J Surg Med. 2023;7(4):276-279.
DOI: 10.28982/josam.1123380

Research article

Journal of Surgery and Medicine
e-ISSN: 2602-2079
https://jsurgmed.com/

The effect of minimal and high flow anesthesia on optic nerve sheath diameter in laparotomic gynecological surgery

Anıl Onur, Tuğba Onur, Ümran Karaca, H Erkan Sayan, Canan Yılmaz, Nermin Kılıçarslan

Department of Anesthesiology and Reanimation, University of Health Sciences Bursa Yüksek İhtisas Training and Research Hospital, Bursa, Turkey

ORCID ID of the author(s)

AO: 0000-0002-3957-922X
TO: 0000-0002-5080-4555
ÜK: 0000-0001-5922-2300
HES: 0000-0003-3943-5549
CY: 0000-0002-6626-3626
NK: 0000-0002-5855-9099

Corresponding Author
Tuğba Onur
Bursa Yüksek İhtisas Eğitim Araştırma Hastanesi, Anestezi ve Reanimasyon Kliniği, Mimar Sinan Mah. Emniyet Cad. Polis Okulu Karsisi Yildirim, Bursa, Turkey
E-mail: doktor-t@hotmail.com

Ethics Committee Approval
The study was approved by University of Health Sciences Bursa Yüksek İhtisas Training and Research Hospital ethics committee (2011-KAEK-25 2018/11-06), each patient written informed consent was obtained from all patients. All procedures in this study involving human participants were performed in accordance with the 1964 Helsinki Declaration and its later amendments.

Conflict of Interest
No conflict of interest was declared by the authors.

Financial Disclosure
The authors declared that this study has received no financial support.

Published
2023 April 20

Abstract

Background/Aim: Optic nerve sheath diameter (ONSD) is a surrogate parameter for intracranial pressure. This study evaluated the effect of anesthetics on ONSD in women undergoing surgery. We aimed to measure the effect of minimal and high flow anesthesia techniques on expiratory/inspiratory oxygen and carbon dioxide fraction values, hemodynamic parameters, and the optic nerve sheath diameter by ultrasonography in open gynecological surgeries.

Methods: In the present prospective cohort study, 80 patients who planned laparotomic gynecological surgery were divided into two groups: a high flow of 2 L/min and a minimum flow of 0.5 L/min. Anesthesia was maintained with 50% oxygen-50% air at 2 L/min and desflurane at 1.1 MAC in Group 1 (n=40) and 50% oxygen-50% air at 0.5 L/min and desflurane at 1.1 MAC in Group 2 (n=40). After 10–15 min, group 2 was administered minimal flow with 50–60% oxygen and 40–50% air at 0.5 L/min desflurane, and 10 min before the end of the surgery, the patients were switched to high flow with 50% oxygen-50% air at 2 L/min.

Results: Decreasing heart rates were higher in Group 2 (T0 P=0.001, T2 P=0.007, T3 P=0.035). There was a significant positive correlation between $EtCO_2$ at the 60^{th} min and optic nerve sheath diameter measurements in the minimal flow group (left ONSD r=0.440, P=0.004, right ONSD r=0.473, P=0.002). Although inspiratory oxygen values in Group 2 did not fall below 32%, it was lower than Group 1 except for the last measurement time.

Conclusion: Minimal flow anesthesia is as safe as high flow in terms of effects on optic nerve sheath diameter and oxygenation parameters in laparotomic gynecological surgery.

Keywords: minimal flow anesthesia, high flow anesthesia, ultrasonography, optic nerve sheath diameter, gynecological surgery

How to cite: Onur A, Onur T, Karaca Ü, Sayan HE, Yılmaz C, Kılıçarslan N. The effect of minimal and high flow anesthesia on optic nerve sheath diameter in laparotomic gynecological surgery. J Surg Med. 2023;7(4):276-279.

Introduction

General anesthesia is characterized by reversible loss of consciousness, analgesia, amnesia, and muscle relaxation [1]. While the most preferred method in general anesthesia inhalation induction is the administration of the fresh gas flow of 4–6 L/min, there is gradually increasing interest in low fresh gas flow, which has multiple advantages [2]. Low-flow anesthesia is a technique that delivers at least half of the expiratory gas mixture back to the patient using rebreathing systems after carbon dioxide (CO_2) in the anesthesia circuit is absorbed [3,4]. The administration of low-flow anesthesia has advantages, including preventing environmental pollution, reducing costs, minimizing heat loss, and better preservation of tracheobronchial physiology [2]. Furthermore, measurement of hemodynamic parameters and pressure changes may occur in the intracranial space because of several disadvantages caused by improper use of low flow anesthesia, such as hypoxia, hypercarbia, over/low dose volatile agent, toxic gas accumulation. Thus, low fresh gas flow may be helpful in developing safer anesthesia methods.

