Original Article/Özgün Araştırma

doi: 10.54875/jarss.2024.79037

Evaluation of the Effect of Suspension Laryngoscopy on Optic Nerve Sheath Diameter: An Observational Study

Süspansiyon Laringoskopi Uygulamasının Optik Sinir Kılıf Çapı Üzerine Etkisinin Değerlendirilmesi: Gözlemsel Çalışma

Gulcin Buyukbezirci[1], Sule Arican[1], Feyza Kolsuz Erdem[2], Resul Yilmaz[1], Mehmet Akif Eryilmaz[3], Hamdi Arbag[3], Aybars Tavlan[1]

[1]Necmettin Erbakan University Faculty of Medicine, Department of Anesthesiology and Reanimation, Konya, Türkiye
[2]Necip Fazıl City Hospital, Clinic of Anesthesiology and Reanimation, Kahramanmaraş, Türkiye
[3]Necmettin Erbakan University Faculty of Medicine, Department of Otorhinolaryngology, Konya, Türkiye

ABSTRACT

Objective: Laryngoscopy is a procedure that induces hemodynamic alterations as well as increased intracranial pressure (ICP). Many procedures have examined ICP changes with optic nerve sheath diameter (ONSD) measurements. However, a small number of research has investigated the influence of suspension laryngoscopy on ONSD measurements. The present study has examined the effect of suspension laryngoscopy on ONSD measurements and ICP.

Methods: The study included 50 patients, who were scheduled for suspension laryngoscopy. Optic nerve sheath diameter measurements were taken after anesthesia induction (T0), after intubation (T1), when the neck was in hyperextension at the start of the suspension laryngoscopy (T2), when the neck was in hyperextension at the end of the suspension laryngoscopy (T3), and 5 minutes after the suspension was terminated and the neck was brought to the straight position (T4).

Results: The mean ONSD measurements were 3.8 ± 0.3 mm in T0, 4.0 ± 0.5 mm in T1, 5.1 ± 0.8 mm in T2, 5.1 ± 0.8 mm in T3 and 4.1 ± 0.5 mm in T4. The T1, T2, T3 and T4 values were considerably higher than the T0 values ($p<0.05$). There was no statistically significant correlation between suspension laryngoscopy time and ONSD measurements (R: -0.050, p: 0.729 - R: 0.089, p: 0.541).

Conclusion: Suspension laryngoscopy causes a significant increase in ONSD measurements. Suspension time, on the other hand, does not lead to a progressive increase. Ending the suspension by straightening the neck at the end of the procedure permits ONSD measurements to approach the baseline values.

Keywords: Suspension, laryngoscopy, intracranial pressure, optic nerve, ultrasonography

ÖZ

Amaç: Laringoskopi hemodinamik değişimlere ve intrakraniyal basınç (İKB) artışına neden olan bir girişimdir. Optik sinir kılıf çapı (OSKÇ) ölçümü ile İKB değişimi pek çok cerrahide analiz edilmiştir. Ancak süspansiyon laringoskopinin OSKÇ ölçümlerine etkisini analiz eden çalışma az sayıdadır. Bu çalışmada süspansiyon laringoskopinin OSKÇ ölçümleri ve İKB üzerine etkisi araştırılmıştır.

Yöntem: Çalışmaya süspansiyon laringoskopi planlanan 50 hasta dahil edildi. Optik sinir kılıf çapı ölçümleri; anestezi indüksiyonu sonrası (T0), entübasyon sonrası (T1), süspansiyon laringoskopi başlangıcında boyun hiperekstansiyondayken (T2), süspansiyon laringoskopi sonunda boyun hiperekstansiyondayken (T3) ve süspansiyon sonlandırılıp boyun düz pozisyona getirildikten 5 dakika sonra (T4) yapıldı.

Bulgular: Ortalama OSKÇ ölçümleri T0'da 3,8 ± 0,3 mm, T1'de 4,0 ± 0,5 mm, T2'de 5,1 ± 0,8 mm, T3'te 5,1 ± 0,8 mm ve T4'te 4,1 ± 0,5 mm idi. T1, T2, T3 ve T4 değerleri T0 değerlerinden anlamlı derecede yüksekti ($p<0.05$). Süspansiyon laringoskopi süresi ile OSKÇ ölçümleri arasında istatistiksel olarak anlamlı bir ilişki yoktu (R: -0,050, p: 0,729 - R: 0,089, p: 0,541).

Sonuç: Süspansiyon laringoskopi OSKÇ ölçümlerinde belirgin artışa neden olur. Ancak süspansiyon süresi progresif bir artışa neden olmaz. Cerrahi sonunda boynun düz pozisyona getirilerek süspansiyonun sonlandırılması OSKÇ ölçümlerinin başlangıç değerlere yaklaşmasını sağlar.

Anahtar sözcükler: Süspansiyon, laringoskopi, kafa içi basınç, optik sinir, ultrasonografi

Received/Geliş tarihi : 29.07.2023
Accepted/Kabul tarihi : 04.12.2023
Publication date : 31.01.2024

***Corresponding author:** Gulcin Buyukbezirci • drgulcin81@gmail.com

Gulcin Buyukbezirci 0000-0002-9438-3414 / Sule Arican 0000-0002-8634-1150
Feyza Kolsuz Erdem 0000-0003-4250-236X / Resul Yilmaz 0000-0002-5527-2893
Mehmet Akif Eryilmaz 0000-0001-5281-969X / Hamdi Arbag 0000-0001-6146-8801
Aybars Tavlan 0000-0002-6064-0179

Cite as: Buyukbezirci G, Arican S, Kolsuz Erdem F, Yilmaz R, Eryilmaz MA, Arbag H, Tavlan A. Evaluation of the effect of suspension laryngoscopy on optic nerve sheath diameter: An observational study. JARSS 2024;32(1):1-10.

