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ORIGINAL ARTICLE

Improvement of Pulsatility index and Minimum Diastolic Blood Flow Velocity by low Dose Mannitol in Cases of Traumatic Brain Injury: a Cross-Sectional Study

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ABSTRACT

Aim: To investigate the impact of low-dose mannitol on the pulsatility index (PI) and minimum diastolic blood flow velocity (FV-min (-1)) in the middle cerebral artery in cases of traumatic brain injury (TBI).
Study design: A cross-sectional study
Place and duration: From October 2018 to September 2020, the Department of Neurosurgery at Riyadh Care Hospital
Methodology: A total of 80 patients with traumatic brain injury (TBI) were considered in the study. The participants had diffused TBI and their GCS was less than 8. All patients were administered the low-dose mannitol (0.3g kg). PI and FV-min were monitored by Transcranial Doppler (TCD) ultrasonography. The TCD ultrasonography was done before the administration of low-dose mannitol (0.3g kg), immediately after its administration, after 1 hour, 2 hours, and 3 hours.
Result: The values taken before the administration of the low-dose mannitol were pathological (PI>1.5 and FV-min <20cm s (-1)). It was observed that administration of low-dose mannitol brought a significant change in the values of PI ($F=8.967$, $p < 0.001$) and FV-min ($F=8.642$, $p <0.0001$).
Conclusion: Low-dose mannitol helps to improve the indicators of disturbance of circulation in a patient with TBI. It increased FV-min and decreased the PI. The most improved results in PI were noticed one hour after the administration and it was 11.1%. Similarly, the maximum effect of low-dose mannitol (0.3g kg) on FV-min was also noticed after one hour and it was a 30.2% increase as compared to the values taken in the beginning. The values were significantly different after 2 hours of administration.
Keywords: Traumatic brain injury, low-dose mannitol, pulsatility index, minimum diastolic blood flow velocity

INTRODUCTION

Brain edema after head injury usually cause raise intracranial pressure, which may disrupt cerebral perfusion as well as oxygenation. This phenomenon leads to ischemic insult to brain. Mannitol is used in the intensive care unit (ICU) for the treatment of brain edema [1]. As per the treatment guidelines given by the Brain Trauma Foundation, the ideal dosage of mannitol is 0.25-1 g/ kg [2]. If the mannitol is given in higher quantities, it can lead to excessive loss of fluid from the body and ultimately can cause a complication. Hence, regular monitoring is mandatory while administering the mannitol. Mannitol is beneficial even in low doses. The advantage of giving it in a low dose is the low risk of hemodynamic instability and hyperosmolarity [3].

Transcranial Doppler (TCD) ultrasonography is an excellent gadget for the assessment of hemodynamics in the brain. The pathological value of FV-min and PI was determined based on TCD ultrasonography and they were such as; PI < 1.4, FV-mean <30 cm s, (-1), and FV-min <20 cm s (-1) [4]. The resistance of the cerebral circulation increases as a result of brain edema. A decrease in diastolic blood flow velocity is seen first. And then the pulsatility index begins to increase [5]. The rise in diastolic blood flow velocity tends to decrease more than the systolic blood flow. This phenomenon results in a rise in the value of the PI [6].

In a clinical setup, the impact of the low-dose mannitol is usually monitored by TCD ultrasonography. It has been evident from some of the Doppler studies used for the monitoring FV-mean and PI of the effect of the low-dose mannitol on the patients of TBI. The results noticed were such that an increase in the value of FV-mean was seen and a decrease in the value of PI was observed [7]. Hence, the present study was conducted for observing the efficacy of low-dose mannitol on the PI and FV-mean of the patient with TBI presenting with disrupted cerebral hemodynamics.

METHODOLOGY

A total of 80 patients, who had been received with TBI, were included in the present study. The present study was conducted at the Department of Neurosurgery at Riyadh Care Hospital from October 2018 to September 2020. An ethical review committee of the institute permitted the study. Those patients who had been hospitalized for at least 48 hours, were considered for the study. Those patients had either third or fourth category diffused TBI according to the classification of Marshall [8]. The patients included in this study had a GCS less than 8. TCD ultrasonography of all the patients was done before the administration of mannitol. The initial readings of FV-min and PI were pathological in all the patients i.e. PI was less than 1.4 and F-min was less than 20 cm s (-1). According to the exclusion criteria set, those patients who had tachycardia (pulse rate more than 100 times per minute), hypotension (systolic arterial pressure less than 100 mmHg), consecutive spasm of basal blood vessels (FV-mean value more than 120 cm s (-1)), and subarachnoid

hemorrhage were not included. Those patients who were detected with disrupted renal functionality and less than 320 mOsm/ kg were also excluded from the study. Furthermore, the patients having history of CVA, had a stroke during the study, and those had post-anoxic injury of the brain were excluded. Exclusion and inclusion criteria were decided after their stabilization and shifting them to the ICU.

