Randomised Controlled Trial

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The duration of spinal anaesthesia in elective caesarean section in Trendelenburg and reverse Trendelenburg positions: a randomized clinical trial

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Objective: One of the common methods of anaesthesia for caesarean sections (CSs) involves the use of spinal anaesthesia in mothers. Various positions are utilized in this method. This study aims to compare the evaluation of two positions, Trendelenburg and reverse Trendelenburg, in candidates for CS to assess the duration of anaesthesia and changes in vital signs in women.

Methods: This study was a randomized clinical trial in which 60 pregnant mothers who met the inclusion criteria entered the study. These mothers were randomly allocated into two equal groups using block randomization. One group of patients received spinal anaesthesia in the Trendelenburg position, while the other group received it in the Reverse Trendelenburg position. Vital signs (systolic and diastolic blood pressure, heart rate, Apgar score, and SPO_2) of participants from both groups were evaluated for 1 h after the induction of anaesthesia. Additionally, sensory level and duration of anaesthesia were measured. Finally, the data from both groups were subjected to statistical analysis using SPSS version 26 software.

Results: The mean (SD) age of participating mothers in the Reverse Trendelenburg and Trendelenburg groups was 28.93 (5.82) and 30.97 (4.94), respectively. The two study groups did not significantly differ in baseline characteristics such as age, BMI, which could potentially impact vital sign outcomes or anaesthesia duration, and education ($P > 0.05$). The mean (SD) duration of anaesthesia in the Trendelenburg position was significantly higher than in the Reverse Trendelenburg position [221.57(min) vs. 159.00(min)] ($P < 0.0001$). There was no significant difference between the two positions, Trendelenburg and Reverse Trendelenburg, in terms of sensory level and its extent ($P = 0.08$). The two study groups did not significantly differ in hemodynamic changes measured 13 times, including heart rate, systolic and diastolic blood pressure, and Apgar score ($P > 0.05$).

Conclusion: In spinal anaesthesia with the Trendelenburg position compared to the Reverse Trendelenburg position, there is a longer duration of anaesthesia. This is while the two positions did not differ in terms of hemodynamic changes and sensory level.

Keywords: Anaesthesia, caesarean sections, hemodynamic, spinal anaesthesia, Trendelenburg

Introduction

Childbirth is a focal point of concern for women, particularly first-time expectant mothers, significantly influencing the mental and social well-being of mothers and their families[1]. Delivery typically transpires naturally or, when necessary, via caesarean section or assisted methods like forceps and vacuum. While childbirth is inherently a self-regulating process, interventions such as caesarean section (CS) become imperative in situations jeopardizing the life of either the mother or the baby[2]. Although CS mark a pivotal advancement in obstetrics, their associated elevated risks, mortality rates, prolonged hospital stays, increased costs, and adverse effects on the normal gut flora composition, infant obesity, and overweight pose notable consequences[3].

CS involves various maternal positioning options, such as inclined sideways, head positioning upwards or downwards, or bending the surgical table. Some obstetricians posit that modifying the pregnant woman's position may enhance outcomes for both mother and baby[4]. The standard surgical position for CS is supine, with two primary configurations: Trendelenburg and reverse Trendelenburg[5].

HIGHLIGHTS

- One of the common methods of anaesthesia for caesarean sections involves the use of spinal anaesthesia in mothers. Various positions are utilized in this method.
- In spinal anaesthesia with the Trendelenburg position compared to the Reverse Trendelenburg position, there is a longer duration of anaesthesia.
- -This is while the two positions did not differ in terms of hemodynamic changes and sensory level.

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The Trendelenburg position involves lying on one's back with the body straight, inclined at 15–30° to raise the legs, facilitating a downward movement of abdominal contents for improved surgical visibility[6]. Conversely, in the reverse Trendelenburg position, the body is straight with the upper body elevated by inclining the bed at 15–30°, positioning it higher than the legs[7].

CS can use either general or regional anaesthesia, chosen based on patient preference, medical condition, and surgery urgency. Many caesarean deliveries are performed for spinal anaesthesia, with hypotension as a common complication, managed through fluids and ephedrine[8]. Spinal anaesthesia is favored for elective caesarean deliveries due to lower risks, but it may have drawbacks. Despite potential issues, anaesthesia in CS aims to ensure a safe delivery with minimal risk for both mother and infant. Studies show spinal and epidural anaesthesia correlate with higher Apgar scores[9].

