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ARAŞTIRMA / RESEARCH

Preoperative inferior vena cava ultrasonography can predict post-induction hypotension in patients undergoing gastrointestinal surgery

Preoperatif vena cava inferior ultrasonografisi gastrointestinal cerrahi altindaki hastalarda indüksiyon sonrası hipotansiyonu tahmin edebilir

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Abstract

Purpose: In this study we aimed to evaluate effectiveness of preoperative IVC ultrasonography in predicting hypotension which develops following anesthesia induction, and in determining hypovolemia occurring in patients undergoing bowel preparation as secondary outcomes.

Materials and Methods: The study included patients with American Society of Anesthesiologists physical status classification (ASA) I-II, aged between 18 and 65 years who were scheduled for gastrointestinal operation under general anesthesia. Fourty-two of the 84 patients included underwent bowel preparation. Patients' maximum diameter of inferior vena cava (dIVCmax) and minimum diameter of inferior vena cava (dIVCmin), inferior vena cava collapsibility index (IVC-CI) and preinduction basal mean arterial pressure (MAP) was measured.

Results: Thirty-nine (46.4%) of the 84 patients developed hypotension after general anesthesia induction. Cut-off for dIVCmax was found as 15.750 mm with ROC analysis. Specificity and sensitivity for the cut-off value of 15.750 mm were calculated as 55.6% and 71.8%, respectively. Cut-off for IVC-CI was found as 32.746 % with ROC analysis. Specificity and sensitivity for the cut-off value of 32.746 % mm were calculated as 83.3% and 74.4%, respectively.

Conclusion: According to our data, IVC ultrasonography may be helpful in prediction of preoperative hypovolemia in patients. IVC-CI was higher and dIVCmax was lower and the incidence of hypotension was higher in patients who underwent bowel preparation compared to the patient who did not undergo.

Keywords: anesthesia, colorectal surgery, propofol, ultrasonography

Öz

Amaç: Bu çalışmada, preoperatif inferior vena kava ultrasonografisinin anestezi indüksiyonu sonrası gelişen hipotansiyonu öngörmede etkinliğini ve ikincil olarak bağırsak hazırlığı yapılan hastalarda oluşan hipovolemiyi tesbitini değerlendirmeyi amaçladık.

Gereç ve Yöntem: Genel anestezi altında gastrointestinal cerrahi operasyon geçirecek 18-65 yaş arası American Society of Anaesthesiologists physical status classification (ASA) I-II hastalar dahil edildi. Çalışmaya dahil edilen 84 olgunun 42'sine barsak hazırlığı yapılmıştı. Hastaların inferior vena kava maksimun çapı (dİVK maks) ve inferior vena kava minimum çapı (dİVK min), inferior vena kava kollabsibilite indeksi (İVK-Kİ, indüksiyon öncesi bazal ortalama arter basıncı (OAB) ve İndüksiyon sonrası cerrahi insizyona kadar hastaların kan basıncı ölçümleri ölçüldü.

Bulgular: Çalışmaya dahil edilen 84 hastanın 39'unda (% 46.4) genel anestezi indüksiyonundan sonra hipotansiyon gelişti. ROC eğrisi analizi ile dİVK maks için cut-off değeri 15.750 mm olarak bulundu. 15.750 mm cut-off değeri için spesifite ve sensitivite sırasıyla %55.6-%71.8 olarak bulundu. ROC eğrisi analizi ile İVK-Kİ için cut-off değeri 32.7460 olarak bulundu. 32.7460 cut-off değeri için spesifite ve sensitivite sırasıyla %83.3-%74.4 olarak bulundu.

Sonuç: İnferior vena kava ultrasonografisi hastalarda preoperatif hipovolemiyi öngörmede faydalı olabilir. Verilerimize göre barsak hazırlığı yapılmayan hastalarla karşılaştırıldığında barsak hazırlığı yapılan hastalarda yüksek İVK-Kİ ve düşük dİVK maks değerleri ve yüksek hipotansiyon insidansı görülmüştür.

