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Original Contribution

The effects of spinal immobilization at 20° on intracranial pressure

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ABSTRACT

Objective: In this study, it was aimed to evaluate whether spinal immobilization at 20°, instead of the traditional 0°, affects intracranial pressure (ICP) via the ultrasonographic (USG) measurement of optic nerve sheath diameter (ONSD).
Methods: 140 healthy, adult, non-smoking volunteers who had no acute or chronic diseases were included this study. Volunteers were randomly divided into two groups; performed spinal immobilization at 0° (Group 1) and at 20° (Group 2). After spinal immobilization (at 0 or 20°), measurements of ONSD were performed at 0, 30, and 60 min in an immobilized position.
Results: When evaluating the change in ONSD over time (at 30 and 60 min) as compared to basal measurements at 0 min, it was found that the ONSD values of both sides (the right and left eyes) were significantly increased in Group 1 and Group 2. For Groups 1 and 2, these differences existed both between 0 and 30 min and between 30 and 60 min.
In addition, in this study, the amounts of increase in the ONSD measurements from 0 to 30 min and from 30 to 60 min (ΔONSD0–30 min and ΔONSD30–60 min) in both groups were compared. The results showed that there was no significant difference between Group 1 and Group 2 in terms of ΔONSD measurements.
Conclusions: Spinal immobilization at 0° as a part of routine trauma management increased ONSD and thus ICP. Secondly, we found that similar to immobilization at 0°, spinal immobilization at 20° increased ONSD.

1. Introduction

According to several international trauma management guidelines, including the Advanced Trauma Life Support guidelines (ACLS), spinal immobilization with a long backboard (LBB) and semi-rigid cervical collar (CC) has been a key recommendation in trauma patients for decades [1,2]. The reason for this recommendation is that spinal cord injury is one of the main causes of both mortality and morbidity in trauma patients [3]. However, in spite of this general recommendation, there is little evidence of the routine use of spinal immobilization [4,5]. In fact, several side effects of spinal immobilization, including pain, changes in vital signs, decreased pulmonary functions, skin ulcers, and increased intracranial pressure have been reported by various studies [6-11].

In our recent study, we investigated spinal immobilization performed at 20°, instead of the traditional 0°, in order to determine whether this reduced such side effects, especially decreased pulmonary function. We found that pulmonary function was improved with spinal immobilization at 20° [12]. However, it is still unclear whether spinal immobilization at 20° has a protective effect on intracranial pressure.

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Therefore, in this study, we aimed to evaluate whether spinal immobilization at 20°, instead of the traditional 0°, affects intracranial pressure (ICP) via the ultrasonographic (USG) measurement of optic nerve sheath diameter.

2. Materials and methods

This study was conducted with healthy adult volunteers recruited from the emergency department (ED) of a training and research hospital between July 2017 and April 2018 after receiving local ethics approval. Written informed consent was obtained from all subjects before spinal immobilization and ultrasonographic measurement were performed.

2.1. Volunteer subjects

After sample size calculation, 140 healthy, adult, non-smoking volunteers who had no acute or chronic diseases were included this study. All were between 20 and 40 years of age, and the study included both male and female participants. The study excluded volunteers with a Body Mass Index (BMI) >30 kg/m^2, those who were pregnant, and those with medical conditions that prevented the application of LBBs

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or CCs. Before the study was conducted, all volunteers underwent systemic physical examinations. Volunteers who had an abnormal physical examination or vital-sign findings were also excluded from the study.

2.2. Study protocol

All volunteers were asked to sleep at least 8 h the night before the study and fast for at least 2 h before their ultrasonographic optic nerve sheath diameters were measured. All measurements were taken between 10 and 11 AM. Volunteers were randomly divided into two groups, and those in the first group (Group 1) had LBBs and CCs applied at 0° ($n = 70$), while volunteers in the second group (Group 2) had LBBs and CCs applied at 20° ($n = 70$) (Fig. 1). After a 30-minute rest period and a brief physical examination, all volunteers were asked to lie down on the LBB, and CCs were applied at either 0° or 20°, depending on the group. Measurements of optic nerve sheath diameter were performed at 0, 30, and 60 min in an immobilized position, and the results were recorded on the study form.

2.3. Ultrasonographic measurements

All USG measurements were performed by a radiologist who was blind to the study. USG measurements were performed on both the right and left optic nerves using a 10 MHz linear probe. All measurements were performed twice for each optic nerve, and the averages of both measurements were used in the data analysis.

2.4. Sample size calculation

The sample size was estimated using G-power for Mac OS (Version 3.1.9.2; Universitat Düsseldorf, Germany). In previous studies, the mean optic nerve sheath diameter was found to be 4.2 ± 0.7 mm in healthy subjects [13]. Our aim was to achieve the power needed to detect a 0.5 mm change in optic nerve sheath diameter. Thus, assuming a two-sided $\alpha = 0.05$, we anticipated requiring a sample size of 50 patients for each group to achieve 95% power. To account for potential protocol violations, we included an additional 20 patients in each group. Thus, 70 healthy subjects were included in each group for this study.

