Preoperative evaluation of inferior venae cava collapsibility index to predict post induction hypotension under general anaesthesia

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Abstract:

Post induction hypotension (PIH) is a largely debated topic in anaesthesia , without any definitive consensus on ideal method for its accurate identification. We hypothesized that inferior venae cava collapsibility index (IVCCI)measured pre-operatively before general anaesthesia could predict this hypotension .The patients were categorized on the basis of their American Society of Anaesthesiologists physical status classification(ASA) to find the optimal cutoff value and sensitivity of this index in predicting PIH.

In this prospective observational study, 157 patients (79 ASA I and 78 ASA II) undergoing routine general anesthesia for surgical procedures were enrolled and their preoperative IVCCI measurements were correlated with non-invasive hemodynamic parameters measured till 12 minutes post induction.

The overall incidence of PIH was 46% (12.7% in ASA I and 79.49% in ASA II patients). The optimal cutoff value of IVCCI for predicting hypotension was 47% .The sensitivity, specificity, positive predictive value (PPV) and negative predictive value (NPV) at 95%CI was 95% (87-98%), 97% (90-99%), 100% and (90%- 97.1%) with ROC (Receiver operating characteristic) of 0.972 (95%CI, P<0.0001). ASA status (β=2.924, OR (Odd ratio) 18.611;P<0.0001), baseline DBP (β=0.056, OR-0.946; p<0.004) and IVC-CI <50 (β=0.410, OR -1.506; p<0.0001) had significant correlation with PIH in linear regression logistic model.

Preoperative IVCCI measurements, baseline DBP and ASAII physical status of patients could significantly and accurately predict PIH before general anaesthesia.

Keywords: *Ultrasonography; Hypotension; logistic models; Vena cava inferior; General surgery; Propofol.*

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Received: 05/05/2022
Accepted: 04/10/2023

DOI: https://doi.org/10.4038/slja.v32i1.9058

Introduction

Post-induction hypotension (PIH) is a known but largely ignored entity in anaesthesia with incidence ranging from 8.9% to 55% .[1-3] Various factors like increasing age ≥ 50yrs, preoperative physical status ≥ASA II, associated comorbidity, baseline

hypotension/hypertension and induction agent used are implicated for causing this phenomenon .[4-6] Identification of such patients in the preoperative period allows to modify and treat some of these factors thereby decreasing the risk of hypoperfusion induced myocardial ischaemia, acute kidney injury and other complications .[7,8]

MATERIAL AND METHODS

After the approval of the research and ethics committee this prospective observational study was registered with no. CTRI/2020/09/028051 and was conducted from Oct 2020 to Sep 2021.

According to Kendale S et al the incidence of post induction hypo-tensionwas 8.9%.[1] Hence we calculated the sample size of 125, using Openepi software keeping the confidence limit at 95% and margin of error of 5%. Hundred and sixty-five patients undergoing general anaesthesia were initially enrolled to cover up for loss of cases due to any reason. Eight patients were thus excluded (5 for non visualization of IVC and 3 for requiring multiple intubation attempts) and ultimately157 patients were analyzed at the end of the study.

ASA I and ASAII patients between the age of 25-60 years, weighing 50-80kg, undergoing elective surgery under general anaesthesia with accessible epigastric region were included and randomized by convenience on the basis of their ASA status .

Patients of ASA≥III, with dyspnoea, uncontrolled HTN, decompensated heart failure, significant valvular disease, significant carotid stenosis, ejection fraction < 40%, increased intra-abdominal pressure, anticipated difficult airway, mental incompetence, pheochromocytoma, non visualized IVC, those patients that were already hypotensive or severely hypertensive (65 mmhg ≤MAP≥ 100 mmhg)and those at high risk with clinical conditions that would prevent the adequate evaluation of both the IVC and blood pressure changes were excluded from the study.

In routine pre-anaesthetic checkup the study procedure for USG was explained to the patient and written informed consent was taken. The patients were kept fasting a minimum of 6 hours fasting and received tablet alprazolam 0.5mg at bedtime and 0.25mg two hours prior to the surgery in the morning.