Anahtar kelimeler: anestezi, kolorektal cerrahi, propofol, ultrasonografi

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INTRODUCTION

Mechanical bowel preparation is associated with osmotic fluid loss. Numerous methods have been described and introduced in bowel preparation. Main methods of bowel cleansing include prolonged fasting and fluid diet, fluid enema, and rectal wash-out, purgatives, magnesium salts, Senna compounds, and oral mannitol[1]. A large amount of fluid is lost during bowel preparation since the colon is completely purged[2]. Decreased plasma volume after bowel preparation procedure increases the risk for intraoperative hypotension[3]. After anesthesia induction, the risk for hypotension is further high in these patients until surgical stimulation because of the cardiovascular depressing and vasodilator effects of anesthetic agents[4].

Preoperative fluid deficit should be determined and restored through history, physical examination, hemodynamic measurements and laboratory outcomes in order to eliminate the risk for intraoperative hypotension[5]. Given the limitations of static parameters, the use of dynamic parameters may be superior in evaluation of hemodynamic response[6,7,8].

Ultrasonography of inferior vena cava (IVC) is a noninvasive, simple, rapid and reliable indicator of intravascular volume status. IVC has a structure which dilates and collapses in accordance with pressure and volume changes.

Whereas the diameter of IVC varies in healthy persons, the maximum diameter has been shown to be lower in hypovolemic patients[9,10]. Collapsibility of IVC is a better indicator of intravascular volume. Venous blood fills into the right atrium because of the intrathoracic pressure decreasing with inspirium in spontaneous breathing. This action causes a transient reduction in the diameter of IVC. The diameter of IVC increases again upon expirium, and returns to the basal value. IVC collapsibility index is defined as dividing of the difference between the maximum (expirium) and minimum (inspirium) diameters by the maximum diameter. IVC-CI is used in estimation of the right atrial pressure in patients with spontaneous breathing[11,12].

In this study we aimed to evaluate effectiveness of preoperative IVC ultrasonography (IVC-max / IVC-CI) in predicting hypotension which develops following anesthesia induction, and in determining hypovolemia occurring in patients undergoing gastrointestinal operation with and without bowel preparation.

MATERIALS AND METHODS

This study was conducted in the operating room of our hospital after receiving approval (ref no: 2016/761) from the ethics committee between January 2017 and June 2017 following the Declaration of Helsinki. Participants were informed about the study both verbally and in writing, and informed consents forms were received.

We used G Power Software to determine the sample size. We calculated the number of patients as 80 (40 patients for each group) to compare two groups with 90% power, 5% type I error level, and 25% effect size for the F test. We enrolled 84 patients to account for the possibility of exclusion.

The study was designed as a prospective observational study. The study included patients with ASA (American Society of Anesthesiologists physical status classification) I-II, aged between 18 and 65 years who were scheduled for gastrointestinal operation under general anesthesia as the group with bowel preparation (n=42 / Group A) and the group without bowel preparation (n=42 / Group B). The patients were instructed to begin clear fluid diet 2 days before bowel preparation, and to apply the laxative solution containing 20 mL cenosite A-B and calcium salt (X-M Solution laxative 250 mL, Yenişehir Laboratuar Ticaret ve Sanayi Şti, Turkey) with 8-hour intervals 24 hours before bowel preparation.

Patients with increased intraabdominal pressure, cardiac failure, difficult airway, chronic obstructive pulmonary disease, the use of diuretics and anti hypertensive, pregnancy, peripheral vascular disease, and a history of pulmonary hypertension were excluded from the study.

Randomization of the patients was obtained through computer at a rate of 1/1. Patients' demographics (age, gender, height, weight, BMI), ASA classification, and duration of preoperative fasting by were recorded an anaesthetist who was not enrolled in the study. After routine monitoring (electrocardiography, non-invasive blood pressure), basal values of blood pressure, and heart rate were recorded. All patients were not premedication.

IVC ultrasonography measurements were made before general anesthesia in a supine position and

during spontaneous breathing. The measurements were carried out with ultrasonography device (Mindray M7 / North America), at abdominal mode using sector probe. Ultrasonography procedure was performed by an anaesthetist who was trained for USG and performed more than 30 measurement, and was blind to the study. IVC ultrasonography was performed in each patient according to the methodology described by American Echocardiography, with a subcostal approach using a paramedian long-axis image[11] (Figure I).