This study aims to investigate how the positioning of pregnant women during caesarean delivery affects the duration of spinal anaesthesia. The goal is to regulate anaesthesia levels without the need for increased drug dosage, given the rising CS rates in Iran and the lack of precise confirmation of this impact[10,11].

Methods

This study is a randomized clinical trial. In this study, the number of samples was 60 pregnant mothers who were candidates for elective CS at Kamali Hospital, Alborz University of Medical Sciences. these mothers presented themselves at the respective hospital and were randomly allocated into two groups of 30 individuals each. This study will be conducted through a census method, and thus, we will not have sampling in the process.

Data collection tools

It consists of a checklist of demographic and clinical patient information prepared in advance using available patient records, as well as the results of patient interviews and clinical examinations. In this study, alongside assessing the duration of anaesthesia, vital signs of the patient are repeatedly measured 13 times during the 1-h onset of anaesthesia.

Before the implementation stages, sufficient explanations regarding the objectives and phases of the research were provided to the units under study, and their participation in the study was subject to their consent. Additionally, the study subjects were assured of the confidentiality of the information. The type of study was a randomized clinical trial, and the allocation method was block randomization.

Pregnant candidates for elective CS were purposefully selected based on inclusion criteria. The sample size was 60 patients who were divided into two groups using block randomization with non-homogeneous block sizes.

In block randomization (randomization unit), non-uniform block sizes (two, four, six, etc.) were considered to conceal the allocation process, which is the most important principle in randomized clinical trials.

Inclusion criteria: The study will be conducted on individuals aged ~20–45, with a height range of 155–170 cm, and categorized as ASA II, pregnancy should be at term (37–42 weeks), the patient must undergo spinal anaesthesia, the pregnant mother should not have used specific medications, should have no underlying diseases, should not have an addiction to any narcotic substance, and should have a BMI of less than 30.

Criteria for exclusion in the study: individuals experiencing very high blood pressure or severe hypotension and tachycardia during the procedure will be excluded from the study, individuals who experience severe bleeding during the caesarean section and are candidates for blood transfusion will be removed from the study, mothers who experience anaesthesia-related complications such as severe vomiting should be excluded from the study, individuals meeting the criteria for the patient's refusal to participate in the study and intrauterine foetal death will be excluded from the study.

After completing the demographic information, patients were sent to the operating room. The operating room temperature was regulated within the standard range of 18–22°C. Before the surgery, the pregnant mother received 1 l of Ringer's solution at a temperature range of 30–40°C (previously stored in the Bair-Marie warmer) through an intravenous injection using catheter number 16.

The amount of serum received during the entire caesarean operation was 5.2 l. The body temperature of the mothers and vital signs such as blood pressure, heart rate, and arterial blood oxygen saturation were measured and recorded using a monitoring device. We monitored the patient's blood pressure to ensure it did not drop below 20% of the normal range. In the event of a drop in blood pressure, we treated the patient with 5 mg of ephedrine. The type of anaesthesia used was spinal anaesthesia.

All patients received 3 ml of 0.5% hyperbaric Marcaine aspen via a 25-gauge needle from Spinal needle Dr. Japan Co. Ltd in the third and fourth lumbar space while in a seated position. The injection had to be performed by a single individual and only with a single try. The first group was placed in a 10° Trendelenburg position after receiving spinal anaesthesia, and the second group was placed in a 10° reverse Trendelenburg position.

The duration of spinal anaesthesia, measured in minutes from the complete cessation of leg movement to the ability to fully bend the knee, was recorded and compared between the two groups by the researcher. The level of spinal anaesthesia based on dermatomes before the start of the caesarean operation and every 15 min in recovery was recorded and compared in both groups. To ensure the resolution of anaesthesia, Broom criteria were used. Additionally, throughout this period, blood pressure, heart rate, arterial oxygen saturation, and newborn Apgar scores were recorded. Finally, the data from these two groups were subjected to statistical analysis.

Data analysis

For statistical analysis, descriptive statistics were used along with analysis of variance for the repeated vital signs data. Yoomen Whitney and Kruskal–Wallis tests were utilized to examine the duration and level of anaesthesia. All statistical findings of the patients were statistically analyzed using SPSS software version 26 for Windows, and a P value less than 0.05 was defined as significant.

