aged 18-70 years old with positive clinical picture of migraine and approved to participate in the study.

Exclusion criteria

1- Patients with contraindications to MRI or a previous surgery of the brain.
2- Patients suffer from meningitis, or venous sinus thrombosis.
3- Patients with other causes of papilledema.

Data collection

Data was collected during March 2022 to October 2022. All patients subjected to the following:

1-Detailed medical history taking (age, sex, clinical data, D.M, and hypertension).

2-Anthropometric measurements: weight (Kg) and height (Cm) and BMI is calculated as: weight (KG)/Height(m^2).

3-Fundus examination.

4-MRI examination of the brain was performed using 1.5 T closed MR Imager using standard surface coil.

5-MR sequences were:

- Sagittal T1WI.

- Axial DWI.
- Axial T2w.
- FLAIR (fluid-attenuated inversion recovery).
- MR venography with contrast. (as contrast study is more accurate than non-contrast study to detect degree of stenosis, using dose .1ml/kg)
- Coronal STIR (fat-suppressed inversion recovery sequence), with special cuts on orbit.

Data collected from MRI were degree of transverse sinus stenosis (No stenosis if less than 25%, Grade 1 if 25-50%, Grade 2 if more than 50%), pituitary height (empty if height less than 4.8 mm), C.S.F measuring around the optic nerve and flattening of the globe.

6- CSF pressure measuring under complete aseptic condition at setting position, high C.S.F pressure was considered if measuring more than 30 cm H_2O.

The study was agreed by the ethical committee of the Qena Faculty of Medicine in January 2022. The ethical approval code: SVU-MED-RAD028-1-22-1-310.

Statistical analysis

Data were collected, coded, revised, and entered to the Statistical Package for Social Science (IBM SPSS) version 26. Categorical variables were presented as numbers and percentages and were compared by chi-square test. Numerical variables were presented as means ± standard deviation (SD) and were compared by independent t-test. A binary logistic regression analysis was done to predict the relationship between predictors and outcome (C.S.F pressure), where the dependent variable is binary. P value < 0·05 was significant.

Results:

A total of 50 migraine patients were included in this cross-sectional study. The migraine patients were divided into two groups regarding C.S.F pressure: Group (1) was 38 patients (76%) had normal C.S.F pressure, and group (2) was 12 patients (24%) had high C.S.F pressure. Our study showed that there was an insignificant relation between C.S.F pressure and socio-demographic feature among the migraine patients (P > 0.05), as shown in (**Table .1**).

Table .1. Impact of socio-demographic features on the C.S.F pressure among the migraine patients

Parameters			**Group 1 (n=38)**		**Group 2 (n=12)**		**P value**
		Total	No.	%	No.	%	
Gender	Male	4 (8%)	2	5.3%	2	16.7%	**0.204**(1)
	Female	46 (92%)	36	94.7%	10	83.3%	
Age (years)	17-30	24 (48%)	19	50%	5	41.7%	**0.807**(1)
	31-40	20 (40%)	15	39.5%	5	41.7%	
	>40	6 (12%)	4	10.5%	2	16.7%	
	Mean ± SD		30.76 ± 8.949		32.0 ± 10.331		**0.689**(2)
Marital status	Married	42 (84%)	32	84.2%	10	83.3%	**0.942**(1)
	Single	8 (16%)	6	15.8%	2	16.7%	
Have kids	Yes	41 (82%)	31	81.6%	10	83.3%	**0.890**(1)
	No	9 (18%)	7	18.4%	2	16.7%	
Family history	Yes	10 (20%)	6	15.8%	4	33.3%	**0.185**(1)
	No	40 (80%)	32	84.2%	8	66.7%	
D.M or hypertension		5 (10%)	4	10.5%	1	8.3%	**0.825**(1)
BMI	Normal	23 (46%)	19	50%	4	33.3%	**0.313**(1)
	Abnormal	27 (54%)	19	50%	8	66.7%	
	Mean ± SD		26.9642 ± 5.74117		29.5427±5.58681		**0.179**(2)