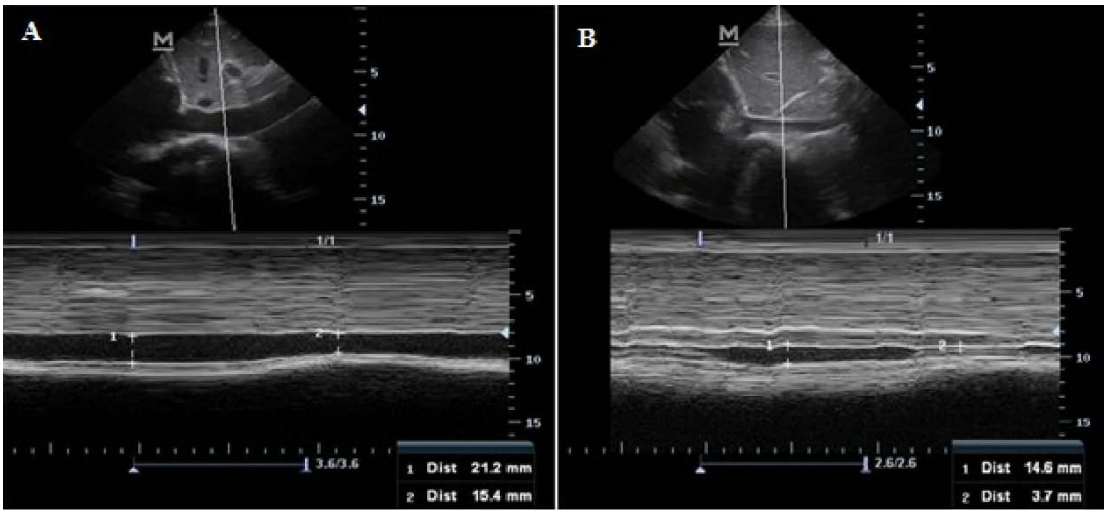

Figure 1. Inferior vena cava (IVC) measurements with subcostal approach using a paramedian long axis image.

Changes in the diameter of the IVC with 2-3 cm distal to the right atrium. Expirium (IVC max) and inspirium (IVC min). A;Minimal inspiratory collapse-Large maximum diameter B; Large inspiratory collapse-Small maximum diameter.

First, 2D image of the IVC was acquired beginning from the right atrium. Pulse wave Doppler was used to distinguish the aorta from IVC. Changes in the diameter of IVC with breathing were measured from 2-3 cm distal to the right atrium. Expirium (IVC max) and inspirium (IVC min) were measured at least 3 times, and IVC collapsibility index (IVC-CI) was calculated using the following formula: IVC-CI = ((IVCmax – IVCmin) / IVCmax) x 100

Data of the patient were excluded if there was a difference higher than 0.2 cm in IVC max measurements between any 2 images. Standard, routine general anesthesia induction was carried out by an anaesthetist who was not enrolled in the study. Propofol (Propofol Fresenius Kabi, Sweden) and remifentanil (Ultiva Glaxo Smith Kline, Italy) were used in anesthesia induction, and desflurane (minimal alveolar concentration (MAC) value of 1 of desflurane (3-4%) and air (50%) in oxygen) and remifentanil were administered as the inhalation anesthetics in maintenance of the anesthesia. Remifentanil was administered with a fixed dose of 1 mcg/kg bolus and 0.2 mcg/kg/min infusion, while propofol was administered as a dose of 1-2 mg/kg and titrated depending on anesthetic depth of the patient. Rocuronium was administered at a dose of 0.6 mg/kg as neuromuscular blocker, and its effect was followed-up with neuromuscular monitoring.

Postinduction patients' blood pressures were recorded every 2 minutes until surgical incision. The study was terminated with surgical incision. A decrease > 30% in MAP, and a MAP < 60 mm Hg was considered as hypotension.

