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Does Passive Leg Raising Affect Intracranial Pressure in Healthy Volunteers?

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Abstract

Background: Ultrasonographic optic nerve sheath diameter (ONSD) measurements taken at the bedside are used to estimate intracranial pressure. Passive leg raising (PLR) is a maneuver that can test whether intravascular volume expansion can improve cardiac output in the presence of circulatory failure. In this study, we investigated whether the PLR maneuver has an effect on ONSD in healthy adults.

Materials and Methods: This prospective study consisted of 32 healthy volunteers. ONSD measurements were taken in three consecutive steps. In the first, patients were placed in a supine position on a flat stretcher. In the second stage, patients were brought to the semi-recumbent position by lifting the stretcher head by 45°. In the third stage, patients were raised in a position with their legs 45° above their trunk.

Results: The ONSD measurements of the subjects for the right eye were 4.75 (0.22) mm for the first position, 4.74 (0.35) mm for the second position and 4.76 (0.21) mm for the third position. The ONSD measurements of the subjects for the left eye were 4.75 (0.27) mm for the first position, 4.75 (0.16) mm for the second position and 4.76 (0.25) mm for the third position. There was no significant difference in ONSD measurements for either of the eyes in any of the three positions.

Conclusion: ONSD values measured at the bedside in the supine position were similar to those of the positions obtained with the PLR maneuver in healthy adults.

Keywords: Optic nerve sheath diameter; Passive Leg Raising; Intracranial pressure,

Introduction

Passive leg raising (PLR) is a maneuver that can be used to test whether intravascular volume expansion improves cardiac output in the presence of circulatory failure[1,2]. PLR causes this by increasing the preload of the right and left ventricles by causing blood translocation among body compartments[3,4]. The most important advantage of PLR is that it does not require any intravenous fluid administration and therefore does not expose the patient to excessive volume load due to reversible hemodynamic effects[2,4].

Although PLR[3,5] offers a prediction of hemodynamic fluid resuscitation for clinicians in critically ill patients, it is difficult to say the same for cerebral brain perfusion. Fluid resuscitation may play a key role in providing optimal cerebral brain perfusion in clinical situations with increased intracranial pressure (ICP) such as traumatic brain injury (TBI), stroke, and intracranial hemorrhage. The reason is that in cases with increased ICP, excessive fluid resuscitation may disrupt cerebral perfusion and cause ischemia[6–8]. Performing a test that can predict intracranial pressure with PLR can be useful in the management of fluid resuscitation in cases where intracranial pressure is suspected.

Optic nerve sheath diameter (ONSD), which can be measured ultrasonographically at the bedside, is a simple, accessible, noninvasive method used to estimate intracranial pressure[9–11]. In patients for whom hemodynamics and cerebral perfusion are critical, the measurement of ONSD with PLR before fluid resuscitation may facilitate decision making for clinicians in terms of providing a clinical clue in predicting potential damages due to excessive volume load. However, there is no data in the literature regarding the effects of the PLR maneuver on ONSD. Therefore, it makes sense to consider the effects in the first stage. In this study, we investigated the effects of the PLR maneuver on ONSD in hemodynamically healthy adults.

Materials and Methods

This prospective cross-over type design study was conducted from November 15, 2019 through February 15, 2020 in the Emergency Department of a tertiary hospital. The principles of the Declaration of Helsinki were adhered to through-

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Table 1. ONSD changes after supine position and PLR maneuver

	1. Position	2. Position	3. Position	pvalue
R-ONSD	4.75 (0.22)	4.74 (0.35)	4.76 (0.21)	0.261
L-ONSD	4.75 (0.27)	4.75 (0.16)	4.76 (0.25)	0.209

R-ONSD: Right Optic Nerve Sheath Diameter, L-ONSD: Left Optic Nerve Sheath Diameter
1.Position: Supine, 2. Position: Semirecumbent, 3. Position: Trunk was placed in the supine position, the legs were raised 45 ° above.
Data were expressed as median (interquartile range).

out the study and written informed consent was obtained from all participants. The study was approved by the University Ethics Committee (protocol number: 2017-KAEK-189_2019.10.30_20).