Ultrasonograpy was done in the pre-operative unit in dorsal recumbent position on spontaneously breathing patients using Sonosite Micromax machine with low frequency (2-5 MHz) curvilinear probe .The probe was placed transversely and the IVC was visualized in B mode from a paramedian subxiphoid view. After a good visualization of the IVC going into the right atrium, the probe was then placed longitudinally 1-2 cm from the midline. The last section of the vein which was proximal to the hepatic vein inflow and 2-3cm from the right atrium was selected for M Mode and measurements were then performed Both end-inspiratory (iIVCD) and end-expiratory (eIVCD) inferior vena cava diameters were measured and IVC collapsiblity index (IVCCI) was calculated . Three consecutive readings were taken and the mean of these three readings was taken for analysis in the study.

$$\text{IVCCI} = \frac{\text{eIVCD} - \text{iIVCD}}{\text{eIVCD}} \times 100$$

eIVCD =inferior vena cava at end expiration (in cm) ,iIVCD =inferior vena cava at end inspiration (in cm)

In the Operating theatre, all patients were monitored continuously with noninvasive blood pressure monitoring , ECG, pulse oximetry and capnography. After pre-oxygenation with 100% oxygen , Injection fentanyl (2µgm/kg) ,anaesthesia was induced using propofol (2mg/kg lean body weight) and Atracurium (0.5mg/kg body weight)by an anesthesiologist of minimum 5 years experience . Patients requiring more than 2intubation attempts were excluded from further data analysis . Haemodynamic monitoring (SBP, DBP, MAP, and HR)was recorded every minute for 4 minutes post induction but before tracheal intubation and then every 2 minutes for another 8 minutes post intubation. Hypotension described as 30% decrease in MAP or bradycardia ≤ 50 beats per minute was treated with either injection mephenteramine (6mg) , fluid or atropine 0.6mg and this was not controlled.

The data entry was done in Microsoft Excel spreadsheet and the analysis was done with the Statistical package for social sciences [SPSS] software, IBM manufactures, Chicago, USA, ver. 21.0 . The presentation of categorical variables was done in the form of number and percentage . On the other hand, the quantitative data were presented as mean ± SD . Results were analyzed using an independent t test .Chi square and ANOVA test and skewness as applicable. Stratified and multivariate logistic regression tests were applied to the significantly associated factors to remove any bias. A value of P< 0.050 was considered significant.

RESULTS

The demographic profile of the patients was comparable .(p>0.05) .The mean age (years) of the patients in group I and in group II was 46.84±9.68 and 49.84±8.63 respectively(P=0.301). There were 18 and 30 males in group I and group II respectively (P=0.885), and 61 and 48 females in group I and group II respectively (P=0.437). The mean weight (kg) of patients in group I was 58.75±6.19 and was 60.10±7.36 in group II (P- 0.282). Patients with gall stone disease(84%), spine fractures, epigastric hernia and breast tumours were included in the study. (P=0.081).

The mean IVCCI in group I was 40.29 and was 54.36 in group II(P<0.0001) The overall incidence of postinduction hypotension was 46% ,12 patients (12.7%) in group I and 60 patients (79.49%) in group II (P<0.0001). Out of 62 patients who had IVCCI of >50 in group II, 60 patients developed hypotension. 10 patients in group I had IVCCI >50 but 12 patients developed PIH. Thus IVCCI ≥50 under estimated (false negative) hypotension in 2 patients of group I and overestimated (false positive) it in 2 patients of group II.(Table 1).

The receiver operating characteristic (ROC) curve analysis showed optimal cut off value of IVCCI of 47% for predicting PIH. (Fig 1).

There were statistically significant variations in heart rate in both the groups at various intervals (P<0.0001) (Table 2).

Table 1: Comparison of IVCCI & Hypotension between Group I and II

IVC-CI	Group I n(%)	Group II n(%)	Total n(%)	Chi-square	t-value	P value
≤ 50	69(87.34%)	16(20.5%)	85(54.14%)	70.599	12.5	<0.0001
> 50	10(12.7%)	62(79.5%)	72(45.86%)			
Skewness	8.03	-1.121				
Mean ±SD	40.29±8.03	54.36±5.95				
Min -max value	30.77-69.06	37.80-64.10				
Hypotension not seen	67	18	85	60.243	-	<0.0001
Hypotension seen	12	60	72			
Total	79	78	157			

Figure 1: Receiver operating curve analysis at 47% cutoff value for IVC-CI
{ROC=0.972(95%CI,0.948-0.996,p<0.0001)
Sensitivity-95%(87-98%);Specificity-97%(9PPV-100%;NPV-90-97.1%.}