The study was a triple-blind clinical trial, after obtaining approval from the Ethics Committee and the Research Deputy of

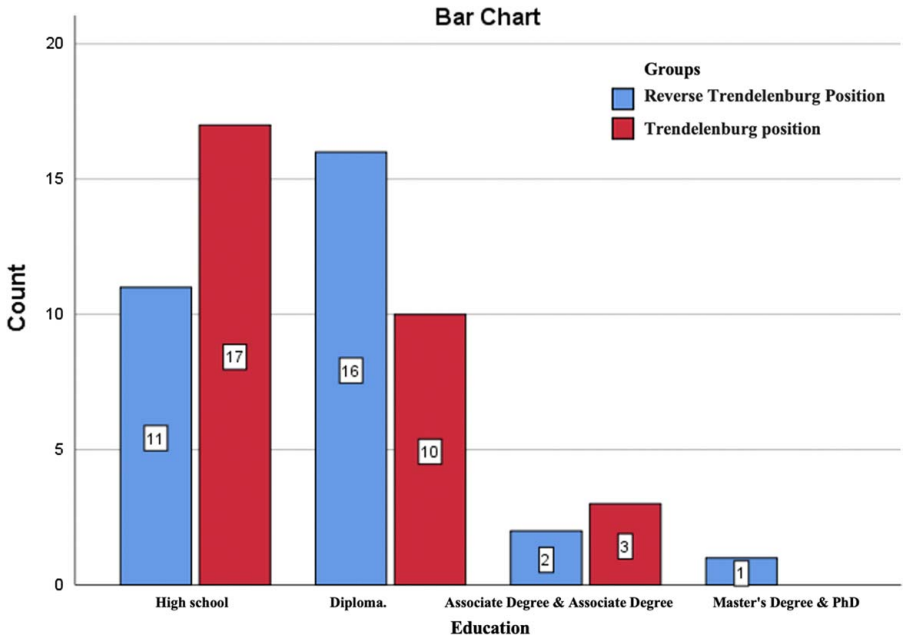

Figure 1. Frequency of education of participants in two groups.

the Alborz University of Medical Sciences (IR.ABZUMS.REC.1401.147), and registered in the Iranian Registry of Clinical Trials (IRCT20211228053560N1).

Research Registry UIN: researchregistry9657.

This manuscript adheres to the applicable CONSORT guidelines[12].

Results

A total of 60 patients were enroled. All vital sign measurements of the participating patients were taken throughout 13 time intervals, starting at the beginning of the study, and repeated every 5 min.

The information regarding age, body mass index, and education levels for both groups. The average age of participating mothers in the study fell within the range of 30 years. The highest education levels among participants in the study were below diploma and at the diploma level. Considering statistically significant levels, it should be noted that the two study groups did not show any significant differences in terms of age, BMI, and education outcomes ($P < 0.05$) (Fig. 1).

Table 1 illustrates the comparison of the duration of anaesthesia between the two study groups. Considering the average and standard deviation of the anaesthesia duration and the statistically significant level in the two groups, which is less than 0.05, it should be noted that the average (standard deviation) of the anaesthesia duration in the Trendelenburg position is significantly higher than in the Reverse Trendelenburg position.

Figure 2 shows the comparison of sensory levels in the two study groups. Considering the statistically significant level which is higher than 0.05, it can be stated that there is no significant difference in sensory levels between the two study groups.

Figure 3 displays the descriptive information of changes in systemic blood pressure during 13 measurements. the result of the Greenhouse-Geisser repeated-measures ANOVA test indicates non-significance. Therefore, there is no significant difference in mean systolic blood pressure between the two study groups.

Figure 3 shows the descriptive information of changes in diastolic blood pressure during 13 measurements. the result of the Greenhouse-Geisser repeated-measures ANOVA test indicates non-significance. Therefore, there is no significant difference in mean diastolic blood pressure between the two study groups.

Table 2 displays the descriptive information on heart rate changes over 13 measurement sessions. the result of the Greenhouse-Geisser repeated-measures ANOVA test indicates non-significance. Therefore, there is no significant difference in the mean heart rate between the two study groups.

Table 3 displays descriptive information on changes in Apgar scores over 13 measurement sessions. which indicate the non-significance of the repeated-measures Greenhouse-Geisser test for time and group interaction, the test is not statistically significant. Therefore, there is no significant difference between the two study groups in terms of mean Apgar scores.

Table 4 illustrates the descriptive data on changes in SO_2 levels over 13 measurement sessions. which indicate the non-significance of the repeated-measures Greenhouse-Geisser test for time and group interaction, the test is not statistically significant. Therefore, there is no significant difference between the two study groups in terms of mean SO_2 levels.