(1) chi-square test – (2) student- t test

Among the studied patients, 82% had chronic migraine, while 18% had an episodic migraine. Concerning symptoms, 2% had suffered from tinnitus, 8% had papilledema as shown in figure 2 (a &b), figure 3 (a &b), figure 4(a &b)) and 4% had cranial nerve affection. Regarding the duration of complain, most patients (72.7%) had more than one-year complain. There was a statistically significant difference between the two groups regarding papilledema (P < 0.001), as shown in (**Table .2).**

Table 2. Impact of clinical features on the C.S.F pressure among the migraine patients

Parameters			**Group 1 (n=38)**		**Group 2 (n=12)**		**P value**
	Total		No.	%	No.	%	
Headache	Chronic	41(82%)	31	81.6%	10	83.3%	**0.890**
	Episodic	9 (18%)	7	18.4%	2	16.7%	
papilledema	Yes	4 (8%)	0	0%	4	33.3%	**<0.001***
	No	46(92%)	38	100%	8	66.7%	
Tinnitus	Yes	1 (2%)	1	2.6%	0	0%	**0.942**
	No	49(98%)	37	97.4%	11	100%	
Cranial nerve affection	Yes	2 (4%)	1	2.6%	1	8.3%	**0.380**
	No	48(96%)	37	97.4%	2	91.7%	
Clinical Attacks per month	≤15	29(58%)	20	52.6%	9	75 %	**0.171**
	>15	21(42%)	18	47.4%	3	25 %	
	Mean ± SD		19.45 ± 9.354		15.92 ± 8.898		**0.255#**
Duration of one attack (hours)	< 24	33 (66%)	27	71.1 %	6	50%	**0.180**
	≥ 24	17 (44%)	11	82.9 %	6	50%	
	Mean ± SD		15.905 ± 14.5963		15.636 ± 14.5895		**0.957#**
Duration of complain (years)	≤ one year	12(24%)	11	33.3%	1	9.1%	**0.118**
	>one year	32(64%)	22	66.7%	10	90.9%	
	Mean ± SD		4.8586 ±5.63609		7.1818 ±6.38464		**0.258#**

*chi-square test - # student t-test

Among the participants, 26% had empty Sella (as shown in figure 2c, figure 3d and figure 4c), 18% had transverse sinus stenosis (as shown in figure 3e), 10% had flattening in the posterior sclera (as shown in figure 3c) , 46% had transverse sinus hypoplasia (as shown in figure 4d), and 56% had different degrees of transverse sinus stenosis and hypoplasia (as shown in figure 2d&e) . There was a statistically significant difference between the two groups regarding TSS grades (P = 0.032)**,** as shown in (**Table .3**). There was an insignificant difference between the two groups regarding the pituitary height (P=0.221) as shown in (**Table .4).**

Table 3. Relationship between radiological findings and C.S.F opening pressure

Parameters			**Group 1 (n=38)**		**Group 2 (n=12)**		**P value**
	Total		No.	%	No.	%	
Optic nerve sheath distension	0	9 (18%)	8	21.1%	1	8.3%	**0.316**
	1	37 (74%)	28	73.7%	9	75%	
	2	4 (8%)	2	5.3%	2	16.7%	
Pituitary empty	Yes	13 (26%)	9	23.7%	4	33.3%	**0.506**
	No	37 (74%)	29	76.3%	8	66.7%	
TSS	Present	9 (18%)	5	13.2%	4	33.3%	**0.113**
	Absent	41 (82%)	33	86.8%	8	66.7%	

