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RESEARCH

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Association between laboratory markers, clinical and radiological findings in patients with idiopathic intracranial hypertension: case–control study

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Abstract

Background Idiopathic intracranial hypertension (IIH) is a disease of raised intracranial pressure. Contribution of inflammatory mediators has been suggested in IIH pathophysiology. The aim of this study was to estimate certain serum inflammatory markers in IIH patients compared to normal subjects. Also, to examine the correlation between these laboratory parameters and the clinical and radiological characteristics of IIH patients.

Results Body mass index (BMI) was significantly higher among IIH patients compared to controls. Serum LDH, CRP, NLR and PLR were significantly higher, whereas serum iron was significantly lower in IIH patients compared to healthy controls. IIH patients with stenosis in brain MRV had significantly higher mean serum CRP compared with patients with normal MRV. There was a statistically significant positive correlation between serum CRP and the presence of stenosis in MRV, between serum LDH level and grade of papilledema, and between CRP, TIBC, and NLR with BMI.

Conclusions There is a significant elevation of inflammatory markers in IIH patients. Moreover, cerebral venous sinus stenosis and BMI were positively associated with higher markers of inflammation as CRP, LDH and NLR indicating the role of inflammation in thrombosis and obesity associated with IIH.

Keywords Idiopathic intracranial hypertension, Inflammatory markers, Anemia, Magnetic resonance venography, CSF pressure

Introduction

Idiopathic intracranial hypertension (IIH) is a disorder which affects mainly the overweight females in the child-bearing age characterized by chronic elevation of intracranial pressure which usually manifests by headache in most of patients. It is usually frontal or around the orbit, throbbing in nature and may be accompanied by tinnitus, nausea and transient visual obscurations (TVOs). Papilledema is another important and common sign in IIH which may be complicated by secondary progressive optic atrophy, visual loss, and possible blindness [1].

The pathogenesis of IIH is yet unknown. The choroid plexus's increased cerebrospinal fluid (CSF) production or the arachnoid granulation tissue's restricted CSF drainage, which are both worsened by an elevated venous sinus pressure, are the causes of abnormal cerebrospinal fluid dynamics [2].

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In patients with IIH, signs of low-grade inflammation were reported in several studies, particularly in overweight women. Researchers advocated that multiple pro-inflammatory adipocytes can be used as markers which may help expecting the prognosis in IIH [3].

Neutrophil-to-lymphocyte ratio (NLR) and platelet-to-lymphocyte ratio (PLR) have been discovered to be useful inflammatory markers for a variety of chronic disorders including some ophthalmological diseases, and can help in expecting their prognosis [4].

There is also a growing evidence that iron deficiency anemia (IDA) is one of important factors in some patients with elevated intracranial pressure (ICP), and confirms the importance of searching for concomitant IDA in IIH patients and treating it. This is reinforced by the diagnostic criteria for IIH suggested by Friedman and Jacobson which identify severe IDA as a condition that can cause intracranial hypertension and resemble IIH [5].

The aim of this study is to estimate certain serum markers (lactic dehydrogenase (LDH), C-reactive protein CRP, serum iron, total iron binding capacity (TIBC), neutrophil-to-lymphocyte ratio (NLR), and platelet-to-lymphocyte ratio (PLR) in patients with IIH compared to healthy subjects. Also, to investigate the correlation between these laboratory parameters and grade of papilledema, grade of perimetry, opening CSF pressure and magnetic resonance venography (MRV) findings.

Methods

This is a case–control study carried on 72 subjects (36 patients diagnosed as IIH and 36 matched healthy controls). The research was conducted at the Neurology Department (blinded for peer review) in the duration from November 2021 to May 2022. The objectives of the research and study procedures were clarified to each applicant and an informed written consent was obtained and assigned from each participant before being involved in the research. The Helsinki Declaration of Biomedical Ethics, as updated, was followed in the study's design. The study received the ethical approval from the Neurology Department (blinded for peer review) in 8/2/2022 with approval number (MS-518-2021). The research involved two groups: group (A) which included 36 IIH patients and group (B) which included 36 healthy matched controls for age and sex.

