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Research Article

Investigating the Relationship between Cerebrospinal Fluid Density and Demographic Characteristics of Surgical Patients admitted to Shahid Bahonar Hospital of Kerman: A Descriptive Cross-Sectional Study in 2016

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ABSTRACT

Introduction: CSF is a dynamic and metabolically active fluid that performs important tasks. This liquid is created by complex transports of the choroid plexus-CP. This action is regulated by neuroendocrine factors and hormonal agents. This study aimed to investigate the relationship between cerebrospinal fluid density and demographic characteristics of orthopedic surgical patients.

Methodology: This cross-sectional study was conducted on 41 patients. Patients admitted to the orthopedic operating room of Bahonar Hospital of Kerman were enrolled in the study. Before induction of local anesthesia, 2-3 drops of cerebrospinal fluid were collected and sent to a laboratory. Data were analyzed in SPSS 20.

Results: Based on the results, CSF density had significant direct relationships with CSF glucose levels and serum sodium levels; however, there was a significant reverse relationship between CSF density and minimum pre-anesthesia blood pressure levels.

Conclusion: The results showed that there was no statistically significant relationship between personal factors and cerebrospinal fluid density.+

Keywords: density, cerebrospinal fluid, orthopedic surgery.

INTRODUCTION

Many surgical operations are performed every day for a variety of reasons and a large proportion of patients cannot tolerate general anesthesia for various reasons.On the other hand, due to the increasing population growth and undesirable growth of medical facilities and hospitals, hospitals must take the maximum benefit of their available facilities. Today, there is an increasing tendency toward utilizing local anesthetic methods, especially for outpatients (1). Spinal anesthesia is one of the most effective methods for inducing local anesthesia in various types of surgical procedures (2). This technique is very easy and does not require any complex equipment or intense care. Patientsare awake during spinal anesthesia and can work well with the therapy team (1). Cerebral spinal fluid (CSF) is the third major body fluid (after blood and urine). CSF has two functions: 1. supplying nutrients for neural tissues and disposal of metabolic wastes; 2. establishing a mechanical barrier to protect the brain and the spinal cord from traumatic impact (3-5). CSF is a dynamic and metabolically active fluid that performs important tasks (6). This liquid is created by complex transports of the choroid plexus-CP. This action is regulated by neuroendocrine factors and hormonal agents (7). The normal values for the density of CSF have already been reported. Glucose and protein levels are the main determinants of CSF density (8-9). The average production rate of CSF is 3-6 ml/min (10-11), as the daily production is about 500-600 ml in adults and its pressure is 100 millimeters of water, which is balanced by its continuous production and reabsorption (8-9). The flow of the cerebrospinal fluid causes some kind of pulsation (12-13). This liquid is secreted in the lateral ventricles and moves toward the third and fourth ventricles of the brain and then it is transferred to the basal cistern and then to the subarachnoid space (14).In healthy humans, ventricular and subarachnoid spaces comprise 25 and 75 percent of the total cerebrospinal fluid volume, respectively (15).The total volume of cerebrospinal fluid in adults is approximately 160 ml (4 and 5).To sustain the brain, the cerebrospinal fluid provides a full complement of vitamins, peptides, nucleosides and growth factors (16-17).For further examinations, the CSF fluid is collected using lumbar puncture (lp) (6).LP is performed by inserting a needle between the third and fourth or the fifth lumbar vertebrae, by using sterile tools and with the least amount of trauma and bymeasuring intracranial pressure (3-5).For the first time, Bear described spinal anesthesia in 1898 and mentioned headache as one of its complications.In 1904, after the introduction of cocaine, it was widely used for spinal anesthesia and because of its simplicity, suitable anesthesia and laxity it became very popular (18-19).Neuraxial blocks (spinal, epidural and caudal) have a broad clinical use for surgery, painless delivery, pain management and chronic pain relief (20).Theblockage of the neuro-spinal axis leads to sympathetic blockade, analgesia, sensory block and motor block and depends on the dose, concentration and volume of the local anesthetic drug (18-19).The neuro-spinal axis blockage is useful when it can provide an acceptable level of analgesia and anesthesia and when it does not lead to adverse complications (18, 21).The cardiovascular effects of spinal block are similar to the simultaneous combined effects of alpha and beta blockers; thus, both heart rate and blood pressure levels are decreased.The sympathectomy caused by spinal block depends on the height of the block (18-19 and 22).The height of the spinal block depends on pharmaceutical factors, demographic characteristics and procedural factors. In addition, intrathecal local anesthetic distribution depends on these factors and an anesthetist cannot change some of these factors (23). One of the most important pharmaceutical factors affecting the block height is baricity, which is the relative density of a local anesthetic in relation to that of the cerebrospinal fluid. The normal density of CSF is 1.00059 g/l (24).Dextrose or distilled water can be added to a local anesthetic solution to make it hyperbaric or hypobaric, respectively. This property, gravity and patients' position can totally affect the distribution of local anesthetic solution in the interactional space. The hyperbaric solutions are distributed to areas most nondependent on intrathecal space; while the hypobaric solutions are distributed to dependent intrathecal areas (20).The effect of the density of CSF on the level of spinal block has been proven in various spinal anesthesia methods (25-26). Patients' height, weight, age, gender, pregnancy, various forms of spine and CSF properties, including its volume and composition can affect the height of the spinal block (20). Due to the importance of spinal anesthesia as well as the importance of the density of CSF and lack of similar domestic studies, the present study was conducted to investigate the relationship between cerebrospinal fluid density and demographic characteristics of patients. This can affect the height and distribution of the spinal block, which are the most important factors in spinal anesthesia.