TSS grades	Normal	41 (82%)	33	86.8%	8	66.7%	**0.032***
	I	7 (14%)	5	13.2%	2	16.7%	
	II	2 (4%)	0	0%	2	16.7%	
Transverse sinus hypoplasia	Present	23 (46%)	16	42.1%	7	58.3%	**0.325**
	Absent	27 (54%)	22	57.9%	5	41.7%	
Transverse sinus hypoplasia grades	0	4 (8%)	4	10.5%	0	0%	**0.194**
	I	11 (22%)	8	21.1%	3	25%	
	II	8 (16%)	4	10.5%	4	33.3%	
Transverse sinus stenosis and hypoplasia	Unilateral stenosis	8 (16%)	6	15.8%	2	16.7%	**0.166**
	Bilateral stenosis	12 (24%)	10	26.3%	2	16.7%	
	Unilateral stenosis-discontinuity	6 (12%)	2	5.3%	4	33.3%	
	Bilateral discontinuity	2 (4%)	1	2.6%	1	8.3%	
Flattened posterior globe	Present	5 (10%)	3	7.9%	2	16.7%	**0.377**
	Absent	45 (90%)	35	92.1%	10	83.3%	

*chi-square test, TSS: transverse sinus stenosis.

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Table 4. Relationship between MRI findings and C.S.F opening pressure

Parameters	**Group 1 (n=38)**	**Group 2 (n=12)**	**P value**
	Mean ± SD	**Mean ± SD**	
Pituitary height	5.255± 1.0919	4.792 ± 1.2471	**0.221**
C.S.F around optic nerve (mm) (Right)	1.134 ± 0.6152	1.358 ± 0.6403	**0.281**
C.S.F around optic nerve (mm) left	1.118 ± 0.6238	1.300 ±0.7160	**0.400**
Rt ONSD (mm)	4.387 ±0.7698	4.758±0.9385	**0.173**
left ONSD (mm)	4.363 ± 0.8358	4.625 ± 1.0074	**0.372**

Student t-test, ONSD: optic nerve sheath diameter

There was a statistically significant (P = 0.005) mild positive correlation between papilledema and C.S.F opening pressure (r=0.391) as shown in **(Table 5).**

Table 5. Correlation between radiological findings and C.S.F pressure among the migraine patients.

Parameters	**C.S.F pressure**	
	r*	**P value**
Papilledema	0.391	**0.005**
Transverse sinus stenosis	0.278	**0.051**

r*Spearman correlation coefficient

Logistic regression analysis for factors affecting C.S.F pressure, papilledema, and grade II TSS were strong predictors of high C.S.F pressure among migraine patients (P =0.014, and 0.033, respectively) as shown in (**Table. 6).**

Table 6. Multivariable logistic regression analysis of factors associated with high CSF pressure

Variables		**Odds ratio (OR)**	**95% CI**		**P value**
			Lower	Upper	
Papilledema		18.50	1.817	188.389	0.014*
Transverse sinus stenosis (reference: no stenosis)	Grade 2	13.714	1.236	152.146	0.033*

ROC curve analysis showed that MR venography can predict intracranial hypertension at cut off 23.50 with area under the curve 0.868 with high sensitivity (81.3%) and specificity (64.7%) (P <0.001), as shown in (**Table .7**) and **(Fig.1).**

Table 7. ROC curve analysis to predict the diagnostic performance of MRV

Parameter	AUC	95% CI		Cut off	Sensitivity (%)	Specificity (%)	P value
		Lower	Upper				
MRV	0.868	0.763	0.972	23.50	81.3%	64.7%	<0.001*