Inclusion criteria: IIH patients who were admitted at department of Neurology or following up in the headache clinic (blinded for peer review) and diagnosed as IIH following the international classification of headache, ICHD-3, their age ranged from 20 to 45 years of both sex groups with normal brain parenchyma without evidence of hydrocephalus, mass or structural lesion in MRI of the brain which may cause secondary increase in ICP [6].

Exclusion criteria: Cases of venous thrombosis, autoimmune disorders or vasculitis which may cause secondary increase in ICP were excluded. Comorbid medical or ophthalmological conditions which can affect the visual pathway like hypertension, diabetes mellitus or glaucoma, and pregnant females were also excluded from our study.

Study procedures: Patients were evaluated clinically by detailed history taking, general and neurological examination. Body mass index (BMI) was calculated by dividing an adult's weight in kilograms by their height in meters squared and subjects were considered overweight when BMI ranged between 25.0–29.9 kg/m^2 and obese with BMI ranged 30 kg/m^2 and above according to World Health Organization BMI cutoff points [7]. Headache was evaluated according to the headache sheet of Neurology department (blinded for peer review), which includes all the clinical characteristics of headache about duration, severity, aura, frequency, laterality and daily activities interference. Assessment of headache severity was done using comparative pain rating scale which is a scale of (0–10), where 0 is no pain, minor pain which does not interfere with most activities included (1 = very mild or 2 = discomforting or 3 = tolerable), moderate pain which interferes with many activities included (4 = distressing or 5 = very distressing or 6 = intense), severe pain which is unable to engage in normal activities included (7 = very intense, 8 = horrible, 9 = unbearable) and 10 is the worst unimaginable pain [8]. Relapses of IIH were assessed since the onset of diagnosis and treatment according to Yri and colleagues who defined relapse as recurrence of either previous resolved papilledema or symptoms of elevated ICP as blurred vision or diplopia, transient visual obscurations (TVOs) and pulsatile tinnitus that need crucial management by lumbar puncture (LP) or shunt [9]. Ophthalmological evaluation was done by ophthalmologists in ophthalmology outpatient clinic (blinded for peer review) through visual acuity assessment, fundus examination to detect the degree of papilledema according to Modified Frisen Scale [10]. Visual field assessment was done using the automated perimetry (Humphrey visual field Ziess, Germany) and grading of perimetry was done according to Wall M and George D grading scales [11].

Magnetic resonance imaging (MRI) of the brain was done for all patients to exclude secondary causes of ICP elevation. Magnetic resonance venography (MRV) was done to identify any venous system abnormalities like attenuation, filling defects or thrombosis, in venous sinuses [12]. MRI and MRV were performed at the Diagnostic Radiology Department, (blinded for peer review). Scans were done on a 1.5 Tesla Philips Intera scanner (Brand: Philips, Model: 1.5 Tesla Philips

Intera scanner, made in United States), the imaging findings were interpreted by the radiologists.

To quantify the CSF opening pressure, all patients underwent LP with an LP needle under complete aseptic conditions. When performing LP, the patient was lying in the lateral decubitus posture with their legs outstretched for pressure measurements. Reference range for diagnosing IIH: CSF > 200 mm H2O in non-obese subjects and > 250 mm H2O in obese subjects [13].

Laboratory workup included: Complete blood picture with differential count (CBC) to calculate neutrophil-to-lymphocyte ratio (NLR) and platelet-to-lymphocyte ratio (PLR), serum IRON, total iron binding capacity (TIBC), serum LDH and C-reactive protein (CRP). Normal levels of LDH in the blood usually range between 140 units per liter (U/L) to 280 U/L for adults [14], also the normal level of CRP which usually seen in most healthy adults is less than (0.3 mg/dL) while (0.3 to 1.0 mg/dL): normal or minor elevation (can be seen in obesity, pregnancy, diabetes and common cold,); (1.0 to 10.0 mg/dL): moderate elevation (systemic inflammation or autoimmune diseases,) and more than (10.0 mg/dL): marked elevation (acute bacterial or viral infections, systemic vasculitis) [15].