Study Population

Thirty-two healthy adults (males and females) were included in this study. The subjects were between the ages of 18 and 45. Those younger than 18 who had previously been diagnosed with a cardiovascular disease such as hypertension, coronary artery disease, arrhythmia, and/or an intracranial pathology such as an intracranial mass, hydrocephalus, stroke, and/or ophthalmological disease (trauma, tumor, infectious, etc.) were excluded. Those who had medication that would affect cerebrospinal fluid pressure were also excluded. Additionally, participants with glaucoma and/or those who were taking medications that might have affected intraocular pressure, along with those who had vasculitic or rheumatologic disease and/or were using drugs for any reason were excluded from the study.

Study Design

ONSD measurements were taken in three consecutive steps (Figure 1). In the first, patients were placed in a supine position on a flat stretcher. ONSD measurements of both eyes were taken while patients were kept in the supine position for one minute. In the second stage, patients were brought to the semi-recumbent position by lifting the stretcher head by 45°; they remained in that position for one minute and ONSD measurements were obtained for both eyes. In the third stage, patients were placed in a position with their legs 45° above their trunk. They were placed in the supine position for one minute and ONSD measurements were taken of both eyes.

Ultrasonographic Measurement Method

The HM70A with the Plus ultrasound system (Samsung Medison Co., Ltd., Seoul, Korea) model and a 7-16 Mhz linear probe were used for ultrasonographic examination. Before this, each patient's head was placed on a stretcher in a comfortable position and their eyes were closed. Their eyeballs were filled with a conductive gel. Eye structures were imaged while asking subjects to look forward with their eyes closed to align their optic nerve directly opposite the probe. Bilateral ONSD measurements were made on images recorded 3 mm behind the optic disc (Figure 2). Three measurements were taken for each eye; the average of the measurements was recorded.

Statistical Analyses

Statistical analyses were performed using SPSS software programme (IBM SPSS Statistics 22; IBM Corp.; Armonk, New York USA).The variables were investigated using analytical methods (Kolmogorov-Smirnov) to determine whether or not they are normally distributed. Descriptive analyzes were given using median and interquartile ranges for non-normally distributed variables. The effect of the PLR maneuver on the change in ONSD over time was investigated using the Friedman test as it did not match to the parametric test assumptions. An overall %5 type -1 error level was used to infer statistical significance.

Results

The mean age of the subjects was 31.25 ± 7.1 years, and 15 of the subjects were female. The mean systolic blood pressure of the subjects was 115.8 ± 6.86 mmhg, the mean diastolic blood pressure was 72.84 ± 5 mmhg, and the mean arterial pressure was 87.13 ± 4.84 mmhg. The mean body mass index of the patients was 23.8 ±2 .44 kg/m2.

The mean ONSD diameters of both eyes of the subjects in the supine position and that resulting from the PLR maneuver are shown in Table 1. No significant difference was found between the positions in ONSD measurements for the eyes (Friedman test p value; 0.261for the right eye and 0.209 for the left).

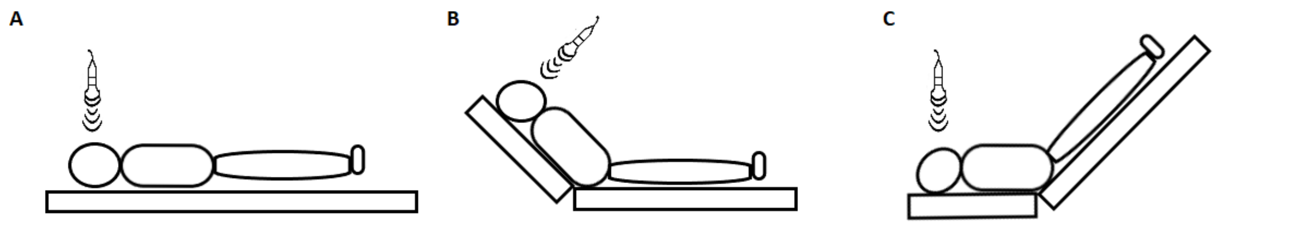

Figure 1. Demonstration of patient positions during ONSD measurements. A.) Supine position. B.) Semirecumbent position. C.) Trunk was placed in the supine position, the legs were raised 45 ° above.