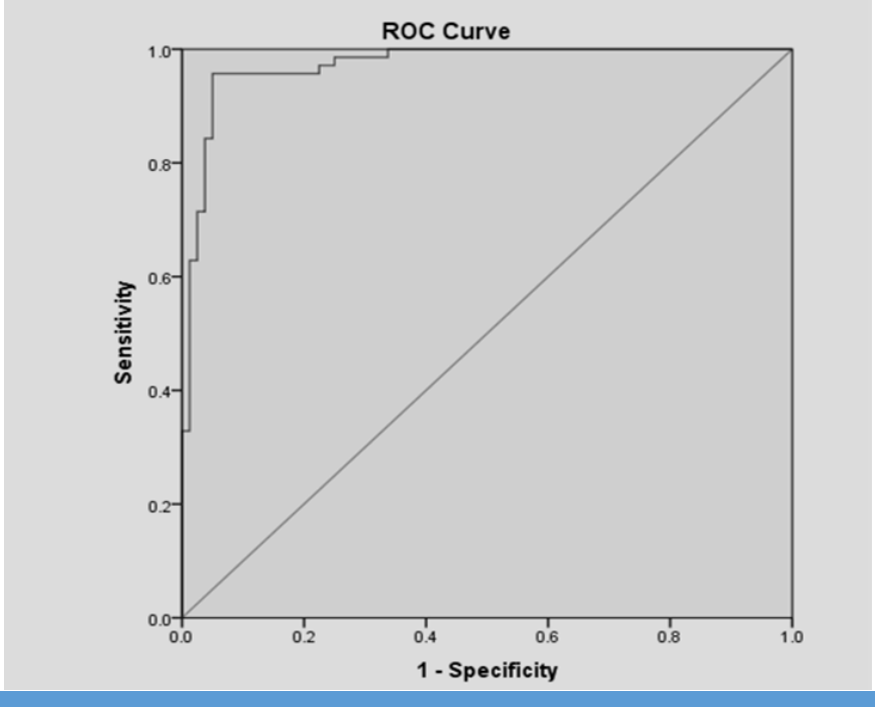

Table 2: Haemodynamic variables (HR and MAP) in both the groups with percentage change from baseline value

Time	Group I HR Mean±SD (% change)	Group II HR Mean±SD (% change)	P-value	Group I MAP Mean±SD (% change)	Group II MAP Mean±SD (%change)	P-value
Baseline	79.65±10.85	81.30±11.86	0.449	93.78±8.58	94.41±15.78	0.760
1 min post induction	77.11±9.34 (3.4556)	87.39±9.87 (7.4907)	<0.0001	93.51±8.58 (0.0213)	94.55±15.18 (0.1482)	0.625
2 min Post induction	78.03±9.37 (2.3037)	88.34±10.03 (8.6592)	<0.0001	92.40±9.14 (1.1659)	94.51±15.30 (0.1059)	0.314
3 min Post induction	78.89±9.38 (1.2269)	89.29±9.95 (9.8277)	<0.0001	86.45±11.29 (7.9473)	79.32±12.17 (15.9834)	<0.002
T^4	80.05±9.88- (0.2253)	90.47±9.89 (11.2792)	<0.0001	82.79±11.52 (11.4664)	94.41±15.78- (26.9145)	<0.0001
Intubation	82.51±11.03- (3.3053)	92.11±10.63 (13.2964)	<0.0001	83.67±11.06 (10.5037)	94.55±15.18 (26.9462)	<0.0001
2 min Post intubation	84.97±11.12 (6.3853)	96.58±11.93 (18.7945)	<0.0001	89.91±10.24 (3.8292)	94.51±15.30 (21.0888)	<0.0001
4 min Post intubation	82.26±9.74 (5.4964)	96.92±10.91 (19.2127)	<0.0001	93.08±8.53 (0.4492)	79.32±12.17 (15.9834)	<0.0001
6 min Post intubation	82.27±9.37 (3.0048)	95.73±10.08 (17.7490)	<0.0001	93.01±6.69 (0.5134)	69.00±13.75 (10.7721)	<0.0001
8 min Post intubation	80.18±8.83 (0.3881)	94.62±9.31 (16.3837)	<0.0001	92.29±6.21 (0.6096)	68.97±13.22 (5.2113)	<0.009

The baseline SBP was higher in group II over group I as group II included hypertensive patients (P< 0.009).The diastolic blood pressure (DBP) decrease from baseline was more in group II after induction and it never touched the baseline in both the groups till 8 minutes post intubation (P<0.006) We observed an

average 26% mean fall in MAP in ASA II patients and it didn't return to baseline till

Table 3: Comparison of SBP and DBP between Groups I and II and the percentage change from baseline