INTRODUCTION

The ultrasonographic assessment of optic nerve sheath diameter (ONSD) is a new and noninvasive measurement technique that has been acknowledged as an indirect indication of intracranial pressure (ICP) (1). Intracranial pressure above 20 mmHg is defined as increased ICP (2). Intraventricular devices are considered gold standard for measuring ICP, however their usage is impractical due to the increased risk of infection and hemorrhage (3). Changes in pressure in the subarachnoid space and cerebrospinal fluid also affect the optic nerve sheath, causing it to expand in diameter. Although there is no cutoff number was found in the literature, it is widely acknowledged that values of 5 mm or higher indicate an increase in ICP (4,5).

Suspension laryngoscopy is a common procedure among otorhinolaryngologists. It enables bimanuel endolaryngeal surgery, and the surgeon can use it to intervene in a wide range of benign and malignant lesions (6). Direct laryngoscopy causes changes in ONSD (7). Furthermore, ONSD modification has been observed in adenotonsillectomy surgery, which is performed in a position very similar to suspension laryngoscopy surgery and employs the use of a mouth gag (8,9).

This study examined the effect of long-term laryngoscopy on ONSD, and thus ICP in suspension laryngoscopy surgery. Our hypothesis is that during suspension laryngoscopy surgery, where aggressive and long-term laryngoscopy is conducted, there will be a large increase in ICP and ONSD, which is an indirect signal.

MATERIAL and METHODS

This study was conducted prospectively in an academic university hospital in accordance with the principles defined in the Helsinki Declaration, with the approval of the Necmettin Erbakan University Ethics Committee (Decision Number: 2021/3412) and was registered in the Australian New Zealand Clinical Trials Registry (Trial ID: ACTRN12622000157774). All patients who agreed to participate in the study provided a written informed consent form. The study included ASA I-III patients between the ages of 18 and 90 who underwent suspension laryngoscopy. The study excluded patients with cerebral pathology, a history of cerebrovascular disease, a history of ocular pathology or disease, and pregnant women. Electrocardiograms (ECGs), pulse oximetry and noninvasive arterial pressure measurements were used to monitor the patients. Muscle relaxation of the patients was monitored with a neuromuscular transducer (NMT). To induce anesthesia, 1 μg kg^{-1} remifentanil (Rentanil, VEM, Tekirdağ, Turkey), 2 mg kg^{-1} propofol (Propofol 1% Fresenius, Fresenius Kabi AB, Uppsala, Sweden), and 0.6 mg kg^{-1} rocuronium (Myocron, VEM, Tekirdağ, Turkey) were used. At Train of Four (TOF) count 0, a C-MAC videolaryngoscope (Karl Storz 8403HX, Tuttlingen, Germany) was utilized for intubation, and sevoflurane (Sevorane®, Aesica Queenborough Ltd. Oueenborough Kent ME11 5EL, England) inhalation and intravenous (iv) remifentanil infusion in a 50% O_2-air mixture were employed for anesthetic maintenance. The vital values were titrated to be within the 20% range of the input values using sevoflurane and remifentanil. Tidal volume and respiratory rates were adjusted to keep end-tidal carbon dioxide ($ETCO_2$) levels were between 35-40 mmHg. The neck of the patients in the supine position was hyperextended, and the vocal cords were clearly visualized by an otolaryngologist (MAE, HA) with a direct laryngoscope (Storz 8590, Germany). By suspending in this position, microlaryngoscopy (Karl Storz 8575 KB, Germany) was performed (Figure 1). For postoperative analgesia,iv 10 mg kg^{-1} paracetamol (Parol 10 mg mL^{-1} iv solution, Atabay, İstanbul, Turkey) was given,and iv 0.01 mg kg^{-1} ondansetron (Zofran, GlaxoSmithKline, Research Triangle Park, England) was given for nausea and vomiting. Optic nerve sheath diameter was measured by ultrasonography at five different times in the same eye. The measurements were made by a trained anesthesiologist (GB). A 12.0 MHz linear ultrasound probe (Esaote MyLab Six Crystaline, Genoa, Italy) was gently applied to the closed upper eyelid with a thin layer of gel. To avoid applying too much pressure, the probe was set to show the optic nerve entry into the eyeball in 2D mode. The image was frozen after providing appropriate contrast enhancement between the hypoechoic image of the optic nerve and the echogenicity of the retrobulbar adipose tissue. An ultrasonography electronic caliper was used to take measurements 3 mm beyond the optical disc (Figure 2). The measurement was performed four times for a single eye, twice horizontally and twice vertically, and the average of these four readings was used to calculate the ONSD. Measurement times were defined as T0 (after induction of anesthesia), T1 (immediately after intubation), T2 (when the neck was extended at the start of the suspension laryngoscopy), T3 (when the neck was extended at the conclusion of the suspension laryngoscopy), and T4 (when the neck was in the straight position five minutes after the suspension laryngoscopy was terminated). Additionally, the $ETCO_2$ readings, saturation values, inspiratory peak pressure (IPP) and noninvasive mean arterial pressure (MAP) of the patients were noted. All patients' body mass index (BMI), age, sex, ASA and Mallampati scores, and suspension laryngoscopy times were also noted.

