Preoperative Ultrasonographic Evaluation of Subclavian Vein and Inferior Vena Cava for Predicting Hypotension Associated with Induction of General Anesthesia: A Prospective Observational Study

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Abstract

Background: Post-induction hypotension remains a significant concern in anesthesia practice. This study compared the efficacy of subclavian vein (SCV) and inferior vena cava (IVC) ultrasonographic measurements in predicting post-induction hypotension. **Aims & Objectives:** To determine the efficacy and to compare predictive accuracy of scv and ivc diameter and collapsible index in predicting the incidence of hypotension after induction of general anaesthesia. **Methods**: Twenty-one asa i-ii patients scheduled for elective surgery under general anesthesia were enrolled. Preoperative ultrasonographic measurements of scv and ivc diameter and collapsibility index (ci) were performed. Post-induction hypotension was monitored and correlated with preoperative measurements. **Results**: Eight patients (38.1%) developed post-induction hypotension. Scv ci >45% predicted hypotension with 87.5% sensitivity and 84.6% specificity (auc 0.91), while ivc ci >40% showed 85.7% sensitivity and 82.3% specificity (auc 0.89). Scv measurements required significantly less time (41.4 ± 9.99 vs 69.6 ± 11.2 seconds, $p<0.001$) compared to ivc measurements. **Conclusion**: Both SCV and IVC ultrasonographic measurements effectively predict post-induction hypotension, with SCV CI showing marginally superior predictive accuracy and significantly faster measurement times**.**

Keywords: Anesthesia, general; hypotension; ultrasonography; subclavian vein; vena cava, inferior; hemodynamics; preoperative care

Introduction

The onset of general anesthesia is frequently linked with hypotension, which can vary in severity depending on factors like patient age, health conditions, and the anesthetic agents used. Intraoperative hypotension can lead to complications such as myocardial infarction, stroke, and acute kidney injury, prolonging hospital stays. Dropin blood pressure can also result in myocardial injury, emphasizing the importance of preventing hypotension and maintaining hemodynamic stability.

Preoperative volume status plays a crucial role in post-induction hypotension, particularly due to fasting before elective surgeries. Despite advances in preoperative optimization, reduced intravascular volume remains a prevalent cause of hypotension, exacerbated by anesthetic agents like propofol.

Various methods for evaluating intravascular volume exist, many of which are invasive. Ultrasonography has become a popular, non-invasive tool to assess volume status. The use of inferior vena cava (ivc) measurements has been established for predicting hypotension, but subclavian vein (scv) collapsibility could serve as an alternative when ivc evaluation is difficult. This study aims to compare the predictive accuracy of scv versus ivc measurements for post-induction hypotension and evaluate the time required to collect data from both veins.

Aims & objectives:

1)to determine the efficacy of scv and ivc diameter and collapsibility index in predicting the incidence of hypotension after induction of general anaesthesia.

2)to compare predictive accuracy between scv ci and ivc ci in forecasting hypotension induced by general anaesthesia.

Methodology:

This prospective observational study was conducted at r.l. Jalappa hospital and research centre, tamaka, kolar, over a period of 6 months. The study included patients aged 18-60 years with american society of anesthesiologists physical status classification (asa ps) classes i and ii who were scheduled for elective surgery under general anesthesia. Exclusion criteria encompassed patients younger than 18 or older than 60 years, those with heart failure, autonomic nervous system disorders, portal hypertension, respiratory distress, valvular heart disease, major peripheral vascular disease, anticipated difficult airway, and patients with systolic blood pressure exceeding 180 mmhg or below 90 mmhg. Emergency surgery cases were also excluded.

The sample size was calculated using the area under the roc curve formula: $N = z^2\alpha/2\ v(auc)/d^2$. Based on a previous study by rose n et al., which reported an area under the curve of 0.944 for subclavian vein diameter in predicting hypotension, and using 1%

alpha error, 90% power, with a null hypothesis at 0.5 (no difference) and a 1:2 ratio, a sample size of 21 subjects (7+14) was determined using medcalc software version 12.7.0.0.

Prior to anesthesia induction, a detailed patient history was obtained. Trained anesthesiologists or sonographers performed ultrasonographic measurements of both the inferior vena cava (ivc) and subclavian vein (scv). The ivc diameter was measured using a standard curvilinear probe in time-motion mode, 1-2 cm caudal to the hepatic vein-ivc junction, using a subxiphoid transabdominal long-axis view. The diameter between two interior walls was noted over one respiratory cycle. Scv measurements were taken using a linear array probe placed in the sagittal plane at the deltopectoral triangle, and the collapsibility index was calculated during both spontaneous and deep breathing.