Time	Group I SBP Mean±SD (% change)	GroupII SBP Mean±SD (% change)	P value	Group I DBP Mean±SD (% change)	Group II DBP Mean±SD (% change)	P-value
Baseline	118.77±11.10	124.45±14.49	<0.009	80.87±8.23	77.73±9.76	0.022
1 minute post Induction	118.66±11.22 (0.0842)	124.32±14.48 (0.1044)	<0.004	80.29±8.14 (0.7172)	78.00±9.04 (0.3473)	0.057
2 minutes post induction	117.50±11.85 (1.0109)	124.24±14.77 (0.1687)	<0.001	79.01±8.67 (1.5085)	78.94±10.26 (1.5566)	0.057
3 minutes post induction	118.72±75.01 (7.2283)	106.63±16.47 (14.5359)	<0.150	73.26±10.53 (8.6558)	67.00±12.24 (13.8041)	<0.0001
4 minutes post induction	106.33±14.67 (9.8736)	93.28±17.66 (-25.0462)	<0.0001	70.85±10.63 (12.7859)	56.24±13.31 (-27.6469)	<0.0001

0 minute post intubation	108.06±14.25 (8.3572)	93.45±16.61 (-24.9096)	<0.0001	71.36±10.24 (12.1305)	56.21±12.28 (27.6855)	<0.0001
2 minutes post intubation	116.02±16.42 (1.5669)	100.94±15.23 (18.8911)	<0.0001	75.20±9.42 (6.1703)	61.38±12.48 (21.0343)	<0.0001
4 minutes post intubation	122.53±11.33 (2.9907)	108.14±15.78 (13.1056)	<0.0001	78.20±7.40 (2.6462)	66.76±11.37 (-14.1129)	<0.0001
6 minutes post intubation	122.98±9.73 (2.8812)	114.86±14.71 (7.7059)	<0.0001	78.48±6.43 (3.3634)	69.28±11.02 (10.8709)	<0.0001
8 minutes post intubation	122.26±8.79 (2.8812)	119.20±11.76 (4.2185)	0.162	78.69±6.16 (2.9553)	74.70±8.99 (3.8981)	<0.006

12 minutes post induction while there was only 3-7% fall in MAP in ASA I patients. ($p<0.02$). (Table 3).The mean Hb (gm/dl) in group I was 12.64±1.05 and 12.43±1.66 in group 11 (P=0.322). The mean dose of propofol used was 104.56±14.12 mg in group I and 105.76±11.67 mg in Group II (P= 0.524).In the multi variate logistic

regression model, ASA grading (β=2.924, odds ratio of 18.611 with 95% C.I. 8.285-41.805; P=0.0001), IVCCI(β=0.410, odds ratio 1.506; 95% C.I. 1.344 – 1.777; P<0.001) and baseline DBP (β=-0.056,OR=0.946;95%CI;p<0.004) showed significant correlation with

DISCUSSION

PIH prevalence is unidentified before the onset of surgical stimulation and only documented if it persists requiring intervention. The incidence of post induction hypotension in our study was 45.8% (15.18% in ASA I and 76.9% in ASA II patients). Researchers have reported varying incidence of PIH ranging from 30%- 58% in patients undergoing general anaesthesia. The difference in the incidence is due to different cutoff values for defining PIH (55mmhg to 65mmhg MAP), use of different induction agents (propofol, etomidate) and different opioid doses (2-5µgm/kg)used .

Table 4: Logistic Regression Analysis to Find Risk Factors of PIH

Variable	β	SE	p-value	e^{β}	95% CI for e^{β}		R^2
					Lower	Upper	
ASA							
ASA Grade	2.924	0.413	<0.0001	18.611	8.285	41.805	33.9%
Inferior Vena Cava Collapsibility Index							
IVCCI	0.410	0.064	<0.001	1.506	1.328	1.709	62.3%
Propofol							
Propofol	0.009	0.012	0.468	1.009	0.985	1.034	0.30%
Pulse							
Baseline Pulse	0.017	0.014	0.228	1.018	0.989	1.047	0.90%
SBP							
Baseline SB	0.007	0.012	0.577	1.007	0.983	1.032	0.20%
DBP							
Baseline DBP	-0.056	0.019	<0.004	0.946	0.911	0.982	5.6%
MAP							
Baseline MAP	-0.009	0.014	0.497	0.991	0.964	1.018	0.3%