Statistical analysis

Data obtained were analyzed using SPSS 20.00 software (Statistical Package for Social Sciences Inc Chicago, IL). The continuous variables are expressed as mean ± SD or number (%). Whereas categorical variables are expressed as number and percentages (%). Normality of the data was tested with Kolmogorov Smirnov. Since there was no normal distribution, continuous variables (age, weight, height) were analyzed with Mann Whitney U test.

Comparison of two groups and analysis of categorical variables were made using Chi-Square test.

Bowel preparation. and other parameters were normally distributed, the correlation coefficients and their significance were calculated using the pearson test. Predictive ability of the group in correct prediction of hypotension was evaluated with calculation of ROC (Receiver Operating Characteristic) and curve the area under curve (AUC). P values < 0.05 were considered statistically significant.

RESULTS

A total of 84 patients who underwent gastrointestinal operation, and in whom inferior vena cava was evaluated with ultrasonography before anesthesia induction were included in the study. The mean age was 53.05 ± 12.92 in Group A and 48.62 ± 11.49 in Group B. M/F ratio was 23/19 in Group A and 20/22 in Group B, and no significant difference was found between the groups (p>0.05). Demographics and basal hemodynamic data were similar between the groups and were no statistically significant (P>0.05) (Table 1).

Table 1. Demographic and basal hemodynamic characteristics of the study groups.

Characteristics	Group A (n=42)	Group B (n=42)	P value
Age, yr (mean±SD)	53.05±12.92	48.62±11.49	0.101
Sex (male/female)(%)	23/19 (54.8%/45.2%)	20/22 (47.6%/52.4%)	0.513
BMI (mean±SD)	27.90±5.01	29.83±5.84	0.108
Length, cm (mean±SD)	1.67±.09	1.63±.076	0.052
Weight, kg (mean±SD)	77.83±14.33	79.54±15.38	0.599
ASA (I/II) (%)	11(26.2)/31(73.8)	17(40.5)/25(59.5)	0.165
Baseline HR (beats / min)	83.45±11.53	82.59±20.02	0.811
Baseline SBP (mmHg)	137.59±18.76	132.50±17.64	0.204
Baseline DBP (mmHg)	75.50±10.47	74.11±8.97	0.518
Baseline MBP (mmHg)	99.04±12.67	94.76±11.40	0.107

Table 2. Comparison of IVC measurement values of study groups

	Group A (n=42)	Group B (n=42)	P value
dIVC max (cm)	13.99±2.85	16.12±3.55	0.003*
dIVC min,(cm)	8.45±3.296	12.11±3.86	0.000*
IVC-CI (%)	40.62±14.33	26.12±12.87	0.000*

Table 3. Comparison of hypotensive rates after induction of study groups.

	Group A (n=42)	Group B (n=42)	P value
Hypotension after induction (%)	27 (69.2%)	12 (30.8%)	0.001*
MBP <60 mmHg	10 (76.9%)	3 (23.1%)	0.035*
MBP mmHg	67.07±14.60	70.14±8.91	0.008*
MBP drop percentage mmHg	34.60±11.57	25.52±8.98	<0.001*
Fasting duration (hour)	11.90±2.69	9.80±2.09	<0.001*

MBP; Mean Blood Pressure, *P<0.05

Data are expressed as mean ± SD or absolute number (percentage).BMI; Body Mass Index, ASA = American Society of Anesthesiologists physical statu, HR; Heart Rate, SBP; Systolic Blood Pressure, DBP; Diastolic Blood Pressure, MBP; Mean Blood Pressure IVC values (dIVCmax / dIVCmin) were markedly lower in Group A than in Group B, and this difference was statistically significant (p<0.05) (Table 2). dIVCmax; Maximum diameter of IVC, dIVCmin; Minimum diameter of IVC, IVC-CI; IVC collapsibility index. *P<0.05. The incidence of postinduction hypotension was found as 46.4% (39 / 84). Twenty-seven (64.2%) patients in Group A developed postinduction hypotension, while 12

(28.5) patients in Group B developed postinduction hypotension, and the difference was statistically significant (p=0.001). The incidence of postinduction hypotension and fasting duration by groups are shown in Table 3. Whether dIVCmax and IVC-CI have a diagnostic value in predicting hypotension was studied with Receiver Operating Characteristics (ROC) curve analysis.