Statistical Analysis

The data obtained in the study were analyzed using the Statistical Package for the Social Sciences (SPSS) software, version 23.0 (IBM SPSS 23.0 for Windows, Armonk, New York, United States). All time-dependent measurements' descrip-

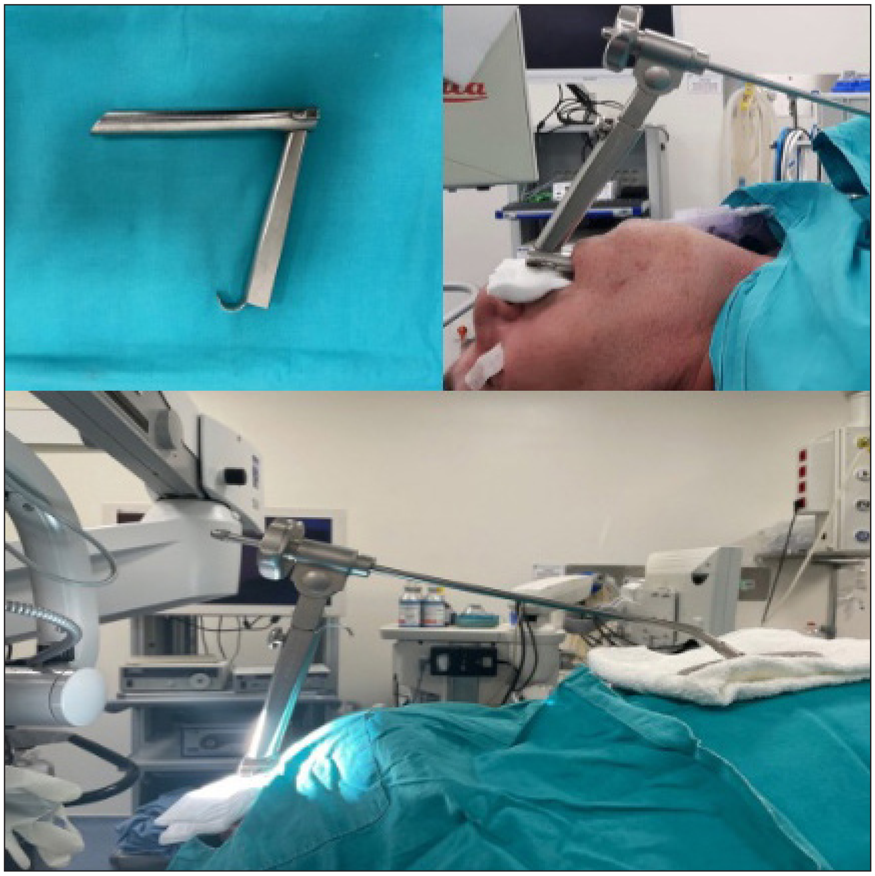

Figure 1: Blade of laryngoscope,hyperextended neck position and suspension laryngoscopy.

Figure 2: Ultrasonographic measurement of optic nerve sheath diameter.

tive statistical values and frequency distributions for general demographic traits are provided. The Shapiro-Wilk test was used to determine whether the measurement values were normal if n was less than 50, and the Kolmogorov-Smirnov test was used if n was greater than 50. If p>0.05, the values were considered to have a normal distribution between the groups, and if p<0.05, they were not considered to have a normal distribution. Following the normality test, the difference between the nonnormally distributed time-based data was calculated using the Friedman test statistics to determine whether there was a statistically significant difference between the time-dependent values. Binary measurement comparisons with the Bonferroni-corrected Wilcoxon test were used to identify the measurement time that resulted in a significant difference between the observed times. The significance level was calculated after Bonferroni correction by dividing P by the number of measurements (0.05/number of measurements). Mauchly's test of sphericity was first examined to determine how time-based data differed from the normal distribution assumption. The Greenhouse Geisser test was then used to rectify the impact of time-dependent correlations by concluding that the sphericity assumption was not met. Due to the lack of a normal distribution assumption, the Spearman correlation coefficient was utilized to analyze the relationship between variables. Upon discovering a significant association between the variables, the R correlation coefficient was used to evaluate the relationship's strength and direction (positive, negative). The Mann- Whitney U test was used to determine whether the Mallampati score made a difference in ONSD measurements because the assumption of normal distribution was not provided, and a $p<0.05$ was considered a significant difference.

Calculation of the Sample Size

The sample size of the study was calculated with the G*Power software, version 3.1.9.4 for Windows (Universität Düsseldorf, Düsseldorf, Germany) based on the data set of the pilot study consisting of five patients. According to the results of the pilot study, the mean ONSD measurement at T1 time was 4.10 ± 0.3 (mean ± SD), while the mean ONSD measurement at T2 time was 5.04 ± 0.65 (mean ± SD). With 95% power and a 0.01 margin of error, the sample size required to detect a 10% difference was computed as 20 patients.

RESULTS

The study included 50 patients. There were no patients who were excluded from the trial and the data of 50 individuals were analyzed. Table I shows the distribution of demographic data.

The mean ONSD measurements were 3.8 ± 0.3 mm at T0, 4.0 ± 0.5 mm at T1, 5.1 ± 0.8 mm at T2, 5.1 ± 0.8 mm at T3 and 4.1 ± 0.5 mm at T4. The greatest increase in ONSD measurements was observed at the start of suspension laryngoscopy (Figure 3).

T0 mean ONSD measurements were considerably lower at all time intervals, but T1 measurements were significantly higher than T0 measurements. T2 and T3 measurements were higher than T0 measurements. T1 and T4 measurements were significantly higher than T0 measurements. In addition, T4 measurements were significantly higher than T0 measure-

Table I: Distribution of Demographic Data

	n=50 (%, mean ± SD)
Age (year)	56.7 ± 15.9
Sex (M/F)	84/16
BMI (kg m^{-2})	27.2 ± 3.2
ASA (I/II/III)	4/44/52
Mallampati (I/II/III/IV)	8/58/24/10
Duration of Suspension Laryngoscopy (minute)	22.7 ± 9.7

SD: Standart deviation, **M:** Male, **F:** Female, **BMI:** Body mass index.