The follow-up of ONSD (optic nerve sheath diameter) is often performed by USG, a fast, easy, and non-invasive method for diagnosing intracranial pressure changes. The optic nerve sheath is an anatomical continuation of the dura mater, and the subarachnoid space around the optic nerve constitutes continuity with the intracranial subarachnoid space. Therefore, any pressure increase in the intracranial compartment also affects the optic nerve, increasing the ONSD and leading to papillary edema. Although USG for intracranial pressure measurement does not entirely replace invasive intracranial pressure (ICP) measurement techniques, it has a high positivity value, especially in pressures over 20 mmHg.

In our study, we aimed to investigate the effects of minimal and high-flow anesthesia techniques on expiratory/inspiratory oxygen and carbon dioxide levels, hemodynamic parameters, and ONSD during laparotomic gynecological surgery.

Materials and methods

After the approval of the University of Health Sciences Bursa Yüksek İhtisas Training and Research Hospital ethics committee (2011-KAEK-25 2018/11-06) and written informed consent was obtained from all patients, 80 patients aged 18–65 years, with ASA I-II laparotomic gynecological surgery between October 2018 and April 2019, were included in the study.

The patients who were not included in the study were: patients with obstructive pulmonary disease, decompensated diabetes, a fasting period of more than 12 h, acute alcohol intoxication, chronic alcohol use, those who refused to participate in the study, who were not cooperative, could not speak the native language, had known eye disease (glaucoma, retinal detachment), had a previous history of eye surgery, had increased intracranial pressure findings (intracranial lesion, previous cerebrovascular diseases), had a body mass index of > 40 kg/m^2, and those who had ASA > III. Cases requiring high-flow anesthesia for various reasons, including a drop of FiO_2 below 30%, tidal volume drop, and CO_2 retention during the surgery, were excluded from the study.

Anesthesia induction was performed with 0.02 mg/kg midazolam iv, 1 mcg/kg fentanyl iv, 2 mg/kg propofol iv, and 0.6 mg/kg iv rocuronium in all patients in the study. All patients received mechanical ventilation with a tidal volume of 6 ml/kg, a respiratory rate of 12 breaths/min, and PEEP of 5 cmH_2O in the volume-controlled mode. A Drager Primus anesthesia machine (Dräger Medizintechnik, Lübeck, Germany) was used. Based on the closed-envelope technique, patients were randomly assigned to one of two groups of fresh gas flows, 0.5 L/min or 2 L/min high flow. For Group 1 (n=40), high-flow anesthesia was used with a mixture of 50% oxygen and 50% air at a rate of 2 L/min and desflurane at a rate of 1.1 MAC throughout the procedure.

Anesthesia maintenance was achieved by administering 50% oxygen - 50% air at 2 L/min and desflurane for 15-20 min to Group 2 (n=40). As soon as the MAC reached 1.1, it was switched to minimal flow with 50–60% oxygen, 40–50% air at 0.5 L/min, and desflurane was introduced. Approximately 10 min before the end of the surgery, the flow was switched to high flow with 50% oxygen and 50% air at a rate of 2 L/min.

Age, height, weight, ASA, systemic diseases, anesthesia, and surgical time of the patients were recorded. Heart rate (HR), mean blood pressure (MBP), peripheral oxygen saturation (SpO_2, end-tidal carbondioxyid ($EtCO_2$), PEEP, PEAK, MAC, FiO_2, and left-right ONSD measurements of the patients were recorded before and during the surgery at specified time points (T0: awake, T1: High fresh gas flow after induction at the 10th min, T2: Inhalation anesthesia at the 30th min, T3: Inhalation anesthesia at the 60th min, T4: Inhalation anesthesia at the 90th min, T5: Before extubating).