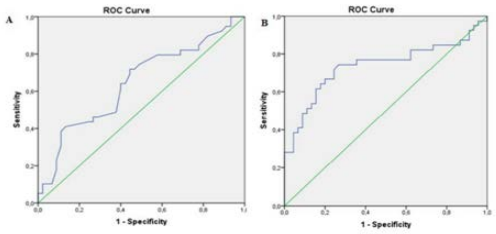

Figure 2. Receiver operating characteristic (ROC) curves showing the ability of preoperative maximum diameter (A) and collapsibility index (B) of inferior vena cava to predict hypotension after induction of general anesthesia.

In the ROC analysis, it was found that maximum diameter and collapsibility index of inferior vena cava have diagnostic value in predicting the development of hypotension. AUC (area under curve) was found as 0.644, 95%CI: 0.524 – 0.763 (p<0.024). Cut-off for dIVCmax was found as 15.750 mm with ROC analysis. Specificity and sensitivity for the cut-off value of 15.750 mm were calculated as 55.6% and 71.8%, respectively (Figure 2/A). AUC was found as 0.737, 95%CI: 0.622 – 0.852 (p<0.001). Cut-off for IVC-CI was found as 32.746 % with ROC analysis. Specificity and sensitivity for the cut-off value of 32.746 % mm were calculated as 83.3% and 74.4%, respectively (Figure 2/B). The triangles on the curves indicate the optimal cutoff values determined by maximizing the Youden index.

DISCUSSION

We found that, evaluation of the patients undergoing bowel preparation with IVC ultrasonography before anesthesia induction was predictive in predicting postinduction hypotension. CI was more predictive than ICVmax. In IVC screening, cut-off values for predicting postinduction hypotension were found axs 33% for IVC-CI, and 1.6 cm for dIVCmax with specificity and sensitivity of 83.3% and 74.4% for IVC-CI, and 55.6% and 71.8% for dIVCmax, respectively.

Ultrasonography of inferior vena cava in order to guide evaluation of intravascular volume status is a noninvasive, an easy to apply hemodynamic monitoring methods which is being increasingly used in recent years. Given the importance of determination of the preoperative volume status, rapid ultrasonographic examination may be useful in guiding treatment of critically ill patients[9].

The guidelines by American Echocardiography Society support the use of diameter and collapsibility index of IVC in evaluation of volume status. IVC-CI >50% in dehydration patients indicates a CVP < 8 mm Hg[13]. Muller et al. found that a collapsibility index >40% predicted response to fluid therapy. In their study with patients in the intensive care unit[14]. Airapetian et al. showed that only inspiration variation of IVC ≥42% could correctly predicted increase in CO after fluid infusion[15]. Zhang et al. found the cut-off values of IVC measurements before general anesthesia induction in predicting postinduction hypotension as 43% for IVC-CI and 1.8 cm for dIVCmax, and demonstrated that IVC-CI is more predictive than dIVCmax[16].

In our study, IVC-CI for postinduction hypotension was lower than the literature. Studies in the literature have compared the correlation of IVC-CI and central pressure, or response to fluid and increase in cardiac output. Even normovolemic patients may develop hypotension after anesthesia induction, explaining this low value.

It is important to evaluate intravascular volume during anesthesia induction in patients undergoing gastrointestinal operation, because hypovolemia leads to low blood pressure, low organ perfusion and subsequent insufficiency in tissue oxygen supply[17]. Evidence suggests that the diameter of IVC is a reliable indicator of volume status, and respiratory variation is valuable in predicting response to fluids. A higher collapsibility index indicates a low volume status especially with a small IVC diameter[12].

In our study, the maximum diameter of IVC was significantly lower, and collapsibility index was higher in patients who underwent bowel preparation, thus developed hypotension. We believe that the most important factor triggering hypotension is intravascular volume status of patients, because there was no significant difference in patients' ages, and ASA 3, 4 patients were not included.