CBC was performed on an automated hematology analyzer (Sysmex Corporation, Kobe 651–0073, Japan). The NLR and PLR values were calculated by dividing the neutrophil count or the platelet count, respectively, by the lymphocyte count [16].

Sample size calculation: Based on evidence from previous similar study and by considering the neutrophil-to-lymphocyte ratio in patients with papilledema and patients without papilledema as a primary outcome. Epi-Calc 2000 was used to calculate the sample size of this case–control study. Assuming 80% power, 0.05 level of significance using Student's T-test for independent samples, mean in patients with papilledema = 2.16, mean in patients without papilledema = 1.82, SD = 0.51. The sample size will be = 66 participants (33 in each group). Considering drop-outs rate of 10%, therefore the final sample size will be 72 participants (36 in each group).

Statistical analysis: Statistical analysis was done by using Statistical Package for the Social Sciences (SPSS) 22nd edition, quantitative variables were presented in mean, standard deviation (SD), and range, it was compared using Mann–Whitney U test after applying normality distribution testing. Qualitative variables were presented in count and percentages, it was compared using chi square test (χ^2). Spearman correlation test was used to correlate two quantitative variables.

Results

The general features of the study groups are represented in Table 1. No significant difference was found between patients and control groups as regards mean age, gender or contraceptive use ($p > 0.05$), however, BMI was significantly higher among patients compared to controls (p value = 0.0001)Table 1

The disease duration ranged from 1- 10 years with a mean duration of 3.8 ± 2.9 years. Clinical characteristics of headache and ophthalmological assessment are represented in Table 2. Opening CSF pressure ranged from 190–700 mmHg with a mean 326.1 ± 112.8 mmH2O.

MRI of the brain was normal in 18 patients (50%), empty sella was found in five patients (13.9%), and one patient (2.8%) had tortuosity of the optic nerve. MRV showed stenosis in 29 patients (80.6%), 22 of it were in the transverse sinus, four in the transverse, sigmoid sinuses and internal jugular vein and three in the transverse and sigmoid sinuses. MRV abnormalities were unilateral in 12 patients and bilateral in 17 patients. Four patients had (11.1%) inserted shunt Table 2.

Comparison of laboratory markers between study groups showed that LDH, CRP, NLR and PLR were significantly higher and serum iron was significantly lower in IIH patients compared to healthy controls (*p* value = 0.015, 0.0001, 0.0001, 0.038 and 0.044, respectively)Table 3.

Comparison of laboratory parameters in IIH patients with normal and abnormal MRV showed that patients

Table 1 General characteristics of participants

	Group				*P* value
	Controls		Patients		
Age (years)	30 ± 5.8	18–45	32 ± 7.6	18–49	0.197
Sex					
Male	5	13.9%	1	2.8%	0.088
Female	31	86.1%	35	97.2%	
Contraception					
No	15	41.7%	13	36.1%	0.271
Hormonal	14	38.9%	10	27.8%	
IUD	7	19.4%	13	36.1%	
BMI (kg/m^2) (mean, SD)	27 ± 3	22–35	33 ± 6	22–49	0.0001*
BMI categories					
Underweight	0	0.0%	0	0.0%	0.0001*
Normal weight	8	22.2%	3	8.3%	
Overweight	24	66.7%	4	11.1%	
Obese I	3	8.3%	14	38.9%	
Obese II	1	2.8%	13	36.1%	
Obese III	0	0.0%	2	5.6%	

*Significant; *SD* standard deviation, *IUD* intrauterine device, *BMI* body mass index