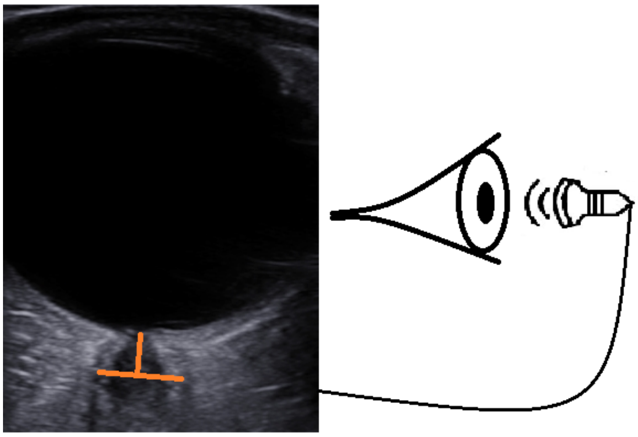

Figure 2. Demonstration of ultrasonographic measurement of ONSD measurement.

Discussion

The results indicate that the PLR maneuver does not affect ONSD measurements in hemodynamically stable healthy volunteers. This may indicate that the effect of hemodynamic change caused by the PLR maneuver on ICP in healthy adults is compensated.

Mean arterial pressure and ICP are two important major components in maintaining optimal cerebral perfusion pressure[7,12–14]. Excessive intravascular volume may lead to an increase in ICP, while lack may cause a decrease in mean arterial pressure[7,14]. In this situation, proper fluid resuscitation may play a key role in maintaining cerebral perfusion in neuro-critical patients[15]. For example, it is possible to say that a patient with a TBI injury who stays in a hypotensive state may suffer secondary ischemic brain damage[15,16]. In addition, excessive or inappropriate fluid resuscitation is also likely to reduce cerebral perfusion pressure by causing an increase in ICP[7]. Accordingly, estimating the effects of intravascular volume regulation on hemodynamics and cerebral perfusion may guide clinicians in the decision-making process of the next step.

Increasing cardiac ouput is the basis of intravenous fluid delivery to a patient[1,17]. It is known that PLR provides approximately 300 cc of venous blood return from the lower extremities[1,18,19]. Thus, the increased cardiac output obtained with PLR predicts the fluid need of the patient. It has been previously shown in the literature that PLR predicts fluid need[1,3–5,18,19]. In addition, the authors of previous studies have demonstrated the correlation of ONSD measurements to ICP in the supine position[9–11,20–22]. In our study, there was no change in ONSD measurements before or after the PLR maneuver. This situation may indicate that the bolus expansion effect in the intravascular area provided by PLR in hemodynamically stable, healthy adults can be quickly compensated for without causing a change in ICP.

Limitation

Our study had some limitations. The small number of our subjects and the fact that the subjects consisted of completely healthy adults were the major limitations of the study. Secondly, based on the subjects' basal vital signs and past medical histories, we considered their ICPs and volume status as normal. Before enrolling the subjects, we did not verify their ICP and volume status with more objective methods such as lumbar puncture, arterial pressure wave form, or stroke volume.

Conclusion

The ONSD measured after the PLR maneuver relative to the position before the PLR maneuver allows for evaluation of ICP under a volume load in an attempt to increase ICP. In our study, similar ONSD values measured before and after PLR were associated with normal physiological responses in hemodynamically stable, healthy adults. Although more research is needed to support a definitive judgment, we assert that based on these results, ONSD values measured as increased after PLR versus normal ONSD values before PLR may predict an intracranial pathology that may lead to a possible increase in ICP in the patient. However, to clarify this issue, the response of patients with increased ICP associated with the PLR maneuver should be investigated.

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