Intraoperative hypotension is a common side effect of anesthesia, but its definition differs among clinical

studies. There are about 140 definitions in the literature, resulting in different hypotension cases[18]. However, intraoperative mean arterial pressure lower than 55 mm Hg has been shown to be associated with acute renal and myocardial damage even in short term[19]. Regardless the presence of cardiovascular disease, the incidence of propofol related hypotension has been found between 25% and 67.5%[20, 21, 22]. In their study, Zhang et al. reported the incidence of hypotension after general anesthesia induction as 46.7%. Etomidate was used in that study as the induction agent, and 50% of patients had cardiovascular disease as comorbidity[16].

We used propofol in anesthesia induction of the patients included in the study. Despite the incidence of hypotension was 46%, only 13 patients (10 in Group A and 3 in Group B) had a mean arterial pressure lower than 60 mm Hg. Whereas the mean arterial pressure did not fall under 60 mm Hg in majority of patients who developed hypotension, more than 30% decrease was seen in basal mean arterial pressure values.

Although its effects on fluid balance have been probably exaggerated, preoperative fasting should be taken into account before the operation. In a study by Jacob et al., measurements read after a fasting period of 10 hours resulted in normal blood volume in patients healthy for cardiopulmonary conditions[23]. Whereas in our study fasting duration was significantly longer in the group with bowel preparation.

This study has several limitations. Since spontaneous breathing was replaced by positive pressure ventilation, we could not measured postinduction IVC-CI. Propofol doses were variable among the patients, and this variability might be resulted from titration of propofol instead of administration with standard monitoring such as entropy / bispectral index monitoring (BIS).

In conclusion; results of this study indicates that patients undergoing bowel preparation are under an increased risk for hypovolemia, because of the completely purged colon and / or insufficient hydration. Screening of the patient who underwent bowel preparation in the operating room in preoperative period with IVC ultrasonography will be guiding in determination the increased risk of hypotension due to hypovolemia, and taking the necessary measures. We believe that IVC ultrasonography may be helpful in prediction of preoperative hypovolemia in patients who underwent bowel preparation.

Yazar Katkıları: Çalışma konsepti/Tasarımı: STU, AT; Veri toplama: ŞS, AT; Veri analizi ve yorumlama: ŞA; Yazı taslağı: AT, ŞS; İçeriğin eleştirel incelenmesi: STU; Son onay ve sorumluluk: ŞS, ŞA, AT, GH, STU; Teknik ve malzeme desteği: ŞS; Süpervizyon: ŞA; Fon sağlama (mevcut ise): yok.
Bilgilendirilmiş Onam: Katılımcılardan yazılı onam alınmıştır.
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Author Contributions: Concept/Design : STU, AT; Data acquisition: ŞS, AT; Data analysis and interpretation: ŞA; Drafting manuscript: AT, ŞS; Critical revision of manuscript: STU; Final approval and accountability: ŞS, ŞA, AT, GH, STU; Technical or material support: ŞS; Supervision: ŞA; Securing funding (if available): n/a.
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REFERENCES