2.5. Statistical analyses

Statistical analyses were performed using SPSS 15.0 (Chicago, IL). A Shapiro-Wilk test was used to assess the normal distribution of all parameters related to the volunteers. Non-parametric data were expressed as median values and interquartile-ranges (25–75%). Parametric data were expressed as means and standard deviation (SDs). Categorical data were expressed as numbers and percentages. Dependent non-parametric samples were analyzed using the Friedman test, and the Wilcoxon test was used to determine of group which was reason of significant difference after Bonferroni correction. In addition, whenever appropriate, 95% confidence intervals were calculated. A p-value < 0.05 was considered statistically significant.

3. Results

In total, 140 healthy subjects were included in this study. In the first group (spinal immobilization at 0°), the mean age of the subjects was 29.6 ± 6.21, and 35 subjects (50%) were female. In the second group (spinal immobilization at 20°), the mean age was 29 ± 6.3, and 35 subjects (50%) were female. In Group 1, the mean BMI value was 23.2 ± 3.41, and in Group 2, this was 22.17 ± 3.65. All subjects' demographic characteristics are presented in Table 1. There were no differences between groups in terms of demographic characteristics and optic nerve sheath diameter at the beginning of spinal immobilization.

When evaluating the change in optic nerve sheath diameter over time (at 30 and 60 min) as compared to basal measurements at 0 min (beginning of spinal immobilization), it was found that the optic nerve sheath diameter values of both sides (the right and left eyes) were significantly increased in Group 1 ($p < 0.001$ and $p < 0.001$, respectively). Similarly, in Group 2 (spinal immobilization at 20°), optic nerve sheath diameter values were increased significantly on both sides ($p < 0.001$

Fig. 1. A: Classical spinal immobilization with LBB and CC at 0°. B: Spinal immobilization at 20°.

Table 1
Subjects' demographic and clinical characteristics.

	Group – 1 (0°)	Group – 2 (20°)	p value
Age – year	29.60 ± 6.21	29.00 ± 6.30	0.5
Length – meter	1.70 ± 0.70	1.71 ± 0.83	0.4
Weight – kg	67.90 ± 12.81	65.76 ± 12.84	0.3
BMI – kg/m^2	23.2 ± 3.41	22.17 ± 3.65	0.08

BMI: Body Mass Index.

and $p < 0.001$) (Table 2). For Groups 1 and 2, these differences existed both between 0 and 30 min and between 30 and 60 min.

In addition, in this study, the amounts of increase in the ONSD measurements from 0 to 30 min and from 30 to 60 min ($\Delta ONSD_{0-30min}$ and $\Delta ONSD_{30-60min}$) in both groups were compared. The results showed that there was no significant difference between Group 1 and Group 2 in terms of ΔONSD measurements (Table 3).

4. Discussion

Performing spinal immobilization at 20° is a new experimental proposal intended to reduce the potentially harmful effects of spinal immobilization at 0°. The first study of spinal immobilization at 20° was conducted by Akkus et al. and included 56 healthy subjects [12]. In this study, the authors intended to evaluate whether performing spinal immobilization at 20° instead of 0° protected pulmonary function, including FEV1, FVC, and FEV1/FVC or not. They reported that FVC values were not decreased with spinal immobilization at 20° and that the amounts of decrease in FEV1 and FEV1/FVC were lower at 20° than at 0°. However, the evidence presented in this proposal is based only on healthy subjects and a small sample size. Therefore, this proposal (spinal immobilization at 20°) requires new evidence and new clinical trials before it can become a part of the routine management of trauma patients. For this purpose, Aksel et al. performed a study that included healthy subjects and investigated whether using the above proposal, instead of spinal immobilization at 0°, affected cerebral oxygenation. Ultimately, they reported that spinal immobilization at 20° did not affect cerebral oxygen saturation [14]. However, there is still a need for new studies focusing on the relationship between spinal immobilization at 20° and other physiological parameters. One of these parameters is intracranial pressure (ICP), and our study aimed to evaluate the relationship between spinal immobilization at 20° and ICP. Considering our results, we believe that this study provides two important findings. First, our findings reveal that spinal immobilization with LBB and CC at 0° seems to increase ICP, which is used to measure ONSD. The second finding answered this study's main question, which was whether spinal immobilization at 20° lessens increases ICP as compared to spinal immobilization at 0°. However, our findings revealed that similar to immobilization at 0°, spinal immobilization at 20° seems to increase ICP. Therefore, we believe that despite not having a harmful effect, spinal immobilization at 20° does not have protective effect in terms of ICP.