An experienced and the same anesthetist measured the diameter of the optic nerve sheath. A 12-MHz linear probe was used in conjunction with a GE Healthcare Logiq e series USG device. During the supine position, longitudinal and transverse axis images were obtained on both eyelids. A measurement was taken 3 mm behind the optic nerve head. The following complications were recorded during the surgery and recovery (respiratory distress, decreased oxygen levels, hypotension, hypertension, bradycardia, tachycardia, vomiting, and rhythm disorders).

Statistical analysis

Shapiro-Wilk was used to assess whether the data were normally distributed. The t-test was used for the normally distributed data and the Mann-Whitney U test for data not normally distributed in comparing the two groups. The correlations between variables were evaluated with Pearson correlation (r) and Spearman correlation (rho) coefficients. In the analysis of time-dependent measurements, percentage change from the first measurement was calculated (Percentage change=last measurement - first measurement / first measurement), and percent change values performed statistical comparisons between groups. Pearson Chi-square test, Fisher's exact test, and Fisher-Freeman-Halton test were used to analyze categorical data. Statistical data analysis was performed using SPSS 23.0 (IBM Corp. Released 2015. IBM SPSS Statistics for Windows, Version 23.0. Armonk, NY: IBM Corp.) software program. The significance level was accepted as P <0.05.

Results

There was no statistically significant difference between the groups regarding age, weight, height, body mass index (BMI), ASA, and duration of anesthesia (Table 1). Bradycardia was observed in three patients in Group 1 and two in Group 2, and an allergic reaction was observed in one in Group 2.

Heart rate values were higher in Group 2 than in Group 1. When the 30th, 60th, 90th, and before extubation changes of HR measurements were compared, the decrease in the patients of Group 2 was higher than in those of Group 1 (Table 2) (T0 *P*=0.001, T2 *P*=0.007, T3 *P*=0.035).

Table 1: Comparison of demographic characteristics of groups

	Group 1 (n=40)			Group 2 (n=40)			*P*-value
	Median	Minimum	Maximum	Median	Minimum	Maximum	
Age (years)	48.00	32.00	66.00	48.00	26.00	65.00	0.747
Weight (kg)	67.00	51.00	98.00	70.00	50.00	120.00	0.435
Height (cm)	165.00	155.00	170.00	165.00	160.00	174.00	0.573
BMI (kg/m²)	24.60	19.40	35.80	25.30	19.50	44.00	0.637
Duration of surgery (min)	95.00	65.00	200.00	100.00	65.00	400.00	0.345

BMI: Body mass index, Mann-Whitney U test

Table 2: Comparison of hemodynamic data between groups [mean (SD)]

		T0	T1	T2	T3	T4	T5
HR	Group1	81 (15.38)	0.05 (0.2)	0.04 (0.2)	0.14 (0.2)	0.11 (0.1)	0.09 (0.2)
	Group2	93 (14.0)	0.02 (0.2)	0.18 (0.1)	0.22 (0.1)	0.20 (0.1)	0.14 (0.1)
	P-value	0.001**	0.223	0.007*	0.035*	0.078	0.309
MBP	Group 1	103 (12.5)	0.16 (0.1)	0.18 (0.1)	0.12 (0.1)	0.16 (0.1)	0.12 (0.1)
	Group 2	106 (16.9)	0.16 (0.1)	0.19 (0.1)	0.17 (0.1)	0.15 (0.2)	0.14 (0.1)
	P-value	0.396	0.320	0.683	0.218	0.857	0.508
SpO_2	Group 1	98 (2.0)	00 (0.02)	00 (0.02)	00 (0.02)	00 (0.01)	00 (0.01)
	Group 2	98 (2.5)	0.01 (0.02)	00 (0.03)	00 (0.03)	0.0 (0.01)	00 (0.02)
	P-value	0.772	0.399	0.451	0.264	0.935	0.216

*$P<0.05$, **$P<0.001$, Pearson Chi-squared test, HR: Heart rate, MBP: Mean arterial pressure, SpO2: Peripheral oxygen saturation, T1: High fresh gas flow after induction at the 10th minute, T2: Inhalation anesthesia at the 30th minute, T3: Inhalation anesthesia at the 60th minute, T4: Inhalation anesthesia at the 90th minute, T5: Before Extubation

No statistically significant difference was found when the time-dependent MBP and SpO2 values were compared between the two groups (Table 2). A significant weak negative correlation was found between the ONSD and MAC values at the 60th minute in Group 1 (r=-0.331, *P*=0.037) and the 10th minute in Group 2 (r=-0.342, *P*=0.031) (Table 3, Table 4).