The patients were intubated so that their ventilation stays under control and they could be sedated with midazolam (1 µg kg min) and morphine (0.5 µg kg min). A total of 60 (75%) patients underwent craniotomy and 28 (35%) patients were given inotropic support. The inotropic support included noradrenaline 0.1 – 0.15 µg kg min or dopamine 5-10 µg kg min. Continuous monitoring of partial pressure of carbon dioxide on expiration and mean arterial pressure was done. A 20% mannitol solution was administered over 20 minutes. The total quantity of mannitol given to each patient was 0.3g kg.

The first reading (t1) was taken before the administration of the mannitol. The second reading (t2) was taken after the administration of the mannitol. The third reading (t3) was taken after one hour of administration, the fourth reading (t4) was taken after two hours and the fifth reading (t5) was taken after three hours of administration of mannitol. The data were carefully collected and analyzed in IBM SPSS version 26. All the patients or their attendants gave written informed consent.

RESULT

A total of 80 patients were included in the study. A total of 56 (70%) participants were male and 24 (30%) were females. The mean age of the patients was 52.5±18.2 years and ranged from 35 years to 80 years. Out of those 80 patients, 60 (75%) underwent craniotomy and 28 (35%) were given inotropic support. The age, gender, GCS, performance of craniotomy, and provision of inotropic support are given in table 1. The readings of FV-min and PI at different instances and time intervals are given in Table 2

Table 1: Gender, Age, GCS, Craniotomy, and inotropic support

Variable	Number	Percentage
Gender		
Female	24	30
Male	56	70
Age (Years)		
35-50	39	48.75
51-60	20	25
61-70	10	12.5
71-80	11	13.75
GCS		
1	1	1.25
2	5	6.25
3	26	32.5
4	24	30
5	10	1.25
7	14	17.5
Provision of inotropic support	28	35
Craniotomy	60	75

Table 2: Distribution of PI and FV-min at different instances and time intervals

	Initial reading (t1)	Reading after administration (t2)	After one hour (t3)	After two hours (t4)	After three hours (t5)
PI	2.39±0.72	2.12±0.75	2.11±0.73	2.24±0.82	2.36±0.82
FV-min	13.9±5.1	17.6±6.2	18.1±5.4	17.6±5.9	14.5±6.1

DISCUSSION

The present study involves the administration of low-dose mannitol in patients of TBI who had pathological values of FV-min and PI. Changes in their values were observed and monitored by TCD ultrasonography before, after, and after 1, 2, 3 hours. The results obtained from the TCD ultrasonography showed that PI was decreased and FV-min was increased in the middle cerebral artery. The maximum decrease in PI was observed one hour after the administration of mannitol. Likewise, the maximum increase in FV-min was also seen after one hour of mannitol administration. The period in which changes occur at maximum level after mannitol administration refers to the period of significant FV-min and PI decrease as compared to that of readings taken in the beginning. These changes in the values of FV-min and PI are seen to have a direct impact on mannitol. According to the results obtained in the study, the effect of the mannitol remains for 2 hours. The 0.3 g/ kg dose of mannitol helps in meeting the therapeutic demand and it provides an osmotherapy which can be given 4-6 hours in TBI patients with edema.

A similar study was conducted by Lin et al. A total of 14 patients were considered in their study. All the patients had TBI. They were divided into two groups. They were given mannitol in 5 minutes. An abrupt increase in the value of FV-mean was seen in 10 minutes. After that, a constant flow was seen for 30 minutes. They kept observing the effect of mannitol continuously during the whole duration of the study. The amount of mannitol given in their study was 0.5 g/ kg. They concluded that administering a higher dose of mannitol resulted in faster results. However, only FV-mean was seen in this study, and FV-min was studied [7].

Vicenzini et al conducted a study to observe the results of low-dose mannitol on the patients. The dosage given in this study was 20% mannitol in 100 ml over 200 minutes. They observed the hemodynamic changes in the cerebral hemorrhage in 90 minutes. According to the study results, there was a significant increase seen in FV-mean, and a significant decrease was seen in PI. These changes were persistent for 60 minutes. This result is consistent with our study as our study also showed significant changes in the first one hours. The participants in this study did not have TBI. The duration of observation and monitoring of the hemodynamic changes was not very long [9].

It was also studied by Li et al, included 21 children. The FV-min, FV-max, and PI of the patients were monitored on the daily basis before and after 30 minutes of administration of the mannitol. A significant increase in the values of FV-max and FV-min was seen. [10].

CONCLUSION

Low-dose mannitol is significantly beneficial in the improvement of the indicators of hemodynamic disruption in a patient with brain edema. The effect lasts as long as 2 hours. The drug has minor adverse effects which are why it can be relied upon and administered frequently in TBI patients.

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