Several previous studies have shown that spinal immobilization with a rigid cervical collar causes increased ICP. For instance, in a study conducted by Davies et al. that included 19 patients who had traumatic brain injuries and micro-ventricular catheters, the authors evaluated the effect of a rigid cervical collar on ICP. The authors measured ICP 20 min after and directly before the application of a rigid cervical collar. Finally, they found that after the application of the cervical collar, ICP statistically significantly increased, reaching 4.5 mm ± 4.1 [15]. Similarly, in another study conducted by Hunt et al. with 30 patients who had experienced severe traumatic brain injuries, were intubated, and had micro-ventricular catheters, it was found that the application of rigid cervical collar caused an increase in ICP values, which reached 4.6 mm Hg ± 3.1 [16]. In another study conducted by Kolb et al. with 20 subjects who performed lumber puncture for several clinical conditions, the authors evaluated changes in cerebrospinal fluid pressure (CSFP) after the application of a cervical collar. They found the amount of change in CSFP after the application of a cervical collar to be 24.8 mm ± 28.4 ($p = 0.01$) [17]. In our study, ICP was not measured directly, such as by using a ventricular catheter or lumbar puncture. Instead, we evaluated ICP change using ONSD measurements. In spite of this difference in measurement methods, we believe that our findings support the previous results: spinal immobilization with CC and LBB increased ONSD and thus ICP. In contrast to the authors of previous studies, we hypothesized that this ICP increase can be lessened by performing spinal immobilization at 20°. However, our findings have revealed that this hypothesis is not true.

Table 3
Comparing of amounts of increasing values of ONSD (ΔONSD) according to groups

	Group-1	Group-2	p value
Right ΔONSD			
• 0th minute–30th minute	0.30 (0.13–0.40)	0.25 (0.1–0.4)	0.9
• 30th minute–60th minute	0.35 (0.20–0.45)	0.32 (0.20–0.55)	0.8
Left ΔONSD			
• 0th minute–30th minute	0.25 (0.08–0.35)	0.20 (0.10–0.35)	0.3
• 30th minute–60th minute	0.35 (0.20–0.55)	0.30 (0.20–0.45)	0.3

ONSD: optic nerve sheath diameter. Comparing data between groups were performed with Mann-Whitney *U* test.

4.1. Limitations

This study had certain limitations. First, the subjects in this study were young and healthy. Therefore, the findings of this study cannot be generalized to other population groups, especially elderly patients with brain injuries. Secondly, considering our methodology and population, even though the increases in ICP were significant statistically, we cannot be sure that they are clinically important. If the study had been conducted with patients who had brain injuries, our results might have differed.

5. Conclusion

In this study, our findings revealed that spinal immobilization with LBB and CC at 0° as a part of routine trauma management increased ONSD and thus ICP. Secondly, regarding this study's main question,

Table 2
Basal measurements and changes of ONSD values over time.

	Basal measurement at 0th minute	30th minute	60th minute	p value
Group 1 (0°)				
• Right ONSD	5.5 (5.3–5.6)	5.8 (5.5–5.9)	5.8 (5.6–6.0)	<0.001[a]
• Left ONSD	5.5 (5.3–5.6)	5.6 (5.5–5.8)	5.8 (5.6–6.0)	<0.001[a]
Group 2 (20°)				
• Right ONSD	5.5 (5.3–5.6)	5.7 (5.5–5.9)	5.8 (5.5–6.0)	<0.001[a]
• Left ONSD	5.5 (5.3–5.6)	5.7 (5.4–5.8)	5.8 (5.5–6.0)	<0.001[a]

ONSD: optic nerve sheath diameter.
All measurements were presented median values and interquartile ratios (IQR) 25–75%. Data of three dependent groups were compared by Friedman test.
[a] Statistically significance differences were caused all measurements (difference of 0–30 min and difference 30–60 min).

which was whether spinal immobilization at 20° lessens increased ICP as compared to performing spinal immobilization at 0°, we found that similar to immobilization at 0°, spinal immobilization at 20° increased ONSD. Therefore, we believe that despite not having a harmful effect, spinal immobilization at 20° does not have a protective effect in terms of ICP.

Ethics committee approval

The local ethical committee was approved this study (Kecioren Training and Research Hospital, local ethical committee).

Informed consent

Not applicable.

Author contributions

1) Conceived and designed the experiments: ŞKÇ, YK, SÖ.
2) Performed the experiments: SÖ, ŞKÇ, EE, ÖG.
3) Analyzed and interpreted the data: ŞKÇ, EE, YÇ.
4) Contributed reagents, materials, analysis tools or data: ŞKÇ, YÇ, YK, EE, ÖG.
5) Wrote the paper: ŞKÇ, SÖ, YK.

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None.

Conflict of Interest

None.

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