METHODOLOGY

This cross-sectional study was performed on 41 patients. Patients admitted to the orthopedic operating room of Bahonar Hospital of Kerman were enrolled in the study. All the patients underwent orthopedic surgery as well as spinal anesthesia and there was no contraindication for spinal anesthesia. A 25G spinal needle was used and before the local anesthesia, 2-3 drops of cerebrospinal fluid were collected and sent to a laboratory. Informed written consent was obtained from all patients. The demographic characteristics of the patients were determined and then the cerebrospinal fluid density was analyzed to achieve research objectives.Data were analyzed in SPSS 20.

Findings

A total of 41 patients were enrolled in the study, of which 27 patients (65.9%) were male and 14 patients (32.1%) were female.The mean age of the patients was 44.2 ± 27 and the youngest patient was 11 and the oldest one was 91 years old. Other demographic data are presented in Table 1.

Table 1 – The Demographic data of the studied patients

Variable	Frequency (mean)	% (SD)
Gender		
Male	27	65.9
Female	14	32.1
Educational qualifications		
Under diploma	9	21.9
Diploma	14	34.1
University degree	18	43.9
Marital status		
Single	18	43.9
Married	23	54.1
Pregnant		
Yes	6	42.9
No	8	57.1
Addiction		
Yes	8	19.5
No	33	80.5
Age	44.2	27
Duration of addiction	1.4	0.54
number of children	4.4	2.02
Weight	58.2	17.6
Height	160.4	25.1
Wrist circumference	16.5	1.6
Ankle circumference	23.3	2.3
Trunk length	58.7	4.6

The personal characteristics of the patients are also presented in Table 2.

Variable	Frequency (mean)	% (SD)
Skin color		
Dark	6	14.6
Brunette	26	63.4
Bright	9	21.9
Eye color		
Black	11	26.8
Light brown	21	51.2
Etc.	9	21.9
Hair color		
Black	25	60.9
Bright	3	7.3
White	13	31.7

Spinal anesthesia was used for all the patients and most of the patients experienced anesthesia for the first time. Other information on anesthesia is presented in Table 3.

Variable	Frequency (mean)	% (SD)
Anesthesia times		
First time	34	82.9
Second time	7	17.1
Amount of anesthetic drug	3.6	0.5
Anesthesia time	1.05	0.2
Duration of anesthesia	2.04	1.2
Pre-anesthesia blood pressure		
maximum	119	17.6
minimum	74.1	12.07
Post-anesthesia blood pressure		
maximum	117.5	15.7
minimum	74.8	7.7

The cerebrospinal fluid density in the studied patients was 1005.04 with a SD of 0.92.Other laboratory parameters are presented in Table 4.

Variable	Frequency (mean)	% (SD)
CSF density	* 1005.04	0.92
Blood Ph	7.39	0.04
Blood glucose	113.8	51.2
CSF glucose	59.3	16.4
CSF protein	39.8	49.3
White blood cell count	8.529	3.4
Hemoglobin	12.8	1.9
Platelet	204.8	80.6
Urea	27.4	11.6
Creatinine	0.88	0.21
Sodium	137.7	2.6
Potassium	4.1	0.3
INR	1.2	0.3
PTT	30.6	6.3
PT	13	1.8

* All the density values are multiplied by 1000.