Table 1

Comparison of duration of anaesthesia in two study groups

Groups	SD	Mean	*P*
Reverse Trendelenburg Position	37.28	159.00	0.0001*
Trendelenburg position	37.12	221.57	

*t-test.

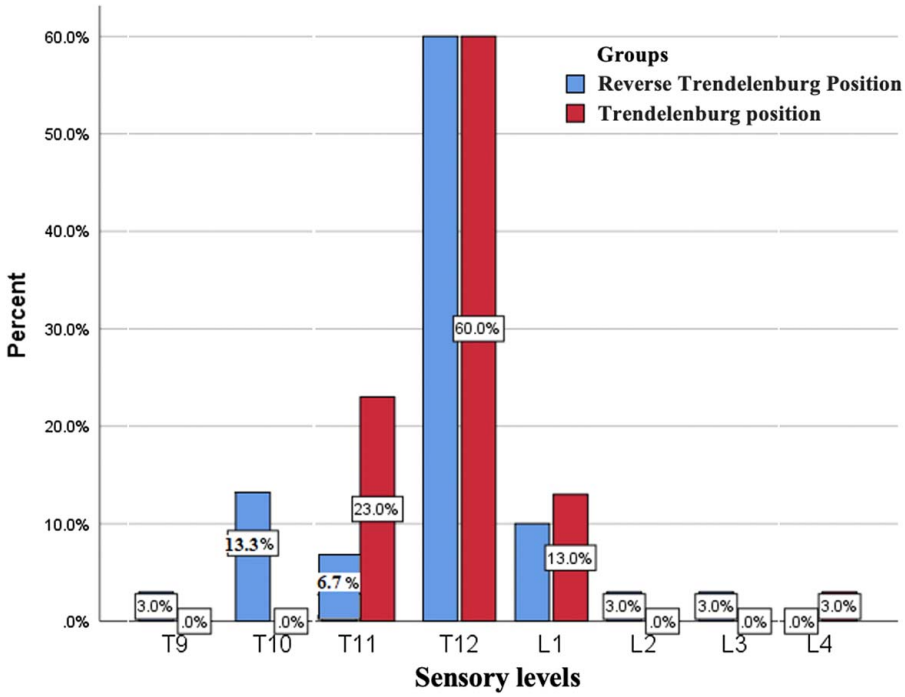

Figure 2. Frequency distribution of sensory levels in two study groups.

Discussion

CS has become a common method of childbirth for women in recent decades, and the use of spinal anaesthesia for this surgical procedure has attracted considerable attention from obstetricians, gynaecologists, and anesthesiologists. Spinal anaesthesia is the preferred method for Caesarean surgery, eliminating significant risks associated with airway problems such as difficult intubation and aspiration.

One of the fundamental challenges in this area is for specialized physicians to employ suitable drugs and patient positioning to enhance the anaesthesia process and extend the duration of spinal anaesthesia. Of course, an appropriate method for patient positioning should provide the best conditions to maintain suitable anaesthesia vital signs. Evaluating the two Trendelenburg positions and reverse Trendelenburg in women candidates for CS to assess the duration of anaesthesia and vital signs changes is significantly important, and this study is robust in this field[13].

