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Comparing The Common Femoral Vein Diameter and The Inferior Vena Cava Diameter as A Predictor of Post-Induction Hypotension in Non-Cardiac Patients Undergoing General Anesthesia

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ABSTRACT

Background: Maintaining the stability of hemodynamics is crucial for the reduction of the rate of postoperative complications. Hypotension during surgery has profound effect on the heart, which may lead to myocardial injury, and hypoperfusion of the kidneys. Therefore, predicting post-induction hypotension (PIH) is crucial to surgical patients.

Objective: This study aimed to validate common femoral vein (CFV) diameter as a predictor for post-induction hypotension as compared to inferior vena cava (IVC) diameter.

Patients and Methods: 90 non-cardiac patients undergoing surgery under general anesthesia were recruited for the study. The diameters of (IVC) and CFV were measured by ultrasonography prior to the surgery and post induction. Blood pressure was monitored at predetermined points of time: before anesthesia, at zero time, and at 2 min intervals after that.

Results: In the current study, our results were consistent with the previously reported literature. The CFV diameter showed significant increase post induction compared to pre-induction. Such increase was concomitant with significant PIH in susceptible patients. Moreover, the changes observed in CFV diameter were synchronous with increase in IVC diameter in patients suffering from PIH. No significant changes were observed between age groups in either the IVC or CFV diameter. According to our observations, hypertensive patients suffered more PIH but the results were only significant regarding diastolic blood pressure.

Conclusion: Our results showed comparable predictability of CFV diameter to IVC diameter ultrasonographic measurements in anticipating post-induction hypotension (PIH) in generally anesthetized patients. Therefore, the CFV offers a reliable alternative in cases where the IVC cannot be visualized or had limited accuracy. Variations in CFV and IVC diameters were insignificant in different age categories, which indicate the reliability of both vessels regardless of age group.

Keywords: Post induction hypotension**,** Intraoperative hypotension, Ultrasonography, Inferior Vena Cava, Common femoral vein.

INTRODUCTION

During anesthesia, maintaining normal perfusion of the tissues is of utmost importance. Unfortunately, adequate tissue perfusion cannot be easily measured. Usually, arterial blood pressure and heart rate are the principal parameters for assessing hemodynamics to ensure adequate tissue perfusion. Drugs used for induction of general anesthesia can cause an initial reduction in arterial blood pressure (post-induction hypotension, PIH), which can be usually mitigated by sympathomimetics **(1)**.

PIH is mainly caused by the cardioinhibitory effects and vasodilation caused by drugs used during induction of general anesthesia. Moreover, some patients are already hypovolemic due to fasting and dehydration or due to inadequate compensatory mechanisms, which increase the risk of PIH during the maintenance of anesthesia which might cause persistent hypotension, thus affecting hemodynamic stability and tissue perfusion. Low blood pressure during anesthesia is one of the most feared factors that may cause anesthesia related deaths. Following the induction of general anesthesia. **Bijker *et al.*** **(2)** found that hypotension during and anesthesia can occur with up to 99% of patients.

Predictors of PIH include starting mean arterial blood pressure of less than 65mmHg, age groups of fifty years old or more and use of cardioinhibitory or vasodilatory drugs such as propofol, and high doses of fentanyl. Also, Variability in heart rate (HR) and bradycardia could predict post induction hypotension. However, a thorough analysis of how preoperative volume status affects the emergence of hypotension following induction has not been conducted **(3)**.

Assessing intravascular volume status can be massively helpful in foreseeing PIH, helping anesthesiologists to better manage patient hemodynamics. Inferior vena cava (IVC) ultrasound measures have been suggested as swift and noninvasive means for evaluating volume status **(4)**. In addition, measurement of the common femoral vein (CFV) diameter has been proposed in one study as another predictor of patients' volume status. CFV, a sub-branch of the IVC, is positioned at the compressed point of the aorta at the distal end. In a study involving

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women undergoing Cesarean section with spinal anesthesia, CFV diameter was found to be a good predictor of hypotension in these women **(5)**. Up to our knowledge, the predictability of PIH using CFV diameter in generally anesthetized patients hasn't been investigated. In addition, no comparisons have been performed between the two approaches to better asses the volume status, hence the probability of PIH in patients. In this proposal, we aimed to investigate the reliability of both parameters common femoral vein CFV diameter as compared to IVC diameter as a predictor for post-induction hypotension using bedside ultrasonography.