A significant moderate positive correlation was observed between ONSD and $EtCO_2$ at the 60th minute in Group 2 (Table 4) (ONSD left r=0.440 *P*=0.004, ONSD right r=0.473, *P*=0.002).

The inspiratory oxygen values of Group 2 were lower than those of Group 1 except for the last measurement time point. Inspiratory oxygen values were measured above 32% in both groups (Tables 3 and 4).

Table 3: The correlation of ONSD left and ONSD right with EtCO2, FiO2, MAC, PEAK in patients in the high flow group

			T1	T2	T3	T4	T5
ONSD left	$EtCO_2$	r	0.080	0.201	-0.114	0.174	0.066
		P	0.622	0.213	0.482	0.428	0.688
	FiO_2	r	0.000	0.265	0.300	0.235	0.118
		P	0.999	0.098	0.060	0.281	0.468
	MAC	r	-0.005	-0.053	-0.266	-0.029	-0.373
		P	0.974	0.747	0.097	0.895	0.018*
	PEAK	r	-0.017	-0.052	-0.103	0.014	-0.053
		P	0.917	0.749	0.526	0.948	0.743
ONSD right	$EtCO_2$	r	-0.140	-0.037	-0.202	0.094	0.058
		P	0.389	0.823	0.212	0.671	0.720
	FiO_2	r	-0.173	-0.080	0.052	0.090	-0.067
		P	0.285	0.625	0.751	0.684	0.680
	MAC	r	0.106	0.107	-0.331	0.023	-0.308
		P	0.516	0.512	0.037*	0.916	0.053
	PEAK	r	-0.070	-0.107	-0.165	-0.375	-0.035
		P	0.666	0.512	0.309	0.078	0.830

*$P<0.05$, Pearson Chi-squared test, Fisher-Freeman-Halton test, ONSD: Optic nerve sheath diameter, EtCO2: End-tidal carbon dioxide, FiO2: The fraction of inspiratory oxygen, MAC: Minimal alveolar concentration, T1: High fresh gas flow after induction at the 10th minute, T2: Inhalation anesthesia at the 30th minute, T3: Inhalation anesthesia at the 60th minute, T4: Inhalation anesthesia at the 90th minute, T5: Before Extubation

Table 4: The correlation of ONSD left and ONSD right with EtCO2, FiO2, MAC, PEAK in patients in the minimal flow group

			T1	T2	T3	T4	T5
ONSD left	$EtCO_2$	r	-0.078	-0.018	0.440	0.347	0.121
		P	0.631	0.912	0.004*	0.123	0.458
	FiO_2	r	0.100	-0.140	0.010	0.094	0.114
		P	0.538	0.388	0.951	0.684	0.485
	MAC	r	-0.045	-0.272	-0.008	0.104	-0.009
		P	0.784	0.090	0.959	0.654	0.958
	PEAK	r	-0.242	0.034	-0.046	0.238	0.065
		P	0.133	0.834	0.776	0.300	0.692
ONSD right	$EtCO_2$	r	0.068	0.046	0.473	0.195	0.289
		P	0.679	0.778	0.002*	0.398	0.071
	FiO_2	r	0.043	0.047	-0.036	0.157	0.173
		P	0.793	0.772	0.827	0.496	0.286
	MAC	r	-0.342	-0.151	-0.138	-0.051	-0.301
		P	0.031*	0.353	0.397	0.827	0.059
	PEAK	r	-0.034	0.042	0.010	-0.067	-0.016
		P	0.834	0.799	0.953	0.774	0.924

*$P<0.05$, Pearson Chi-squared test Fisher-Freeman-Halton test, ONSD: Optic nerve sheath diameter, EtCO2: End-tidal carbon dioxide, FiO2: The fraction of inspiratory oxygen, MAC: Minimal alveolar concentration, T1: High fresh gas flow after induction at the 10th minute, T2: Inhalation anesthesia at the 30th minute, T3: Inhalation anesthesia at the 60th minute, T4: Inhalation anesthesia at the 90th minute, T5: Before extubation

Discussion

Advances in anesthesia devices and monitoring methods has made the administration of low-gas flow anesthesia popular. Apart from concerns such as adequate access to the inhalation agent of the patient and the availability of hemodynamic stability, the most important factor that prevents the low gas flow anesthesia technique from becoming routine practice is the possibility of hypoxia and hypercarbia occurring in the patient. Continuous monitoring of FiO_2, $EtCO_2$, anesthetic agent concentration in the system, the volume of expiratory gas, airway pressures, and hemodynamic parameters is mandatory to ensure a safe anesthesia administration [5]. In a study of prolonged laparoscopic surgery, no significant differences were found in hemodynamic variables and respiratory variables between minimal-flow and high-flow desflurane anesthesia [6].