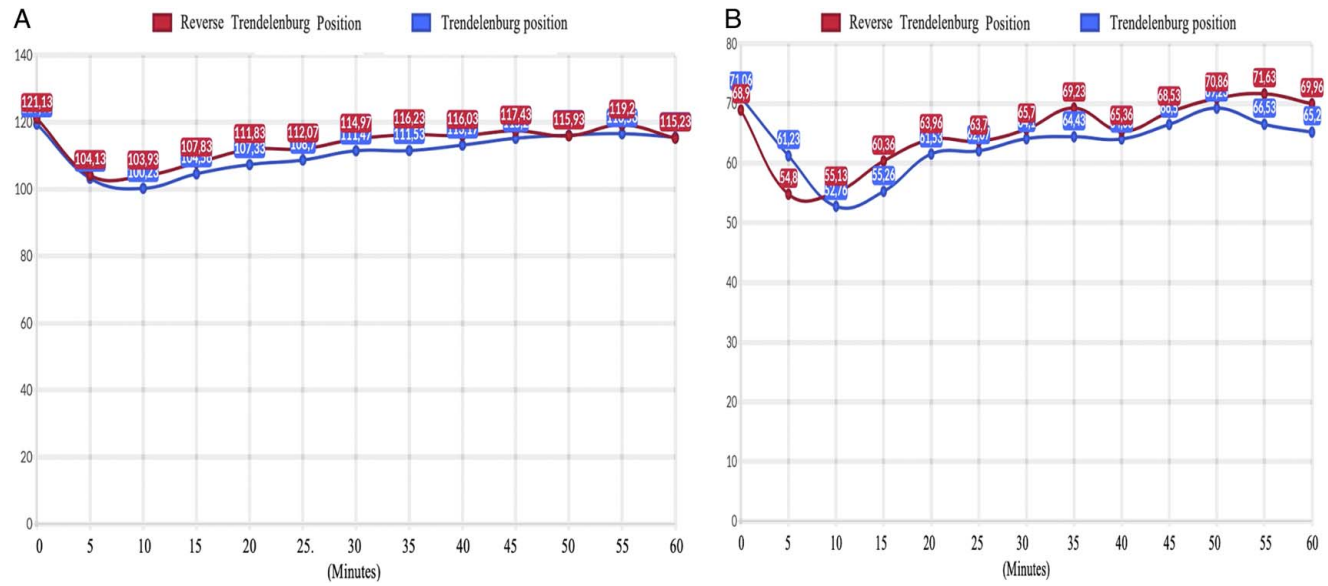

Figure 3. Comparison of average (A) systolic and (B) diastolic blood pressure changes in two study group.

Table 2

The result of the Greenhouse-Geisser test in the repeated measurement of heart rate changes

Source of changes	Test F	Degrees of freedom	Sum of squares	P
Measurement time	16.930	4.261	18 480.638	0.0001
Group	0.236	1	243.713	0.629
Interaction of measurement time and group	1.382	4.261	1508.85	0.238

Table 4

The result of Greenhouse-Geisser test in repeated measurement of SO_2 changes

Source of changes	Test F	Degrees of freedom	Sum of squares	P
Measurement time	1.216	8.535	23.454	0.285
Group	14.403	1	98.371	0.0001
Interaction of measurement time and group	1.804	8.53	34.813	0.069

In the present study, the two study groups did not significantly differ in basic information such as age, BMI, which could influence vital sign outcomes or anaesthesia duration, and educational backgrounds[14]. This indicates that the results obtained from this study were not influenced by the demographic and background factors of the participating patients. In other words, the two study groups are almost harmonized in terms of basic and demographic information.

Difficulties with lumbar puncture for spinal anaesthesia that anesthesiologists may encounter include increased lumbar lordosis, which may be more common in females than in males and also increases with pregnancy and age[15].

In the present study, the results indicated that the mean (SD) duration of Trendelenburg position anaesthesia was significantly higher compared to the reverse Trendelenburg position. Similar findings were observed in other studies where Kumar and colleagues stated that in the comparison of reverse Trendelenburg position with slow onset spinal in the reverse Trendelenburg group compared to the slow onset supine group, sensory and motor block durations in the reverse Trendelenburg group were significantly higher than the supine group. Therefore, it is suggested that reverse Trendelenburg position can be an appropriate position for spinal anaesthesia during caesarean surgery in mothers; however, these results were compared to the supine position method[13,14].

In another study in this field, it has been mentioned that the use of the reverse Trendelenburg position may extend the duration of anaesthesia in patients compared to the horizontal position. However, this study did not carry out a comparative analysis between the Trendelenburg position and its reverse type[15,16].

In another study in this field, it has been noted that the reversed Trendelenburg position of 10° significantly restricts the level of sensory block immediately after spinal anaesthesia and prolongs the duration of unilateral spinal anaesthesia[17].

Certainly, it should be noted that in studies evaluating the effectiveness and appropriateness of the Trendelenburg position alone compared to other horizontal positions in extending the duration of anaesthesia, in a study by Sara Johnson and colleagues, it was mentioned that tilting the head down by 10° (Trendelenburg) might lead to a greater spread of spinal anaesthesia compared to the horizontal group, achieving a higher block with a lower volume of local anaesthetic[18]. This supports the notion of prolonged anaesthesia duration in patients, as in our study[19].

In another study comparing the application of the Trendelenburg position or its omission for spinal anaesthesia, it was stated by the authors that adopting a short head-down position after spinal injection can achieve a higher level of sensory block. This may effectively increase the duration of anaesthesia in patients[20].