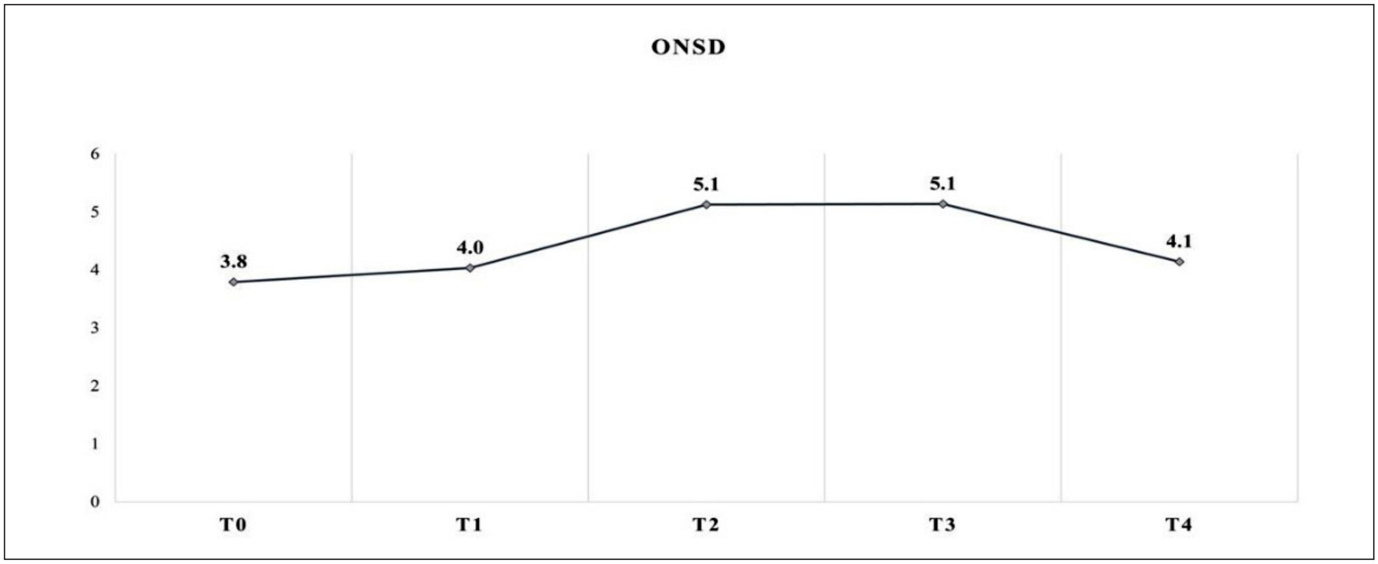

Figure 3: Change of ONSD measurements with respect to time (mm). **T0:** After anesthesia induction, **T1:** After intubation, **T2:** when the neck was in hyperextension at the start of the suspension laryngoscopy, **T3:** when the neck was in hyperextension at the end of the suspension laryngoscopy, **T4:** 5 minutes after the suspension was terminated and the neck was brought to the straight position.

ments. Table II provides the comparison of ONSD measurements between times.

Table II: Changes in Optic Nerve Sheath Diameter Measurements Between Different Time Points

Median ONSD Measurement (mm)	Time	Wilcoxon Test	
		Test Value	p
T0 3.7	T1	-1.130	**0.004***
	T2	-3.320	**0.000***
	T3	-3.360	**0.000***
	T4	-1.390	**0.000***
T1 4.0	T0	1.130	**0.004***
	T2	-2.190	**0.000***
	T3	-2.230	**0.000***
	T4	-0.260	1.000
T2 4.9	T0	3.320	**0.000***
	T1	2.190	**0.000***
	T3	-0.040	1.000
	T4	-1.930	**0.000***
T3 5.0	T0	3.360	**0.000***
	T1	2.230	**0.000***
	T2	0.040	1.000
	T4	-1.970	**0.000***
T4 4.0	T0	1.390	**0.000***
	T1	0.260	1.000
	T2	1.930	**0.000***
	T3	1.970	**0.000***

ONSD: Optic nerve sheath diameter, ***:** $p<0.05$. **T0:** After anesthesia induction, **T1:** After intubation, **T2:** when the neck was in hyperextension at the start of the suspension laryngoscopy, **T3:** when the neck was in hyperextension at the end of the suspension laryngoscopy, **T4:** 5 minutes after the suspension was terminated and the neck was brought to the straight position.

Considering the association of hemodynamic and respiratory characteristics with ONSD measurements at different time periods, a decrease in heart rate was associated with an increase in ONSD (Table III).

Regarding the changes in hemodynamic and respiratory parameters over time, heart rate T0 values were significantly different from T2 and T3 values (p=0.002, p=0.010). T1 values were significantly different from T3 values (p=0.010). Also, T4 values were significantly higher than T2 values (p=0.010) (p=0.002). End tidal carbon dioxide and IPP T3 values were found to be significantly higher than T1 values (p=0.01) (Figure 4).

There was no significant correlation detected between suspension laryngoscopy time and T3 and T4 ONSD measurements (R=-0.050, p=0.729 - R=0.089, p=0.541). Regarding the relationship between BMI, Mallampati scores, and ONSD values, there was no significant correlation (p>0.05) (Table IV).

DISCUSSION

This study investigated the effects of suspension laryngoscopy on ONSD and ICP. According to the study results, the suspension laryngoscopy resulted in a significant increase in ONSD measurements when compared to the baseline. This increase was in values indicating an increase in ICP. While the suspension period did not affect the increase in ONSD, the ONSD measurements approached the baseline values at the end of the procedure.