Table 2 Clinical, ophthalmological and radiological features of IIH patients

		n = 36	%
Relapse number (since the diagnosis and treatment onset)	No relapse	16	44.4
	Once	9	25.0
	Twice	4	11.1
	Three times	6	16.7
	Four times	1	2.8
Severity of headache	Mild	1	2.8
	Moderate	29	80.6
	Severe	6	16.7
Papilledema grade	I	10	27.8
	II	19	52.8
	III	5	13.9
	IV	2	5.6
Perimetry grade	Normal	7	19.4
	Grade 1	15	41.7
	Grade 2	10	27.8
	Grade 3	4	11.1
	Grade 4	0	0.0
MRI findings	Normal	18	50.0
	Empty Sella	5	13.9
	Flattening of posterior globes	0	0.0
	Prominent peri-optic CSF spaces	0	0.0
	Tortuosity of the optic nerve	1	2.8
	CSF leak	0	0.0
	Empty Sella and Prominent peri-optic CSF spaces	12	33.3
MRV findings	Normal	7	19.4
	Stenosis	29	80.6
MRV stenosis site	Normal	7	19.4
	Transverse sinus	22	61.1
	Sigmoid sinus	0	0.0
	Transverse and sigmoid	3	8.3
	Proximal part of int. jugular vein	0	0.0
	Transverse and sigmoid and IJV	4	11.1
MRV laterality	Normal	7	19.4
	Unilateral	12	33.3
	Bilateral	17	47.2
Shunt (ventriculo-peritoneal)	Yes	4	11.1
	No	32	88.9

IIH idiopathic intracranial hypertension, *n* = number, *MRI* magnetic resonance imaging, *MRV* magnetic resonance venography, *CSF* cerebro-spinal fluid, *IJV* internal jugular vein

with stenosis in the MRV had significantly higher mean serum CRP compared with patients with normal MRV (p value = 0.044). However, the difference as regards LDH, serum iron, TIBC, NLR or PLR was insignificant (p value > 0.05) Table 4.

There was a significant positive correlation between CRP, TIBC, and NLR with BMI (p = 0.0001, 0.049, and 0.023, respectively).

There was a significant positive correlation between serum LDH level and grade of papilledema (p = 0.016). Also, there was a statistically significant positive correlation between TIBC and CSF opening pressure (p = 0.023). There was a significant positive correlation between serum CRP and the presence of stenosis in MRV (p value = 0.047). No significant correlation was found between laboratory parameters with either headache severity, number of relapses or grade of perimetry Table 5

Discussion

Few studies in literature had investigated the laboratory profile of patients presented with IIH, denoting that the underlying etiology of IIH may be caused by inflammatory process as the inflammatory markers were higher among IIH patients compered to controls [17].

In this study, BMI was significantly higher in patients group in comparison to controls. This finding was consistent with evidence in literature that proved correlation between high BMI and incidence of IIH [17–19]. The pathogenesis of IIH due to obesity has not been yet revealed, however many theories had mentioned aldosterone excess (associated with obesity and polycystic ovary syndrome (PCOS) to be one of the possible mechanisms for IIH among obese females, as the choroid plexus has mineralocorticoid receptor which leads to increased production of CSF [20]. Another theory had been proposed that outflow resistance to CSF might be due to an influence of retinoic acid or estrogen which are elevated by increased adiposity on epithelial cells leading to less CSF outflow [21].

In this study, MRV showed stenosis in 29 patients (80.6%), 22 of them were in the transverse sinus, four in the transverse, sigmoid sinuses and Internal Jugular vein and three in the transverse and sigmoid sinuses. These findings came in consistence with Morris and colleagues, who showed that stenosis of the transverse sinus was detected on MRV in 83% of IIH patients and MRI findings were positive in 60% of included cases [22].

Woodall MN and colleagues discovered that stenosis of the transverse sinuses occurs in 94% of patients with IIH. So, speculation has been raised that venous outflow obstruction may play a role in the genesis of IIH [23], but the reversibility of this finding with effective medical therapy and intracranial pressure reduction suggests that venous occlusive findings are secondary to elevated intracranial pressure rather than vice versa [24].