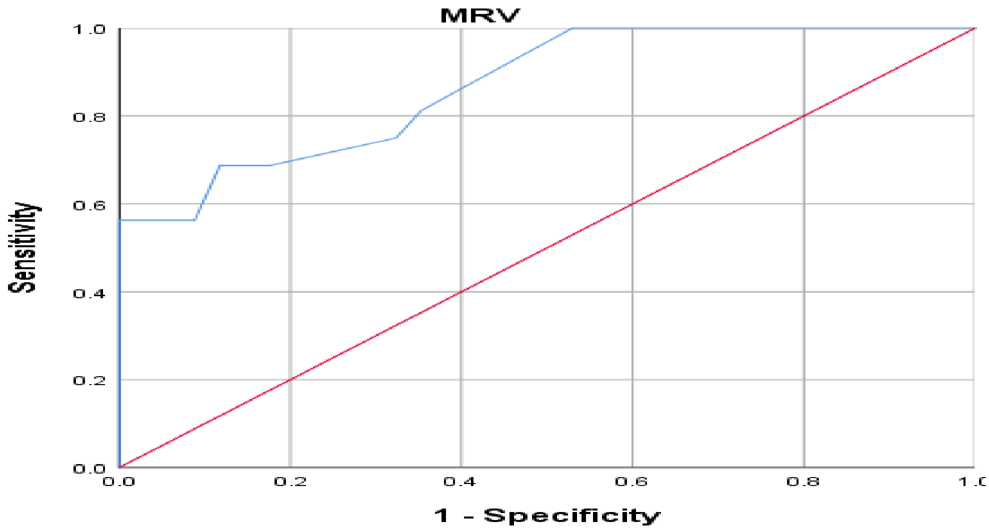

Fig.1. Roc curve of diagnostic performance of MR venography

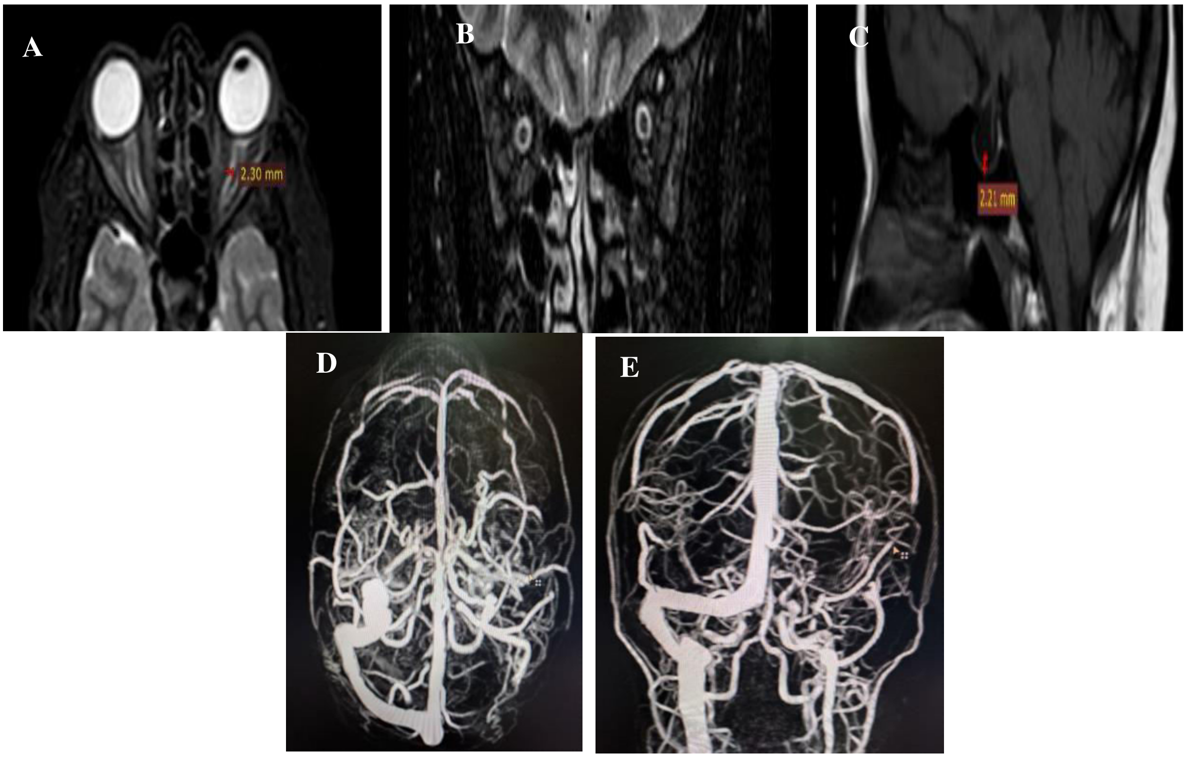

Fig.2. Female patient 35 years presented with chronic left side frontoparietal throbbing headache of 5 years duration. **(A & B**) Axial and coronal T2WI fat suppression shows moderate increase CSF around optic nerve suggesting grade 2 papilledema. (**C**) Sagittal T1WI shows severe reduction of the pituitary height suggesting empty sella. (**D &E**) Axial and coronal MRV shows left transverse sinus stenosis and hypoplasia.