The suspension laryngoscopy has significantly contributed to the advancement of endolaryngeal surgery and laryngology (10). It has the advantage of providing a high-resolution image and allowing bimanual surgery. The major disadvantage is the abnormal alignment of the oropharyngeal structures

Table III: Optic Nerve Sheath Diameter and Its Interaction with Hemodynamic and Respiratory Parameters

ONSD median		HR median	Sat median	MAP median	$ETCO_2$ median	IPP median
T0	3.7	73	98	75.5		
T1	4.0	73.5	99	79.5	35	18
T2	4.9	65	99	79	36	19
T3	5.0	68.5	98	79	36.5	19
T4	4.0	68	98	79.5	37	19
R		-.155	-.007	-.011	.101	.076
P		**0.015***	0.909	0.858	0.113	0.231

SD: Standart deviation, **ONSD:** Optic nerve sheath diameter (mm), **HR:** Heart rate (beats min^{-1}), **Sat:** Saturation (%), **MAP:** Mean arterial pressure (mmHg), **$ETCO_2$:** End-tidal carbon dioxide (mmHg), **IPP:** Inspiratory peak pressure (cmH_2O), **R:** Correlation coefficient, ***:** $p<0.05$. **T0:** After anesthesia induction, **T1:** After intubation, **T2:** when the neck was in hyperextension at the start of the suspension laryngoscopy, **T3:** when the neck was in hyperextension at the end of the suspension laryngoscopy, **T4:** 5 minutes after the suspension was terminated and the neck was brought to the straight position.

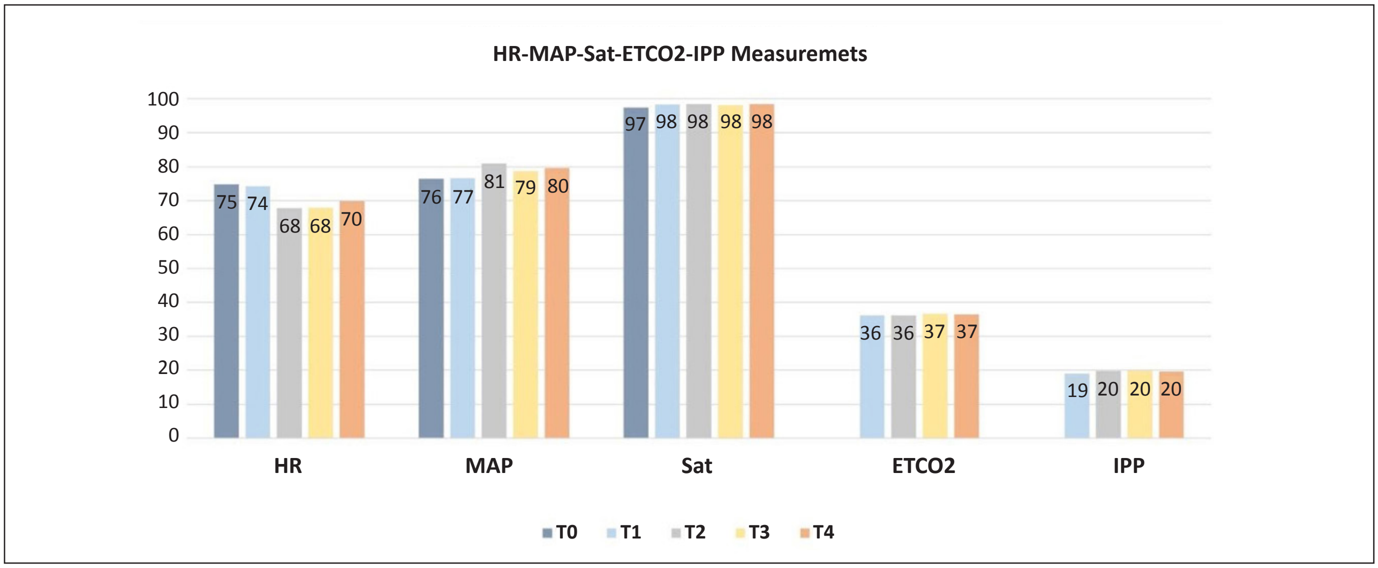

Figure 4: Variations in hemodynamic and respiratory parameters over time. **HR:** Heart rate (beats min-1), **MAP:** Mean arterial pressure (mmHg), **Sat:** Saturation (%), **ETCO$_2$:** End-tidal carbon dioxide (mmHg), **IPP:** Inspiratory peak pressure (cmH$_2$O), **T0:** After anesthesia induction, **T1:** After intubation, **T2:** when the neck was in hyperextension at the start of the suspension laryngoscopy, **T3:** when the of the suspension laryngoscopy, **T4:** 5 minutes after the suspension was terminated and the neck was brought to the straight position.

Table IV: Relationship between BMI and Mallampati Scores and ONSD Measurements

		ONSD T0	ONSD T1	ONSD T2	ONSD T3	ONSD T4
BMI (n=50)	R	0.054	0.035	-0.039	-0.050	0.089
	P	0.710	0.811	0.789	0.729	0.541
Mallampati I, II (n=33)	Mean ± SD	3.74 ± 0.35	3.99 ± 0.52	5.08 ± 0.83	5.11 ± 0.85	4.09 ± 0.56
	U	352.5	344.5	320.5	312.5	337.0
	P	0.136	0.188	0.411	0.511	0.244
Mallampati III, IV (n=17)	Mean ± SD	3.88 ± 0.31	4.11 ± 0.36	5.21 ± 0.67	5.18 ± 0.67	4.22 ± 0.45
	U	352.5	344.5	320.5	312.5	337.0
	P	0.136	0.188	0.411	0.511	0.244

SD: Standart deviation, **BMI:** Body mass index, **R:** Spearman's rho correlation coefficient, **U:** Mann Whitney U test coefficient.

caused by applying substantial forces to them with a straight rigid laryngoscope (11). During the surgery, serious pressure occurs on the tooth, jaw and tongue root. Laryngoscopy and tracheal intubation are known to raise sympathetic activity and ICP, both of which are easily tolerated by healthy patients (12). Proprioceptor stimulation at the base of the tongue during laryngoscopy raises systemic blood pressure, heart rate and plasma catecholamine concentrations (13). In comparison to tracheal intubation laryngoscopy, suspension laryngoscopy maintains the laryngoscope in the patient's oropharynx for a longer period of time. As a result, the changes in hemodynamic parameters and ICP caused by this powerful and persistent stimulation can be much more pronounced.