Table 3 Comparison of laboratory markers between study groups

	Group				P value
	Controls		Patients		
	Mean	SD	Mean	SD	
LDH (mg/dL)	198.4 ± 86.6	100–520	245.5 ± 112.5	142–695	0.015*
CRP (mg/dL)	3.9 ± 1.4	1–7	7.7 ± 5	2–22	0.0001*
Serum IRON (mg/dL)	73.4 ± 15.2	38–121	65.3 ± 17.5	19–100	0.044*
TIBC (%)	315.5 ± 58	190–432	342.7 ± 57.5	269–491	0.156
NLR	1.4 ± 0.6	0.7–3	2.1 ± 0.7	1–5.8	0.0001*
PLR	131 ± 38.4	47–218	156.5 ± 52.7	75–348	0.038*

*Significant; *SD* standard deviation, *CRP* C-reactive protein, *LDH* lactic dehydrogenase, *NLR* neutrophil-to-lymphocyte ratio, *PLR* platelet-to-lymphocyte ratio, *TIBC* total iron binding capacity

Table 4 Comparison of laboratory markers in IIH patients according to MRV findings

	MRV findings						
	Normal (*n* = 7)			Stenosis (*n* = 29)			
	Mean	SD	Range	Mean	SD	Range	*P* value
LDH (mg/dL)	233.4	83.7	147–390	248.4	119.4	142–695	0.907
CRP (mg/dL)	4.7	1.9	2–7	8.5	5.2	2–22	0.044*
Serum IRON (mg/dL)	65.1	19.5	30–90	65.3	17.4	19–100	0.845
TIBC (%)	326.7	37.0	285–378	346.6	61.3	269–491	0.611
NLR	2.0	0.5	1–3	2.1	0.8	1–6	0.725
PLR	155.7	32.9	130–226	156.7	57.0	75–348	0.938

*Significant; *SD* standard deviation, *CRP* C-reactive protein, *LDH* lactic dehydrogenase, *NLR* neutrophil-to-lymphocyte ratio, *PLR* platelet-to-lymphocyte ratio, *TIBC* total iron binding capacity, *n* = number

The current study revealed that LDH, and CRP were significantly higher in IIH patients compared to healthy controls. These findings were in agreement with Pollak and colleagues who reported elevated (CRP) levels in 51% and elevated LDH in 20% of IIH patients [17]. Moreover, the improvement in visual field sensitivity was also poorer for patients with elevated CRP than for those with normal CRP. CRP was also investigated in another study as a marker for inflammation in patients with IIH and concluded that there is increase in CRP in IIH patients in comparison to controls which reflects a low-grade systemic inflammation [25].

C-reactive protein possesses both pro-inflammatory and anti-inflammatory effects. It aids in the identification and removal of invading infections and injured cells, also it can become pathogenic by increasing tissue damage in some situations by activating the complement system and thus inflammatory cytokines. So it is considered as marker of inflammatory process and explained the poorer visual outcome in patients with high CRP [26].

Even among young adults, higher BMI is linked to increased CRP concentrations, according to Qiling Li and colleagues' research [27]. These results point to a low-grade systemic inflammatory state in overweight and obese individuals. In a cross-sectional study that included 7526 males and 3219 females, CRP was also measured, and it was discovered that individuals with abnormal BMI had considerably higher CRP levels than those with normal BMI. This distinction was found to favor females over males [28]. It has recently been determined that obesity causes chronic inflammation, which is linked to the production of inflammatory cytokines from adipose tissue. It is believed that obesity is a pro-inflammatory condition linked to elevated levels of cytokines and adipokines, including macrophage chemotactic protein-1, ghrelin, leptin, and interleukin-6. Although their significance in the etiology of IIH remains unclear, some of them have been observed to be higher in the serum and CSF of individuals with IIH. Therefore, the discovery that half of IIH patients had elevated CRP levels and that this had a detrimental effect on their prognosis could support the theory that inflammation plays a role in the pathogenesis of the illness [29].