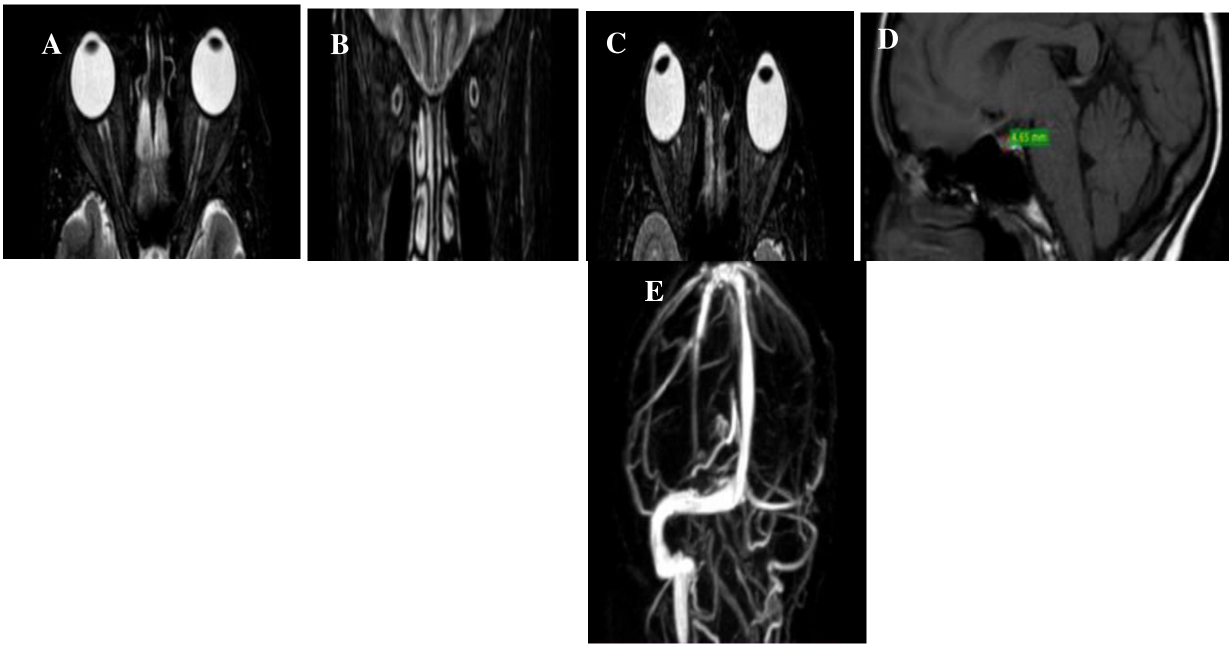

Fig.3. Female patient 28 years presented with chronic pulsatile headache of 3 years duration and blurring of vision. (**A& B**) Axial and coronal T2WI fat suppression shows mild increase CSF around optic nerve suggesting grade 1 papilledema . (**C**) Axial T2WI fat suppression shows flattening of the posterior sclera. **D**: Saggital T1WI shows reduced pituitary hight suggesting empty sella.(**E**) Coronal MRV shows stenosis at the lateral part of the left transverse sinus.