Kendale S et al reported incidence of PIH (<55 mmhg MAP) to be 8.9%,and Sudfield et al took data of 2037 patients, 368 (18.1%) patients developed PIH, 503 (24.7%) patients developed early intraoperative hypotension and 181 (8.9%) patients developed both.[1,9] Luoro et al reported an incidence of 20.14% ,while Jor et al , Purushothaman et al, Szabo et al and Mohammed S et al reported an overall incidence of 19-36.5%.[10,11,12,13,14] Like our study, Zhang et al reported an overall 47% incidence in 90 patients (40.7% in ASA 1and 50% in ASA II) but they recruited patients of higher age (56± 18yrs) and used a relatively more haemodynamically stable drug etomidate as compared to propofol in our study.[15] Arthur K Au et al reported a high incidence of 55% PIH in 40 patients undergoing elective routine surgery.[3]

Kendale et al, Reich et al , Sudfield et al, Jor et al , Szabo et al and Zhang et al reported age >50 to be a factor affecting PIH.[1,2,9,11,13,15] Similar to our study, Sudfield et al reported lower incidence of 7% PIH in ASA I patients as compared to 16.6% in ASA II patients.[9] Mohammed et al reported incidence of PIH of 21% in ASA I and 11% in ASA II patients but patients were of mean age of ≤ 30.24 years.[14] Kendale S et al and Reich et al reported ASAIII, MAP<70 mmhg, propofol induction to be a risk factor for developing this hypotension and advocated etomidate induction in such patients.[1,2] Jor et al observed that along with age >65, baseline hypertension and diabetes could be the causative factors of PIH and advocated preoperative bolus fluids which was 96.4% effective.[11]

Thus preoperative identification of these patients is important to modify the anaesthesia plan accordingly. Stawicki et al in 2009 used the hand held USG experience of intensivists to assess the IVC dimensions and deduced that IVCCI correlated best with CVP in the setting of low (<0.20) and high (>0.60) collapsibility ranges.[16] The American Society of Echocardiography (ASE) approved the assessment of the size of the IVC and its collapsibility in the determination of volume status in critical non ventilated patients.[17] Researchers have debated the role of IVCCI in scenarios like general anaesthesia, spinal anaesthesia and in septic shock patients. They have given different cut off values for determining volume status of patients and the general agreement ranges between 43-50% among those undergoing general anesthesia, 12.9–25.64% under spinal anaesthesia and upto 40% in ICU patients. ASE guidelines and Porter et al in 2015 correlated IVC diameter ≤ 2.1 cm with or without 50% collapse with sniff to right atrial pressure (RA) (0-10mmhg), IVC diameter > 2.1 cm with IVCCI< 50% with a sniff to RA pressure (10-20 mm Hg) except in athletes who can have IVC >2.1cm. [17,18, 19]

Kalshetty et al assessed the IVCCI relation with 500 ml fluid bolusesin spontaneously breathing ASA I and II patients, which was 32.2% at baseline that decreased to 26.3% after these bolus.[20]

The mean IVCCI was 40.29±8.03 and 54.36±5.95 in group I and II respectively in our study. Our results were in accordance with Zhang et al and Purushothaman et al as they both took an IVCCI cut-off value of 43% while Szabo and Arthur et al took a cutoff value of 50% .[15,12,13,3] Mohammed and Luoro et al did not find any corelation of this index with hypotension. AUC as reported by Mohammed et al was 0.46 at 43% IVCCI cutoff and there was no correlation between IVCCI and PIH in their study. The average IVCCI for the patients who exhibited hypotension was 33% ±18% (25.7–40.4%) compared to 30.8% ±15% (23.8–37.7%) for those who did not have intraoperative hypotension in the study by Luoro et al .[14,10]

In the study, we excluded 3 patients in Group I and 2 in Group II due to non-visualization of the IVC. Our failure rate turned out to be 3.03%. Szabo et al, Mohammed S et al and Zhang et al and had to exclude 7 (7%) , 14 (13.5%) and 22 patients (20%) respectively from their studies which was slightly higher as compared to our study.[13,14,15]

The limitation of our study was that the IVCCI measurements were not repeated peri-operatively because of sharing of space with surgeon We did not record invasive BP measurements and ASA III and IV patients were not included in the study. We observed higher incidence of hypotension in otherwise healthy looking ASA11 patients with co morbidities, hence it can be presumed that the incidence will be higher in ASA111and 1V patients .However further studies involving higher physical status patients are recommended. for definitive results . These results can be extrapolated for all patients undergoing various other surgery under general anaesthesia also. .

CONCLUSION

For safe anaesthesia practice, ultrasound guided IVCCI measurements in patients with comorbidities is recommended. due to high incidence of PIH(79%) observed in ASA11 patients of the study..The role of

point of care ultrasound is imperative in improving patient outcome due to its easy availability, reproducibility ,good sensitivity, specificity.and non invasive character. .

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