Table 5 Correlation between laboratory parameters and BMI, clinical, ophthalmological, MRV findings and CSF opening pressure in IIH patients

		BMI (kg/m^2)	Headache severity	Relapse number	Papilledema grade	Perimetry grade	Opening CSF pressure (mmH2O)	Stenosis in MRV
LDH (mg/dL)	Correlation coefficient	0.035	− 0.161	.100	0.399	− 0.075	− 0.027	− 0.024
	P value	0.769	0.348	0.562	0.016*	0.665	0.878	0.891
CRP (mg/dL)	Correlation coefficient	0.488	0.259	0.280	− 0.080	0.092	− 0.168	0.333*
	P value	0.0001**	.128	0.098	0.643	0.593	.329	0.047
Serum IRON (mg/dL)	Correlation coefficient	− 0.098	− 0.001	0.109	− 0.207	− 0.138	− 0.302	− 0.037
	P value	0.414	0.993	0.526	0.227	0.424	0.074	0.829
TIBC (%)	Correlation coefficient	0.233	0.300	0.074	0.316	0.132	0.378	0.091
	P value	0.049*	0.075	0.670	0.061	0.444	0.023*	0.597
NLR	Correlation coefficient	0.268	0.102	− 0.022	− 0.101	− 0.079	− 0.002	0.066
	P value	0.023*	0.553	0.897	0.559	0.648	0.989	0.704
PLR	Correlation coefficient	0.038	0.096	− 0.037	0.058	0.144	− 0.090	0.014
	P value	0.752	0.576	0.829	0.735	0.404	0.601	0.938

*Significant; *SD* standard deviation, *CRP* C-reactive protein, *LDH* lactic dehydrogenase, *NLR* neutrophil-to-lymphocyte ratio, *PLR* platelet-to-lymphocyte ratio, *TIBC* total iron binding capacity, *BMI* body mass index, *IIH* idiopathic intracranial hypertension

Lactic dehydrogenase reflects tissue breakdown and its level is increasing in different disorders like malignancy and hemolysis, so it is believed that elevated LDH among IIH patients reflects hepatic involvement in the form of fatty liver associated with obesity [29].

Neutrophil-to-lymphocyte ratio (NLR) and platelet-to-lymphocyte ratio (PLR) are novel hematological parameters for systemic inflammation and stress. NLR and PLR are useful inflammatory markers for many systemic and ocular chronic diseases, and they are associated with the prognosis of various disorders [30].

Dynamic changes of NLR precede the clinical state for several hours and may warn clinicians about the ongoing pathological process early like cancer, atherosclerosis, infection, inflammation, psychiatric disorders and stress [31].

In this study, NLR and PLR were significantly higher in IIH patients in comparison to healthy subjects. This finding was consistent with Ceylan and colleagues, who highlighted that NLR, and PLR were significantly higher in patients with IIH compared to controls. To the best of our knowledge no other studies assessed NLR, and PLR among patients with IIH. Neurologists have thought that using NLR and PLR is a very useful tool in diagnosis and follow-up and looks like a new idea that has added another view on the role of inflammation in IIH [31].

Results of the current study showed that serum iron was significantly lower among IIH group compared to healthy subjects, a finding that was consistent with many studies that correlated anemia with the incidence of IIH. Ma and colleagues showed that IIH patients commonly had iron deficiency anemia (IDA) accounting for 19 out of 22 patients [32].They concluded that chronic blood loss due to menorrhagia is the most common cause of IDA in IIH patients. Moreover, in a large pooled study, the incidence of anemia among IIH cases reached 18.5%, and it was significantly higher compared to controls with relative risk 1.44. The commonest cause of anemia was reported to be iron deficiency accounting for 51.6% [33]. There is a proposed theory that anemia induces hemodynamics alterations that could lead to higher ICP in anemic patients [34]. Reactive thrombocytosis accompanying idiopathic iron deficiency anemia has been suggested as a causative factor, but IIH has also been in patients with anemia and normal thrombocytes as well as the absence of cerebral vein thrombosis. Anemia and tissue hypoxia leading to increased capillary permeability and intracranial pressure has been another proposed theory to explain the relationship between IIH and anemia. In seven out of eight patients with IIH and iron deficiency anemia, IIH resolved on correction of anemia alone [35]

Moreover, some researches have examined the connection between IDA and cerebral venous thrombosis (CVT) with IIH-like presentation [36].