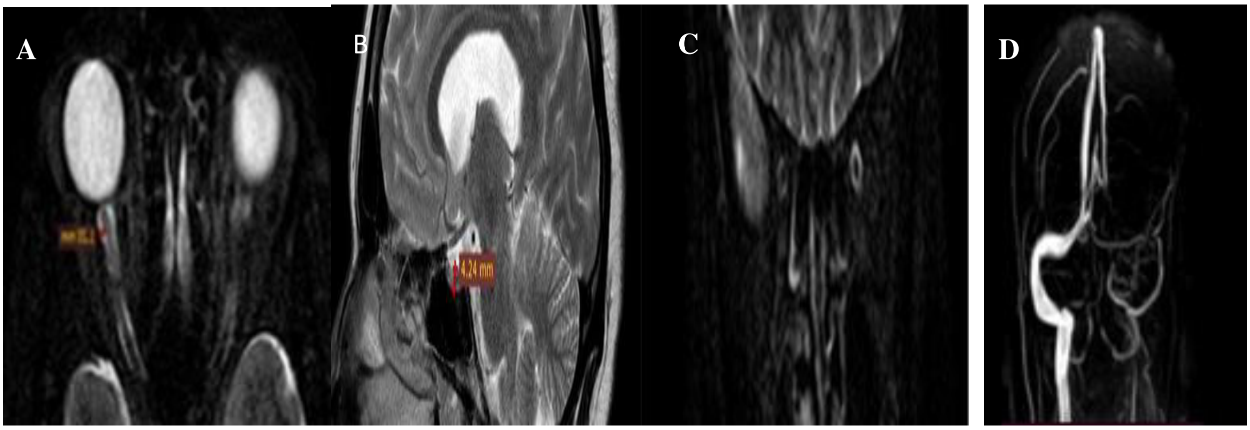

Fig.4. Female patient 45 years presented with chronic throbing headache of 4 years duration and blurring of vision .(**A, B**) Axial and coronal T2WI fat suppression shows mild increase CSF around optic nerve suggesting grade 1 papilledema. (**C**) Sagittal T2WI shows moderate reduction at the pituitary height suggesting empty sella. (**D**) Coronal MRV shows left transverse sinus hypoplasia.

Discussion

According to epidemiological studies, migraine is one of the third-most prevalent diseases worldwide and the main cause of disability in those under the age of fifty **(Ailani et al., 2021).** The lifetime prevalence is about 16% in the general population **(Sacco et al., 2020)**. The prevalence of the condition is two to one in favor of women, with prepubescent boys being more susceptible than other age groups (**Martin et al., 2021**).

The mean age of the studied patients was 31.02 ± 9.295 years and ranged from 17 years to 51 years, which is lower than the mean age of patients in a study conducted by **Onder et al., 2020** (35.9 ± 9.9 years) and **Guliyeva et al., 2020** (34.38 ± 15.48 years) with a range between 18 and 62 years.

Regarding gender, there were predominance of females in our study representing 92% of cases while 8% patients were males. The current results were agreed with

Onder et al., 2020 who enrolled 158 consecutive migraineurs and the majority were females (84.8%), and supported by **De Simone et al., 2014** who enrolled 44 chronic migraine patients and 39 were females (88.6%) and higher than **Guliyeva et al.,'** study who enrolled 99 migraineurs patients (77.7% females).

In the current study, Patients with intracranial hypertension were slightly older than those with normal intracranial pressure (32 ±10.331 years vs. 30.76 ± 8.949 years, respectively) with an insignificant difference (P=0.689). These findings are consistent with **Elmaaty et al., 2021** who showed that the mean age among patients with intracranial hypertension was (32.8 ± 8.5 years).

The mean BMI of our patients was 27.5830 ± 5.75616 and the median was 26.3778 with a range between 18.93 and 39.75. These results are consistent with those of **Onder et al., 2020** who found that the mean BMI of migraine patients was 26.02 ± 5.05, and supported by **De Simone et al., 2014** who found that the median BMI of chronic migraine patients was 26.17. In terms of obesity, 54% of our patients were overweight or obese. These results agree with those of **De Simone et al., 2014** who stated that 56.818 % of chronic migraine patients were overweight or obese. Our results were higher than those of **Onder et al.**, 2020 who found that only 17.7% of patients were obese. This can be explained by the high percentage of chronic migraine among our patients (82%), compared to only 18% in **Onder et al.,**' study (104). This can be interpreted as both migraine and obesity sharing similar genetic and environmental risk factors **(Bigal et al., 2007).**

In the current study, although there was a statistically insignificant difference between C.S.F pressure and BMI (P=0.313), overweight or obese patients had higher C.S.F pressure than those with normal weight (66.7% vs. 33.3% respectively). The mean BMI was higher among migraine patients with intracranial hypertension than those with normal intracranial pressure (29.5427 ± 5.58681 vs. 26.9642 ± 5.74117) with an insignificant difference (P=0.179). These results agree with **Westgate et al., 2021** who found that increased BMI is associated with increased ICP.