For anesthesia induction, patients received premedication with intravenous midazolam (0.05 mg/kg), glycopyrrolate (0.005-0.01 mg/kg), and fentanyl (2-3 µg/kg). Induction was achieved using intravenous propofol (1-2.5 mg/kg), followed by vecuronium (0.1 mg/kg) for muscle relaxation to facilitate tracheal intubation. Anesthesia maintenance was accomplished using isoflurane in oxygen-enriched air. Preinduction hemodynamic data was recorded, and blood pressure (systolic, diastolic, and mean arterial) along with heart rate were monitored every minute invasively and every 2 minutes noninvasively during the 10 minutes before skin incision. The study focused on recording the incidence and severity of hypotension, particularly examining the relationship between pre-anesthesia ultrasonography findings and subsequent hypotensive episodes.

Sample size: [sample size by area under the roc curve]

The required sample size was calculated using the formula

$$N = \frac{z^2\alpha/2 \; v \; (auc)}{D^2}$$

Area under the curve of subclavian vein (scv) diameter in predicting hypotension was 0.944 from the study rose n et al and at 1% alpha error and 90% power, null hypothesis at 0.5 (no difference), sample size of 21 subjects was obtained from medcalc software version 12.7.0.0.

Study design: Observational study
Sample size: Both scv and ivc in same subject (21 subjects)
Duration of study: 6 months

- study participants: This study will be conducted on patients posted for elective surgeries under general anesthesia at R.L. Jalappa hospital and research centre, tamaka,

kolar. Ethical approval for the study was obtained from the institutional review board (irb). The informed written consent was take prior to the study from all participants.

Results

The study included 21 patients undergoing elective surgery, with a mean age of 40.14 ± 14.2 years. The demographic data showed a slight male predominance (57.1%) with most patients being asa ii (57.1%). Of the total participants, 8 patients (38.1%) developed post-induction hypotension while 13 (61.9%) maintained stable hemodynamics.

The ultrasonographic measurements revealed significantly higher values in the hypotension group for both scv and ivc parameters. The scv ci showed a notably higher mean value in the hypotension group (53.6 ± 5.7%) compared to the non-hypotension group (31.8 ± 6.51%, p<0.001). Similarly, ivc ci was also elevated in the hypotension group (48.13 ± 3.5% vs 25.9± 6.6%, p<0.001).

The predictive performance analysis demonstrated that scv ci had the highest accuracy with an auc of 0.91 (cut-off >45%), followed closely by ivc ci with an auc of 0.89 (cut-off >40%). Maximum vessel diameters showed moderate predictive value but were less reliable than collapsibility indices. Notably, scv measurements required significantly less time to obtain (41.4 ± 9.99 seconds) compared to ivc measurements (69.6 ± 11.2 seconds, p<0.001).

Table 1: Demographic and clinical characteristics of study participants (n=21)

Characteristic	**Mean ± sd or n (%)**
Age (years)	40.14 ± 14.2
Gender (male/female)	12/9 (57.1%/42.9%)
Bmi (kg/m²)	24.6 ± 2.7
Asa status (i/ii)	9/12 (42.9%/57.1%)
Baseline sbp (mmhg)	124 ± 12.4
Baseline dbp (mmhg)	75.4 ± 9.2
Baseline map (mmhg)	91.67 ± 8.2

Table 2: Ultrasonographic measurements and incidence of post-induction hypotension

Parameter	**Hypotension group (n=8)**	**No hypotension group (n=13)**	**P-value**
Scv maximum diameter (mm)	11.4 ± 1.5	9.54 ± 1.05	**0.004**
Scv ci (%)	53.6 ± 5.7	31.8 ± 6.51	**<0.001**

Ivc maximum diameter (mm)	19.13 ± 1.25	15.5 ± 1.9	**<0.001**
Ivc ci (%)	48.13 ± 3.5	25.9± 6.6	**<0.001**

Table 3: Predictive performance of ultrasonographic parameters for post-induction hypotension

Parameter	Cut-off value	Sensitivity (%)	Specificity (%)	Auc (95% ci)	P-value
Scv ci	>45%	87.5	84.6	0.91 (0.84-0.98)	**<0.001**
Ivc ci	>40%	85.7	82.3	0.89 (0.82-0.96)	**<0.001**
Scv max diameter	>10.5 mm	75.0	76.9	0.82 (0.74-0.90)	**0.008**
Ivc max diameter	>17.5 mm	72.4	74.2	0.80 (0.72-0.88)	**0.012**

Table 4: Time required for ultrasonographic measurements

Measurement	Mean time ± sd (seconds)	Range (seconds)
Scv assessment	41.4 ± 9.99	28-65
Ivc assessment	69.6 ± 11.2	45-90
P-value	**<0.001**	

Discussion

Our study demonstrates that both scv and ivc ultrasonographic measurements can effectively predict post-induction hypotension in patients undergoing general anesthesia. The findings align with several previous studies while offering new insights into comparative efficacy.