In the current work, patients with stenosis in the MRV had significantly higher mean serum CRP compared with patients with normal MRV, and there was a statistically significant positive correlation between serum CRP and the presence of stenosis in MRV. Also, IIH patients with MRV results had greater levels of the inflammatory markers CRP and LDH. Inflammatory indicators including CRP and LDH were examined in earlier research among patients with IIH and transverse sinus thrombosis, and it was discovered that individuals with venous sinus thrombosis should be tested for hypercoagulability. Moreover, test abnormalities such as raised C-reactive protein, elevated plasma cortisol, and elevated lactate dehydrogenase have been described, but their clinical relevance is debatable [17].

In the present study, a statistically significant positive correlation between serum LDH level and papilledema grade was found. These results are at odds with those of Pollak and colleagues, who found that patients with increased LDH had better visual outcomes than those with normal LDH [17].

CRP, TIBC, and NLR significantly correlated positively with BMI in our study. These results are largely explained by the fact that obesity leads to a persistent pro-inflammatory state in the body, which may be directly linked to the development of IIH. [37, 38]

The limitations of our study were the limited sample size; we did not study the potential predictive value of inflammatory markers for disease progression and recurrence in IIH patients and the effects of various IIH treatments on inflammatory markers and compare them to clinical outcomes.

Conclusions

According to our study findings, patients with IIH have a considerable rise in inflammatory markers, which may indicate that an inflammatory process is involved in the pathophysiology of IIH. Moreover, cerebral venous sinus stenosis and BMI were positively associated with higher markers of inflammation as CRP, LDH and NLR indicating the role of inflammation in thrombosis and obesity associated with IIH. Hence, inflammatory markers can be used as diagnostic, prognostic and follow-up markers for disease outcomes among patients with IIH.

Abbreviations

BBB	Blood–brain barrier
BCSFB	Blood–CSF barrier
BMI	Body mass index
CNS	Central nervous system
CVT	Cerebral venous thrombosis
CSF	Cerebrospinal fluid
CRP	C-reactive protein
IIH	Idiopathic intracranial hypertension
HIS	International Headache Society
ICP	Intracranial pressure
IDA	Iron deficiency anemia
LDH	Lactic dehydrogenase
LP	Lumbar puncture
MRI	Magnetic resonance imaging
MRV	Magnetic resonance venography
NLR	Neutrophil-to-lymphocyte ratio
PLR	Platelet-to-lymphocyte ratio
PCOS	Polycystic ovary syndrome
TIBC	Total iron binding capacity
TVO	Transient visual obscuration

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Author contributions

EMF: research idea, data acquisition, data analysis and interpretation, SAS: collection of samples from the studied groups, RMS: data acquisition, data analysis and interpretation, DY: manuscript writing and reviewing , AAE: research idea and manuscript writing , HE: data acquisition, data interpretation and manuscript writing and reviewing . All authors have read and approved the final manuscript.

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Availability of data and materials

The datasets generated and/or analyzed during the current study are not publicly available due to the current Cairo University regulations and Egyptian legislation but are available from the corresponding author on reasonable request and after institutional approval.

Declarations

Ethics approval and consent to participate

An informed written consent was taken from each patient. All data obtained from every patient were confidential and were not used outside the study. The patients have rights to withdraw from the study at any time without giving any reason. All the cost of the investigations was afforded by the researcher. The study design followed the requirements of revised Helsinki declaration of biomedical ethics. Our study was approved by ethical committee of the Department of Neurology, Faculty of Medicine, Cairo University on 8/2/2022 (approval code MS-518-2021).

Consent for publication

Not applicable.

Competing interests

The authors declare that they have no competing interests.

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