Regarding the migraine subtype, we found that 82% of the studied patients had chronic migraines, while 22% had episodic ones. These results disagree with those of **Onder et al., 2020** who found that only 18% of migraine patients had chronic migraine compared to 78% with episodic migraine. This can be explained by the high prevalence of obesity among our patients (54%) compared to **Onder et al.,'** study (17.7%) and higher prevelance of IIH in our study (24%).

In our study, we found that 8% of migraine patients had papilledema. These findings agree with **Onder et al., 2020** who stated that 6.3% of migraine patients had papilledema. In the current study, there was a statistically significant relation between C.S.F pressure and papilledema (P< 0.001); four patients among twelve patients with high C.S.F pressure (33.3%) had papilledema, compared to 0% among those with normal C.S.F pressure. These findings are consistent with **Rigi et al., 2015** who stated that papilledema cannot occur in the absence of high intracranial pressure, but high Intracranial pressure can occur in the absence of papilledema.

Regarding transverse sinus stenosis, we found that 18% of our patients had TSS. These findings were less than those of **Favoni et al., 2019** who found that 47.5% of chronic migraine patients had TSS. This can be interpreted as our study included both subtypes of migraine; chronic and episodic. In the current study, there was an significant difference between patients with C.S.F pressure >30 cm H_2O and those with C.S.F pressure < 30 cm H_2O regarding TSS distribution. Similarly, **Favoni et al.,** 2019 stated that there was a statistically insignificant difference in transverse sinus stenosis distribution between patients with opening pressure <200 mm H_2O and those with opening pressure >200 mm H_2O.

The present study indicated statistically significant difference between C.S.F pressure and grades of transverse sinus stenosis (P =0.032); 16.7% of patients with high C.S.F pressure had grade 1 TSS, compared to 13.2% among patients with normal C.S.F pressure, and 16.7% of those with high C.S.F pressure had grade 2 TSS, compared to 0% among those with normal C.S.F pressure. Four patients (33.3%) of migraine patients with high C.S.F pressure had transverse sinus stenosis; of those 50% had grade 2 TSS (stenosis of more than 50%). These findings are lower than those of **Riggeal et al., 2013** where the median average percent stenosis among patients with IIH was 56%. Seventy-one percent of patients had stenoses > 50%.

The current study showed that the mean optic nerve sheath diameter (ONSD) of the right eye was 4.476 ± 0.8190 mm and ranged from 2.9 mm to 7.1 mm while the mean optic nerve diameter of the left eye was 4.426 ± 0.8764 mm and ranged from 2.9 mm to 6.9 mm. These findings were slightly lower than **Gökçen and Hamamcı, 2020** who found that the mean ONSD measurement of the left eye was 4.80 ± 0.36 mm and mean ONSD of the right eye was 4.82 ± 0.37 during the attack period of the migraine patients.

The current study stated that transverse sinus stenosis had sensitivity of 81.3% and specificity of 64.7% in detecting intracranial hypertension. Our findings agree with **Morris et al., 2017** who found that bilateral transverse sinus stenosis was a sensitive (93%) imaging marker of IIH.

Conclusion

MR venography can be used in detecting intracranial hypertension in patients presenting with attacks of chronic or episodic like headache. The most contributing factors for intracranial hypertension among migraine patients were papilledema and grade II TSS. There was an insignificant relation between C.S.F pressure and other MRV findings. These results need to be confirmed with larger sample size for detection of other radiological predictors.

Limitations

1-If there is contraindication of contrast injection in cases of renal impairment.

2-some cases can't afford the high cost.

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