Invasive measurement techniques are the gold standard for ICP measurement. However, due to the substantial difficulties that these procedures may produce, they are not commonly used (14). Changes in ICP impact the diameter of the optic nerve sheath (15). However, there is a wide variation in the cutoff values of ONSD compared to invasive monitoring (16). Shirodkar et al. detected that cutoff values of 4.6 mm in women and 4.8 mm in men had high sensitivity and specificity (17). The generally accepted value for increased ICP is 5 mm (4,5,18). The cutoff value for ICP increase with a 95% confidence interval was calculated as 4.11 mm in women and 4.48 mm in men in the study of Goeres et al., suggesting that it may have more clinical benefits than the usually recognized 5 mm. These values are the lowest cutoff values we have found in the literature (19). Except for two individuals, all ONSD measurements in the T2 time period, when we measured the first effect of suspension laryngoscopy, were above the cutoff when the lowest values in the literature were adopted as the cutoff value. The T2 mean ONSD value was greater than 5 mm, commonly used in the literature, and it was 34% greater than the T0 mean ONSD value. These results indicate that suspension laryngoscopy increases ICP.

The literature has shown that laryngoscopy causes alterations in ONSD; however, the situation varies depending on the type of laryngoscope employed. Wang et al. detected an increase in ONSD both immediately and five minutes after intubation with a Macintosh laryngoscope (1). Singh et al.'s investigation showed that this rise lasted for up to 10 minutes (14). Küçükosman et al. examined changes in ONSD after intubation with three different laryngoscope types. While the Macintosh and McCoy laryngoscopes induced a considerable increase in ONSD, the C-MAC videolaryngoscope caused a 0.2 mm increase in ONSD (7). Our study results are supported by the literature. In our study, the C-MAC videolaryngoscope employed for endotracheal intubation resulted in an average increase of 0.2 mm. The application that caused a significant increase in ONSD was suspension laryngoscopy, which used a rigid and flat laryngoscope. We believe that by exerting sufficient pressure on the soft tissues, this structure, which is not appropriate for the anatomy of the oropharynx, has the ability to seriously excite proprioceptor and somatovisceral reflexes, resulting in a significant increase in ONSD.

The suspension laryngoscopy provides proper surgical circumstances by hyperextending the neck. Head-neck posture is one of the most investigated characteristics in connection to ICP. During the surgical operation, the head-neck, body, and operating table are not in the horizontal axis, which may induce changes in ICP. Mavrocordatos et al. discovered a rise in ICP in the position when the operating table was at 30° trendelenburg, regardless of the head-neck position. They analyzed the changes in ICP in different locations of the head-neck and operating table. The mean ICP values in this investigation were 10.7 ± 4.0 mmHg with the neck extended, head straight and the operating table in a 0° horizontal position (15). This is the position employed in suspension laryngoscopy and the values reveal that it has no effect on ICP. The study also revealed that when the neck is extended, only right or left rotation of the head occurs and that ICP may increase if the operating table is in the 30° trendelenburg position, although this is not statistically significant (15.6 ± 5.5, 15.3 ± 5.5 mmHg) (15). The reason for these results is that head flexion and rotation inhibit cerebral venous return, while neck extension has no effect on venous return (20). However, the study did not indicate the degree of extension given to the neck. The same is true for our study. We also did not adopt a precise neck extension angle. We attempted to achieve adequate image quality by hyperextending the neck. As a result, we are unable to explain the effect of neck extension on ICP. Based on the findings of the study conducted by Mavrokordatos, we may conclude that the instrumentation used in suspension laryngoscopy is the primary cause of the increase in ONSD. There is a need for separate ONSD measurements after patient positioning and following suspension laryngoscopy to acquire clear conclusions about which parameter influences the increase in ONSD.

There are three studies in the literature that examine the effect of oropharyngeal instrumentation on ONSD, which may be similar to suspension laryngoscopy. All three studies were conducted in the pediatric population and in a similar neck position. Yu et al. discovered that 70° neck extension with an intraoral retractor raised the ONSD in a study of 30 patients younger than 12 months. The operation time in this trial was 133 ± 36.5 minutes and measurements were taken 10 minutes after neck position alterations. Although the measurement taken toward the end of the procedure while neck extension was still being performed was more than the baseline measurements, it was not greater than the first measurement taken in the presence of a retractor. The final measurement was taken with the neck straight, and while the decline persisted, the baseline measurements could not be reached (21). Despite the difference in patient population and surgical time, our results are similar to this study. In our study, while suspension laryngoscopy and neck extension increased the ONSD significantly, the increase did not continue progressively, and even after the neck fell into the straight position, the baseline levels could not be attained. One of the important differences of this study is that the measurements are made 10 minutes after the position change. Our measurements were taken immediately following the positions and interventions. This demonstrates that changes in pressure among adult patients are rapidly reflected into ONSD. Further research can be conducted to see if the same issue holds true in children under the age of 12 months.