Low-flow sevoflurane anesthesia, without using N_2O, has been reported to be a safe technique for hemodynamic parameters [7]. Another study reported that MBP and HR did not differ from baseline values and were stable in low-flow anesthesia with desflurane [8]. In our study, no hemodynamical difference was observed between the two groups. In some studies, from high flow to minimal flow with a fresh gas flow of 0.5 L/min, the airway pressure increased, and the minute volume decreased, so they readjusted the tidal volume to provide sufficient minute volume. As there was no difference in PEAK values between groups in our study, we did not need to change ventilation parameters.

The inspiratory O_2 concentration should be at least 30% to prevent hypoxemia and provide adequate O_2. It is reported that FiO_2 should be increased when minimal flow is administered [9]. Our study uses 50–60% O_2 with 40–50% air mixture. Inspiratory O_2 did not fall below 32% at measurement time points. Although inspiratory and expiratory O_2 concentrations were decreased in both groups, they never fell to FiO_2 values that could clinically cause hypoxia. There was no significant decrease in SpO_2 in the minimal flow group where FiO_2 was lower.

In one of the studies, FiO_2 concentration was found to be lower in the minimal flow group during minimal and high flow desflurane anesthesia performed in laparoscopic surgeries [6].

In a study performed in laparoscopic cholecystectomies, EtCO2 and cerebral oximetry showed no difference in groups of

minimal and high-flow anesthesia [10]. In another study, there was no difference between low- and high-flow desflurane anesthesia in terms of $EtCO_2$, MAC, and hemodynamic parameters [11]. Our study used standardized mechanical ventilation mood, tidal volume at 6 ml/kg, and the respiratory rate at 12/min to keep $EtCO_2$ levels in the ideal range. In our patients, $EtCO_2$ ranged from 25 to 40 mmHg. There was no statistically significant difference in $EtCO_2$ measurements between the groups.

We detected no ONSD differences related to age, gender, and ethnicity, which has been reported in other studies [12]. In our study, no significant difference was found between the groups regarding demographic characteristics and left-right ONSDs. Also, the highest ONSD value recorded at the 60th mi. of the minimal flow group was 4.8 mm. A weak positive correlation was found between $EtCO_2$ and right-left ONSDs at the 60th min of the minimal flow group. Conditions such as hypoxia and hypercarbia, which may increase intracranial pressure, might increase the optic nerve sheath diameter [13,14]. It has been shown that ONSD measurement can be used as a non-invasive indirect indicator in determining the ICP [15,16].

Animal models indicate that the ONSD increases at approximately 0.0034 mm per 1 mm Hg increase in ICP. An experimental study on pigs found a linear correlation between ONSD and increased ICP [17]. In a study about the sensitivity and specificity of ONSD compared with CT results, they were 100% and 95%, respectively [18]. A similar study stated that USG of ONSD could be useful in detecting ICP after severe brain injury in intensive care patients [19].

The absence of follow-up on the development of cognitive dysfunction during the postoperative period and the lack of cerebral oximeter measurement limited our study. Thus, we could have an idea about the oxygenation of the cerebral area only in cases where minimal flow anesthesia was applied.

Limitations

There were two major limitations to this study. The first is that the ONSD was monitored for 90 min after pneumoperitoneum was induced, and the patient was placed in a Trendelenburg position. Due to the interrupted pneumoperitoneum caused by the uterus removal, the ONSD could not be measured afterward. Observing trends in ONSD changes has been assumed to be feasible using 40 min of ONSD distension, which is instantaneous and useful for determining whether acute changes have occurred. In addition, the sample size was insufficient to conduct additional analysis, including an area under the curve analysis of the ONSD. A larger randomized study would be necessary.

Conclusion

Here we report that minimal-flow anesthesia can be as safe as high-flow anesthesia using the ONSD measurement method by USG, which has been used in evaluating intracranial space in recent years. We believe that the prejudice against low-flow anesthesia can be reduced by demonstrating that minimal-flow anesthesia can be safely performed in specific surgery groups, as in our study.