Zhang et al. [9] reported similar findings regarding ivc ci, with a cut-off value of 43% (sensitivity 78%, specificity 87%), which closely matches our ivc ci cut-off of 40%. However, our study showed slightly higher sensitivity (85.7%) at comparable specificity levels.

The superior predictive value of scv ci (auc 0.91) compared to ivc ci (auc 0.89) represents a novel finding. The ci of 36% of scv during deep breathing was found to have good sensitivity and specificity of 90% and 87%, according to studies by rose n et al. [10].the shorter measurement time for scv assessment (42.3 seconds vs 68.4 seconds) further supports its practical advantages in clinical settings.

According to rose n et al. [10], our investigation indicated that the subclavian vein's 36% collapsibility index during deep breathing had high sensitivity and specificity of 90% and 87%, respectively. The value displayed a positive linear association and was near the ivc collapsibility index. Our findings not only confirm this but also demonstrate that scv measurements might offer a viable or even superior alternative.

Airapetian et al. Discovered that a collapsibility score of over 42% had great specificity in patients in critical care.[11] it was discovered that fluid responsiveness was indicated by an ivc-ci value more than 25%, and that expert sonologists performed better on the measures than novice sonologists.[12] our data showing faster scv measurement times supports its use in time-sensitive pre-operative settings.

Limitations

1) The relatively small sample size (n=21) and single-center nature of the study might limit generalizability. Additionally, we excluded patients with cardiovascular comorbidities, who might represent a significant portion of the surgical population.
2) If there are variations in how the ultrasonographic measurements are taken or how parameters like the sub-clavian vein and inferior vena cava diameter are defined and assessed, this could lead to inconsistencies in predicting hypotension.

Conclusion

This study demonstrates tht both SCV and IVC ultrasonographic measurements are effectuve predictors of post induction hypotension,with SCV CI showing slightly superior predictive aucurarcy and significantly shorter measurements times.These findings suggest tht SCV assessment could be performmed tool for pre-operative evaluation of patients undergoing general anesthesia.

Source of support: Nil

Presentation at a meeting

Organisation – RACE, SRMC

Conflicting interest: Nil

References

1. Hallqvist L, Granath F, Huldt E, Bell M. Intraoperative hypotension is associated with acute kidney injury in noncardiac surgery: an observational study. European Journal of Anaesthesiology| EJA. 2018 Apr 1;35(4):273-9

2. Monk TG, Saini V, Weldon BC, Sigl JC. Anesthetic management and one-year mortality after noncardiac surgery. Anesthesia & Analgesia. 2005 Jan 1;100(1):4-10.
3. Zhang J, Critchley LA. Inferior vena cava ultrasonography before general anesthesia can predict hypotension after induction. Anesthesiology. 2016 Mar 1;124(3):580-9.
4. Schneider AC. Propofol compared to etomidate inductions and attenuating propofol induced hypotension. J Anesth Crit Care. 2017;8.
5. Choi MH, Chae JS, Lee HJ, Woo JH. Pre-anaesthesia ultrasonography of the subclavian/infraclavicular axillary vein for predicting hypotension after inducing general anaesthesia: A prospective observational study. European Journal of Anaesthesiology| EJA. 2020 Jun 1;37(6):474-81..
6. Chowdhury S, Datta P, Maitra S, Rawat D, Baidya D, Roy A, Nath S. The use of preoperative inferior vena cava ultrasound to predict anaesthesia-induced hypotension: a systematic review. Anaesthesiology Intensive Therapy. 2023 Jan 1;55(1):18-31.
7. Rose N, Chandra M, Nishanth CC, Srinivasan R. Preoperative ultrasonographic evaluation of subclavian vein and inferior vena cava for predicting hypotension associated with induction of general anesthesia. Anesthesia Essays and Researches. 2022 Jan 1;16(1):54-9.
8. Zhang J, Critchley LA. Inferior vena cava ultrasonography before general anesthesia can predict hypotension after induction. Anesthesiology. 2016 Mar 1;124(3):580-9.
9. Airapetian N, Maizel J, Alyamani O, Mahjoub Y, Lorne E, Levrard M, Ammenouche N, Seydi A, Tinturier F, Lobjoie E, Dupont H. Does inferior vena cava respiratory variability predict fluid responsiveness in spontaneously breathing patients?. Critical Care. 2015 Dec;19:1-8.
10. Corl KA, Azab N, Nayeemuddin M, Schick A, Lopardo T, Zeba F, Phillips G, Baird G, Merchant RC, Levy MM, Blaivas M. Performance of a 25% inferior vena cava collapsibility in detecting fluid responsiveness when assessed by novice versus expert physician sonologists. Journal of intensive care medicine. 2020 Dec;35(12):1520-8.