The overall effectiveness of studies conducted on comparing the inverted Trendelenburg position and restricted Trendelenburg has been limited. In the present study, the results indicated that there was no significant difference between the two positions, Trendelenburg and inverted Trendelenburg, concerning the level and spread of sensory block. In related studies in this field, different results were obtained compared to our study, such as in the study conducted by Kumar and colleagues, where significantly higher sensory levels above the T8 vertebra were found in the group using the inverted Trendelenburg position compared to the supine position. This indicates higher and lower sensory levels in the inverted Trendelenburg position than in the supine position[21,22].

This study highlights the effectiveness of the reverse Trendelenburg position in providing a superior block height and proper timing for anaesthesia during spinal anaesthesia and caesarean section compared to lying in the lateral position without elevating the head. Gradual onset, appropriate block height, and improved hemodynamics accompany this position. In other words, this study confirms the effectiveness of employing the reverse Trendelenburg position in achieving the appropriate block height and timing for anaesthesia. The findings in this study indicated that the two study groups did not significantly differ in terms of hemodynamic changes measured during 13 sessions, including heart rate, systolic and diastolic blood pressure, and Apgar scores. The studies obtained in the field report a stable and appropriate hemodynamic status in patients in both the Trendelenburg and reverse Trendelenburg positions[23,24]. This is corroborated by a study conducted by Kumar and colleagues[14], which described an appropriate hemodynamic status for patients in the reverse Trendelenburg position for spinal anaesthesia. In 2002, a study by Ahmad Setaayesh and colleagues compared the Trendelenburg and horizontal positions for spinal anaesthesia and found no significant differences in vital signs, arterial blood oxygen saturation, and Apgar score between the two groups[16]. It can be stated that the Trendelenburg position is a safe position

Table 3

The result of the Greenhouse-Geisser test in the repeated measurement of Apgar score changes

Source of changes	Test F	Degrees of freedom	Sum of squares	P
Measurement time	121.472	2.554	75.418	0.0001
Group	2.204	1	7.212	0.143
Interaction of measurement time and group	0.921	2.554	0.572	0.420

concerning vital signs and hemodynamic changes[15]. Overall, employing an appropriate method and position for spinal anaesthesia in candidates for caesarean section can play a significant role in improving the conditions of spinal anaesthesia in mothers and increasing the duration of this anaesthesia and their sensory levels[25,26]. Studies of this nature need to be conducted in this field to evaluate the various complications associated with each of the positions.

Conclusion

The results of the current study indicated that the mean (standard deviation) duration of anaesthesia in the Trendelenburg position was significantly higher than that in the Reverse Trendelenburg position. The findings demonstrated no significant difference between the two study groups in terms of hemodynamic changes during 1 h from the onset of anaesthesia, including heart rate, systolic and diastolic blood pressure, and Apgar score. There was no significant difference observed between the Trendelenburg and reverse Trendelenburg positions concerning the sensory level and its extent.

Study limitations include the lack of long-term follow-up to determine the consequences of spinal anaesthesia, which may be recommended to be investigated in future studies.

Ethical approval and consent to participate

All procedures performed in this study involving human participants were in accordance with the ethical standards of the institutional and/or national research committee and with the 1964 Helsinki Declaration and its later amendments or comparable ethical standards.

Consent

Patient consent: Informed consent was obtained from the patient for publication and any accompanying images. A copy of the written consent is available for review by the Editor-in-Chief of this journal on request.
Parental consent: Informed consent was obtained from the patient's parents/legal guardian for publication and any accompanying images. A copy of the written consent is available for review by the Editor-in-Chief of this journal on request.
Consent to participate: From the under 16 years old was given by a parent or legal guardian.
Consent for publication: Not applicable.

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Author contribution

B.M. and M.A.: conceptualized and designed the study, drafted the initial manuscript, and reviewed and revised the manuscript. M.H. and M.F.: designed the data collection instruments, collected data, carried out the initial analyses, and reviewed and revised the manuscript. S.R. and S.M.P.: coordinated and supervised data collection, and critically reviewed the manuscript for important intellectual content.

Conflicts of interest disclosure

The authors deny any conflict of interest in any terms or by any means during the study.

Research registration unique identifying number (UIN)

The study was a triple-blind clinical trial, after obtaining approval from the Ethics Committee and the Research Deputy of the Alborz University of Medical Sciences (IR.ABZUMS.REC.1401.147), and registered in the Iranian Registry of Clinical Trials (IRCT20211228053560N1).

Guarantor

Dr Banafsheh Mashak.

Availability of data and material

Data sharing is not applicable to this article as no datasets were generated or analyzed during the current study.

Provenance and peer review

Not commissioned, externally peer-reviewed.

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