1. Zmora O, Pikarsky AJ, Wexner SD. Bowel preparationaration for colorectal surgery. Dis Colon Rectum. 2001;44:1537-49.
2. Holte K, Nielsen KG, Madsen JL, Kehlet H. Physiologic effects of bowel preparationaration. Dis Colon Rectum. 2004;47:1397-402.
3. Reich DL, Hossain S, Krol M, Baez B, Patel P, Bernstein A, et al. Predictors of hypotension after induction of general anesthesia. Anesth Analg. 2005;101:622–8.
4. Au AK, Steinberg D, Thom C, Shirazi M, Papanagnou D, Ku BS, Fields JM. Ultrasound measurement of inferior vena cava collapse predicts propofol-induced hypotension. Am J Emerg Med. 2016;34:1125-8.
5. Butterworth JF, Mackey DC, Wasnick JD. Morgan & Mikhail's Clinical Anesthesiology, 5th ed. New York, McGraw-Hill, 2013.
6. Marik PE, Baram M, Vahid B. Does central venous pressure predict fluid responsiveness? A systematic review of the literature and the tale of seven mares. Chest. 2008;134:172-8.
7. Renner J, Scholz J, Bein B. Monitoring fluid therapy. Best Pract Res Clin Anaesthesiol. 2009;23:159-71.
8. Thiele RH, Bartels K, Gan TJ. Inter-device differences in monitoring for goal-directed fluid therapy. Can J Anaesth. 2015;62:169-81.
9. Dipti A, Soucy Z, Surana A, Chandra S. Role of inferior vena cava diameter in assessment of volume status: a meta-analysis. Am J Emerg Med. 2012;30:1414–9.
10. De Vecchis R, Baldi C. Inferior vena cava and hemodynamic congestion. Res Cardiovasc Med. 2015;4:28913.
11. Rudski LG, Lai WW, Afilalo J, Hua L, Handschumacher MD, Chandrasekaran K et al. Guidelines for the echocardiographic assessment of the right heart in adults: a report from the American

Society of Echocardiography endorsed by the European Association of Echocardiography, a registered branch of the European Society of Cardiology, and the Canadian Society of Echocardiography. J Am Soc Echocardiogr. 2010;23:685-713.
12. Seif D, Mailhot T, Perera P, Mandavia D. Caval sonography in shock: A noninvasive method for evaluating intravascular volume in critically ill patients. J Ultrasound Med. 2012;31:1885–90.
13. Nagdev AD, Merchant RC, Tirado-Gonzalez A, Sisson CA, Murphy MC. Emergency department bedside ultrasonographic measurement of the caval index for noninvasive determination of low central venous pressure. Ann Emerg Med. 2010;55:290-5.
14. Muller L, Bobbia X, Toumi M, Louart G, Molinari N, Ragonnet B, et.al Respiratory variations of inferior vena cava diameter to predict fluid responsiveness in spontaneously breathing patients with acute circulatory failure: need for a cautious use.Crit Care. 2012;16:188.
15. Airapetian N, Maizel J, Alyamani O, Mahjoub Y, Lorne E, Levrard M et al. Does inferior vena cava respiratory variability predict fluid responsiveness in spontaneously breathing patients? Crit Care. 2015;19:400.
16. Zhang J, Critchley LA. Inferior vena cava ultrasonography before general anesthesia can predict hypotension after induction. Anesthesiology. 2016;124:580-9.
17. Brienza N, Giglio MT, Marucci M, Fiore T. Does perioperative hemodynamic optimization protect renal function in surgical patients? a meta-analytic study. Crit Care Med. 2009;37:2079-90.
18. Bijker J, van Klei W, Kappen T, van Wolfswinkel L, Moons K, Kalkman C. Incidence of intraoperative hypotension as a function of the chosen definition. Anesthesiology. 2007;107:213-20.
19. Walsh M, Devereaux PJ, Garg AX, Kurz A, Turan A, Rodseth RN et al. Sessler DI. Relationship between intraoperative mean arterial pressure and clinical outcomes after noncardiac surgery: Toward an empirical definition of hypotension. Anesthesiology. 2013;119:507-15.
20. Claeys MA, Gepts E, Camu F. Haemodynamic changes during anaesthesia induced and maintained with propofol. Br J Anaesth. 1988 ;60:3-9.
21. Bano F, Zafar S, Sabbar S, Aftab S, Haider S, Sultan ST. Intravenous ketamine attenuates injection pain and arterial pressure changes during the induction of anesthesia with propofol: A comparison with lidocaine. J Coll Physicians Surg Pak. 2007;17:390-3.
22. Larsen R, Rathgeber J, Bagdahn A, Lange H, Rieke H. Effects of propofol on cardiovascular dynamics and coronary blood flow in geriatric patients. A comparison with etomidate. Anaesthesia. 1988;43:25-31.
23. Jacob M, Chappell D, Conzen P, Finsterer U, Rehm M. Blood volume is normal after pre-operative overnight fasting. Acta Anaesthesiol Scand. 2008;52:522-9.