The study by Karali et al. examined 40 pediatric patients with a mean age of 6 years. Preinduction, after retractor insertion, before retractor removal, and after retractor removal, measurements were taken. The mean time of retractor attachment was 42.82 ± 9.49 minutes. Optic nerve sheath diameter, measures increased as long as the retractor remained attached. When the retractor was removed, the ONSD measurement fell, but the baseline value could not be attained. The surgery was carried out with the patient's neck extended and the operating table in a 15° trendelenburg position. The extent of the neck extension is not specified (9). The authors attributed these findings to an increase in ICP caused by somatovisceral reflexes induced by stimulating the retractor's proprioceptors in the tongue base and epipharynx. Unlike this study, our study did not observe progressive increase in the measurement taken at the end of the suspension. This can be attributed to the operating table being in a neutral position and the surgical time being substantially shorter.

Altıparmak et al. investigated 35 pediatric patients with a mean age of 7 years in their study. Measurements were taken following anesthetic induction, intubation, neck extension and retractor placement and 20 minutes after retractor placement. Unlike our study, the degree of neck extension was calculated in this study and was found to be unrelated to ONSD. Measurements continued to increase in each time period. No measurements were taken in this study while the neck was straight at the end of the procedure (8). The most significant difference in our study is that while the positions and surgical times were similar, the presence of a retractor resulted in a steady increase in measures. Our study showed neither progression nor regression. The study found that measurements taken after intubation were higher than measurements taken after anesthesia induction. With the stimulation of the tongue root and epiglottis with abundant innervation, laryngoscopy generates a sympathoadrenergic response and a rise in ICP (22). Suspension laryngoscopy involves much more vigorous and extended airway manipulation. As a result, we detected that the effect of suspension laryngoscopy on ONSD measurements was significantly greater than the effect of direct laryngoscopy. However, we did not detect a progression in the increase at the end of suspension. While applying a certain pressure to the tissues with the suspension, the initial net effect is visible and the ONSD values do not continue to increase during the suspension. This is possibly because the applied forces do not change, and the suspension and the instruments that manipulate the airway are held constant. The application of a different surgery, such as adenotonsillectomy, and the emergence of different autoregulatory responses depending on the age group may explain why the increase in the study of Altıparmak et al. continued despite the similar duration of surgery. More research is needed to explain these divergent findings.

Cardiovascular complications are the most common complications during suspension laryngoscopy. Manipulation and neck hyperextension during suspension laryngoscopy may cause carotid sinus pressure and bradycardia due to increased baroreceptor signals and vagal stimulation (23,24). Furthermore, stimulation of the supraglottic area may elicit a sympathoadrenergic response, resulting in hypertension and tachycardia (25). When compared to other time periods, the highest mean arterial pressures (80.94±14.41) and lowest heart rates (67.8±12.1) were obtained at the beginning of suspension laryngoscopy. However, none of these values are outside the physiological limits. This can be attributed to the patients being given a balanced general anesthetic.

Carbon dioxide, a potent cerebral vasodilator, causes an increase in ICP (5). It is well known that when IPP rises, so does ICP (26). As a result, rigorous control of partial carbon dioxide pressure and IPP can prevent an increase in ICP. End-tidal CO_2 levels and IPP evaluated at various time intervals in the study did not exceed physiological levels at any time interval. Furthermore, while significant changes in hemodynamic measures were observed between time periods, these changes were within physiological limits, similar to respiratory parameters. As a result, we suggest that hemodynamic and respiratory factors have no effect on ONSD measurements.

The present study had some limitations. We could illustrate the increase in ICP more objectively if we used invasive measurement methods with ultrasonography. We could have examined the impact of anesthesia on hemodynamic parameters more objectively if we had monitored the depth of anesthesia using bispectral index and entropy and viewed the $ETCO_2$ and partial carbon dioxide pressure measurements simultaneously. It could be determined whether there is correlation between the neuroendocrine response and ONSD measurements if catecholamine levels and the force applied to the base of the tongue could be measured during the suspension laryngoscopy procedure. To reduce variability in ultrasonographic measurements, we used the single observer approach. Therefore, we could not examine the interobserver variability suggested by Dubourg et al. (27). The absence of ONSD measurements in isolated neck hyperextension prior to suspension initiation is another limitation of this study. Therefore, it was impossible to show that neck hyperextension and suspension have different effects on ONSD measurements. Additionally, the results regarding changes in ICP could differ if ONSD were measured at set intervals throughout the suspension.

CONCLUSION

The suspension laryngoscopy causes a significant increase in ONSD measurements. The suspension time, on the other hand, does not lead to a progressive increase. At the end of the procedure, the neck is straightened and the suspension is removed, allowing ONSD measurements to approach the baseline values. Therefore, we recommend performing an ultrasonographic ONSD measurement in patients at risk of increased ICP during suspension laryngoscopy and immediately returning the head to a straight position at the end of the procedure.

AUTHOR CONTRIBUTIONS

Conception or design of the work: GB, SA, FKE, RY, MAE, HA, AT
Data collection: GB, SA, FKE, RY
Data analysis and interpretation: GB, SA, FKE, RY
Drafting the article: GB, MAE, HA, AT
Critical revision of the article: GB, SA, FKE, RY, MAE, HA, AT
Other (study supervision, fundings, materials, etc): MAE, HA, AT
The author (GB, SA, FKE, RY, MAE, HA, AT) reviewed the results and approved the final version of the manuscript.