The results showed that there was no statistically significant relationship between the underlying factors and the cerebrospinal fluid density (Table 5).

Variable	CSF density		P value
	Mean	**SD**	
Gender			
Male	1005.04	1.02	0.910
Female	1005	0.66	
Pregnant			
No	1005	0.75	0.352
Yes	1004.5	1	
Addiction			
Yes	1005	0.81	0.939
No	1004.96	0.89	
Skin color			
Dark	1006	0.1	0.086
Brunette	1004	0.87	
Bright	1005	0.54	
Eye color			

Black	1004	1.1	0.267
Light brown	1005	0.67	
Etc.	1004	0.57	
Hair color			
Black	1004	1	0.594
Bright	1005	0.1	
White	1005	0.64	
Anesthesia times			
First time	1005	0.93	1
Second time	1005	0.1	

There were significant direct relationships between CSF density and CSF glucose and serum sodium; however, there was a significant reverse relationship between CSF density and minimum pre-anesthesia blood pressure.Other values are presented in Table 6.

Variable	Correlation Coefficient	P-value
Age	-0.021	0.902
Weight	-0.093	0.63
Height	0.101	0.709
Wrist circumference	0.025	0.775
Ankle circumference	-0.053	0.775
Trunk length	-0.058	0.738
Blood Ph	0.009	0.981
Blood glucose	0.216	0.375
Pre-anesthesia blood pressure		
Maximum	-0.256	0.150
Minimum	-0.363	0.038
Post-anesthesia blood pressure		
Maximum	-0.145	0.422
Minimum	-0.343	0.54
CSF glucose	0.415	0.020
CSF protein	0.054	0.744
White blood cell count	0.039	0.838
Hemoglobin	0.103	0.589
Platelet	-0.182	0.335
Urea	0.377	0.057
Creatinine	0.191	0.349
Sodium	0.494	0.023
Potassium	-0.071	0.767
INR	0.490	0.106
PTT	-0.074	0.818
PT	0.478	0.116

DISCUSSION

A total of 41 patients were enrolled in the study, most of which were male. The mean age of the patients was 44.2 ± 27. Spinal anesthesia was used for all the patients and most of the patients experienced anesthesia for the first time. The cerebrospinal fluid density in the studied patients was 1005.04 with a SD of 0.92. The results showed that there was no statistically significant relationship between the personal factors and the cerebrospinal fluid density. There were significant direct relationships between CSF density and CSF glucose and serum sodium; however, there was a significant reverse relationship between CSF density and minimum pre-anesthesia blood pressure. E. Schiffer et al. in their study observed that cerebrospinal fluid density was associated with gender; it was lower in women and was not associated with other variables (27); however, this correlation was not observed in the present study. Polis and Cicutti conducted a study entitled “densities of cerebrospinal fluid and spinal anaesthetic solutions in surgical patients at body temperature” and found that pregnant women and premanopausal women had lower CSF densities compared to postmenopausal women and men (8). In the study of Polis and Cicutti the density of cerebrospinal fluid was lower in women than in men and much lower densities were observed in pregnant women. In the present study also these values were lower in women and pregnant women than in men; however, the differences were not statistically significant. The difference can be attributed to the small sample size of the present study. Richardson and Wissler reported lower CSF densities in pregnant women compared with other women (28). In Richardson and Wissler’s study, the density of cerebrospinal fluid was lower in pregnant women than in non-pregnant women and in the present study also these values were lower in women and pregnant women than in men; however, the differences were not statistically significant. Richardson and Wissler’s study was conducted on women and this was its major difference with the present study.In the study of Gessel et al., it was observed that cerebrospinal fluid density was higher in men than in women; however, they did not examine other demographic indicators (23).In Gessel’s study, only gender was evaluated and, unlike the present study, other demographic characteristics were not evaluated. Quintela et al. (2015) in their study observed that cerebrospinal fluid density had no significant relationship with anthropometric indices (24).In the study of Quintela, indicators such as height and weight were evaluated and similar to the present study there was no statistically significant relationship between these indicators and cerebrospinal fluid density. More indicators were evaluated in the present study. This study is the first study to fully evaluate the anthropometric, laboratory and clinical indices associated with cerebrospinal fluid densityand can be a guide toward future studies.

Conclusion

The results showed that there was no statistically significant relationship between the personal factors and the cerebrospinal fluid density. In addition, there were significant direct relationships between CSF density and CSF glucose and serum sodium; however, there was a significant reverse relationship between CSF density and minimum pre-anesthesia blood pressure.

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