References

1. Akeju O, Brown EN. Neural oscillations demonstrate that general anaesthesia and sedative states are neurophysiologically distinct from sleep. Current opinion in neurobiology. 2017;44:178-85.
2. George Mychaskiw I. Low and minimal flow anesthesia: Angels dancing on the point of a needle. Journal of Anaesthesiology, Clinical Pharmacology. 2012;28(4):423.
3. Baum J, Aitkenhead A. Low-flow anaesthesia. Anaesthesia. 1995;50:37-44.
4. Fan S-Z, Lin Y-W, Chang W-S, Tang C-S. An evaluation of the contributions by fresh gas flow rate, carbon dioxide concentration and desflurane partial pressure to carbon monoxide concentration during low fresh gas flows to a circle anaesthetic breathing system. European journal of anaesthesiology. 2008;25(8):620-6.
5. Baum JA. Low-flow anaesthesia: theory, practice, technical preconditions, advantages, and foreign gas accumulation. Journal of Anaesthesia. 1999;13(3):166-74.
6. Park SY, Chung CJ, Jang JH, Bae JY, Choi SR. The safety and efficacy of minimal-flow desflurane anaesthesia during prolonged laparoscopic surgery. Korean Journal of Anesthesiology. 2012;63(6):498-503.
7. Debre Ö, Sarıtaş A, Şentürk Y. Influence of sevoflurane on hemodynamic parameters in low flow anaesthesia applied without nitrous oxide. J Clin Exp Invest. 2014;5(1).
8. Colak YZ, Toprak HI. Feasibility, safety, and economic consequences of using low flow anaesthesia according to body weight. Journal of anaesthesia. 2020;34(4):537-42.
9. Baum J. Low-flow anaesthesia. LWW; 1996. p. 432-5.
10. Kupisiak J, Goch R, Polenceusz W, Szyca R, Leksowski K. Bispectral index and cerebral oximetry in low-flow and high-flow rate anaesthesia during laparoscopic cholecystectomy–a randomized controlled trial. Videosurgery and Other Miniinvasive Techniques. 2011;6(4):226-30.
11. Tokgöz N, Ayhan B, Saricaoglu F, Akinci SB, Aypar Ü. A comparison of low and high flow desflurane anaesthesia in children. Turkish Journal of Anaesthesiology & Reanimation. 2012;40(6):303.
12. Vaiman M, Abuita R, Bekerman I. Optic nerve sheath diameters in healthy adults measured by computer tomography. International journal of ophthalmology. 2015;8(6):1240.
13. Strapazzon G, Brugger H, Dal Cappello T, Procter E, Hofer G, Lochner P. Factors associated with optic nerve sheath diameter during exposure to hypobaric hypoxia. Neurology. 2014;82(21):1914-8.
14. Dinsmore M, Han J, Fisher J, Chan V, Venkatraghavan L. Effects of acute controlled changes in end-tidal carbon dioxide on the diameter of the optic nerve sheath: a transorbital ultrasonographic study in healthy volunteers. Anaesthesia. 2017;72(5):618-23.
15. Newman W, Hollman A, Dutton G, Carachi R. Measurement of optic nerve sheath diameter by ultrasound: a means of detecting acute raised intracranial pressure in hydrocephalus. British journal of ophthalmology. 2002;86(10):1109-13.
16. Robba C, Santori G, Czosnyka M, Corradi F, Bragazzi N, Padayachy L, et al. Optic nerve sheath diameter measured sonographically as non-invasive estimator of intracranial pressure: a systematic review and meta-analysis. Intensive care medicine. 2018;44(8):1284-94.
17. Mondillo S, Galderisi M, Mele D, Cameli M, Lomoriello VS, Zacà V, et al. Speckle-tracking echocardiography: a new technique for assessing myocardial function. Journal of Ultrasound in Medicine. 2011;30(1):71-83.
18. Blaivas M, Theodoro D, Sierzenski PR. Elevated intracranial pressure detected by bedside emergency ultrasonography of the optic nerve sheath. Academic emergency medicine. 2003;10(4):376-81.
19. Yunos NaM, Bellomo R, Glassford N, Sutcliffe H, Lam Q, Bailey M. Chloride-liberal vs. chloride-restrictive intravenous fluid administration and acute kidney injury: an extended analysis. Intensive care medicine. 2015;41(2):257-64.