REFERENCES

1. Wang LJ, Chen Y, Bao LY, Zheng NN, Wang YZ, Xing YQ. Ultrasonography assessments of optic nerve sheath diameter as a noninvasive and dynamic method of detecting changes in intracranial pressure. JAMA Ophthalmol 2018;136(3):250-6.
2. Dip F, Nguyen D, Sasson M, Lo Menzo E, Szomstein S, RosenthaL R. The relationship between intracranial pressure and obesity: An ultrasonographic evaluation of the optic nerve. Surg Endosc 2016;30(6):2321-5.
3. Geeraerts T, Merceron S, Benhamou D, Vigue B, Duranteau J. Non-invasive assessment of intracranial pressure using ocular sonography in neurocritical care patients. Intensive Care Med 2008;34(11):2062-7.
4. Harbison Kimberly H, Shah S, Marill K, Noble V. Correlation of optic nerve sheath with direct measurement of intracranial pressure. Acad Emerg Med 2008;1552:201-4.
5. Geeraerts T, Launey Y, Martin L, et al. Ultrasonography of the optic nerve sheath may be useful for detecting raised intracranial pressure after severe brain injury. Intensive Care Med 2007;33(10):1704-11.
6. Larner SP, Fornelli RA, Griffith SD. Consistent technique limits suspension laryngoscopy complications. Int Arch Otorhinolaryngol 2019;23(3):305-10.
7. Küçükosman G, Aydın B, Gülçek N, Okyay R, Pişkin Ö, Ayoğlu H. The effect of laryngoscope types on hemodynamic response and optic nerve sheath diameter. Saudi Med J 2020;41(9):930-7.
8. Altıparmak B, Toker MK, Uysal Aİ, Köseoğlu S,Demirbilek SG. Evaluation of the effect of the mouth gag use on optic nerve sheath diameter of pediatric patients undergoing tonsillectomy or adenotonsillectomy: An observational study. BMC Anesthesiol 2020;20(1):163.
9. Karali E, Demirhan A, Güneş A, Ural A. Evaluation of the effect of Boyle-Davis mouth gag on intracranial pressure in patients undergoing adenotonsillectomy by using ultrasonographic optic nerve sheath diameter measurement. Int J Pediatr Otorhinolaryngol 2020;131:109856.
10. Zeitels SM, Burns JA, Dailey SH. Suspension laryngoscopy revisited. Ann Otol Rhinol Laryngol 2004;113(1):16-22.
11. Gugatschka M, Gerstenberger C, Friedrich G. Analysis of forces applied during microlaryngoscopy: a descriptive study. Eur Arch Otorhinolaryngol 2008;265(9):1083-7.
12. Bekker AY, Mistry A, Ritter AA, Wolk SC, Turndorf H. Computer simulation of intracranial pressure changes during induction of anesthesia: comparison of thiopental, propofol, and etomidate. J Neurosurg Anesthesiol 1999;11(2):69-80.
13. Muller MD, Mast JL, Cui J, Heffernan MJ, McQuillan PM, Sinoway LI. Tactile stimulation of the oropharynx elicits sympathoexcitation in conscious humans. J Appl Physiol 2013; 115(1):71-7.
14. Singh D, Singh A, Sharma A, Sandhu K. Study of changes in optic nerve sheath diameter following tracheal intubation using Macintosh laryngoscope or fibreoptic-guided intubation through ambu Aura-I: A randomised controlled study. Cureus 2021;13(11): e19782.
15. Mavrocordatos P, Bissonnette B, Ravussin P. Effects of neck position and head elevation on intracranial pressure in anaesthetized neurosurgical patients: Preliminary results. J Neurosurg Anesthesiol 2000;12(1):10-4.
16. Blecha S, Harth M, Schlachetzki F, et al. Changes in intraocular pressure and optic nerve sheath diameter in patients undergoing robotic-assisted laparoscopic prostatectomy in steep 45 degrees Trendelenburg position. BMC Anesthesiol 2017;17(1):40.
17. Shirodkar CG, Rao SM, Mutkule DP, Harde YR, Venkategowda PM, Mahesh MU. Optic nerve sheath diameter as a marker for evaluation and prognostication of intracranial pressure in Indian patients: An observational study. Indian J Crit Care Med 2014;18(11):728-34.
18. Maissan IM, Dirven P, Haitsma IK, Hoeks SE, Gommers D, Stolker RJ. Ultrasonographic measured optic nerve sheath diameter as an accurate and quick monitor for changes in intracranial pressure. J Neurosurg 2015;123(3):743-7.
19. Goeres P, Zeiler FA, Unger B, Karakitsos D, Gillman LM. Ultrasound assessment of optic nerve sheath diameter in healthy volunteers. J Crit Care 2016;31(1):168-71.
20. Gooding CA, Stimac GK. Jugular vein obstruction caused by turning of the head. Am J Roentgenol 1984;142(2):403-6.
21. Yu J, Park JY, Kim DH, et al. Effect of neck extension on ultrasonographic optic nerve sheath diameter as a surrogate for intracranial pressure in patients undergoing palatoplasty: A prospective observational study. J Plast Reconstr Aesthet Surg 2020;73(2):369-75.
22. Shribman AJ, Smith G, Achola KJ. Cardiovascular and catecholamine responses to laryngoscopy with and without tracheal intubation. Br J Anaesth 1987;59(3):295-9.
23. Ko HB, Lee DY, Lee YC. Severe bradycardia during suspension laryngoscopy performed after tracheal intubation using a direct laryngoscope with a curved blade. A case report. Korean J Anesthesiol 2010;59(2):116-8.
24. Kiray A, Naderi S, Ergur I, Korman E. Surgical anatomy of the internal branch of the superior laryngeal nerve. Eur Spine J 2006;15(9):1320-5.

25. Tuncer S, Yosunkaya A, Tavlan A, Sarkılar G, Ökesli S. Effects of remifentanil on the haemodynamic response to endotracheal intubation. Selcuk Med J 2001;17(3):175-9.

26. McGuire G, Crossley D, Richards J, Wong D. Effects of varying levels of positive end-expiratory pressure on intracranial pressure and cerebral perfusion pressure. Crit Care Med 1997;25(6):1059-62.

27. Dubourg J, Javouhey E, Geeraerts T, Messerer M, Kassai B. Ultrasonography of optic nerve sheath diameter for detection of raised intracranial pressure: A systematic review and meta-analysis. Intensive Care Med 2011;37(7):1059-68.