PATIENTS AND METHODS

Prospective observational study that was conducted at Souad Kafafi University Hospital-Misr University of Science and Technology (MUST). Non-cardiac patients aged from 18 to 60 years old were scheduled for general anaesthesia for surgery at operating rooms (Soad Kafafi Hospital) from the following departments: General surgery, Orthopaedics, Gynaecology and Neurosurgery departments. Patients had both the IVC diameter and the CVF diameter measured before and after the induction of GA.

Inclusion criteria: Patients aged from 18 to 60 years old, patients scheduled for GA, American Society of Anaesthesia (ASA) classification I, II. (i.e., ASA classification I: A normal healthy patient, for example: no chronic disease, non-smoker, no or minimal alcohol consumption, ASA classification II: patients with mild systemic disease, for example: well controlled diabetes/hypertension, smokers, obesity (30 < BMI < 40), ability to sign the consent.

Exclusion criteria: Patient refusal, history of cardiac disease such as ischemic heart disease, heart failure or cardiomyopathy, veno-occlusive diseases such as Budd chiari syndrome, sinusoidal obstruction or portal hypertension, history of DVT or IVC filter. American Society of Anaesthesia (ASA) classification III, IV (i.e. ASA classification III: patient with a serious systemic condition, for example: poorly managed chronic obstructive pulmonary disorders (COPD), diabetes, and hypertension, hepatitis, morbid obesity, ASA classification IV: patients with life threatening medical condition, for example: recent myocardial infarction, sepsis, severe cardiac valve dysfunction, difficulty in visualizing the common femoral vein (CFV) or inferior vena cava (IVC) as in morbid obesity (i.e. BMI > 40) or previous operation or scar at the selected vein location.

Study Procedures:

Patients was randomly chosen by the anaesthesia team and the surgical team. Three anaesthesiologists performed the study. The first was responsible for induction of GA and maintaining the hemodynamic of the patients. The second took the ultrasound measurements. The third one was responsible for data interpretation. All measurements were blinded between the three anaesthesiologists to prevent observational bias.

Study Protocol: All Patients had a pre-operative assessment visit, which involved gathering medical history, thorough physical examination, and standard laboratory tests. Pre-operatively, patients received the following premedication via intravenous (IV) route: Midazolam 0.03 mg/kg, Metoclopramide 0.1 mg/kg. Pulse oximeter, non-invasive blood pressure monitoring, and a six-lead electrocardiogram were used as normal monitoring procedures when the patient entered the operating room (ECG). The IVC diameter was next measured using a low frequency US probe with a sub-xiphoid short axis, followed by the measurement of the CFV, which was zeroed in relation to the simultaneous blood pressure reading. The General anaesthesia was induced using: Propofol 1-2mg/kg, Fentanyl 1-2 μg/kg and Atracurium 0.5 mg/kg. It was maintained using Sevoflurane 1mean alveolar concentration (1MAC), Incremental doses of Atracurium. Patients underwent intubation with a single-lumen endotracheal tube of appropriate size.

In order to prevent hemodynamic shifts that might interfere with the intended measurements, both vessels' diameters were measured before the skin incision and again right away after induction (the second reading) while maintaining oxygenation (endotracheal intubation (ETT) or laryngeal mask airway (LMA) device insertion).

Sample size:

Sample size was calculated using Power Analysis and Sample Size Software (PASS 2020) "NCSS, LLC. Kaysville, Utah, USA, ncss.com/software/pass". As reported in previous study by **Zhang and Critchley (3),** the IVC collapsibility index (CI) measured from preoperative ultrasound was a trustworthy indicator of hypotension following the onset of general anesthesia. The threshold at which an area under the ROC curve (AUC) of 0.7 for CI was observed was CI greater than 43%. Thus, a minimal total hypothesized sample size of 90 eligible adult patients was needed to validate CFV diameter as a predictor for PIH as compared to IVC diameter taking into consideration 5% level of significance, an effect size of 0.2 and 80% power using two-sided proportional Z- test.

IVC and CFV Ultrasonography:

In the supine position, IVC and CFV measures were made twice: once before general anaesthesia was administered and once after induction. A single anaesthesiologist took all the IVC and CFV measures to reduce human error. The IVC was performed using the American Society of Echocardiography's advised technique, a paramedian long-axis view through subcostal approach. To distinguish the IVC, we used the Doppler waveform and phasic collapse with respiration. Without exerting any pressure that would have affected the CFV's diameter, the CFV was seen with B-mode US during end expiration, 2–4 cm below the level of the inguinal ligament, above the inguinal canal, where the femoral artery could be sensed most easily.

Anaesthesia Management:

Before surgery, all patients observed an eight-hour fast. Once in the operating room, routine monitoring (including an electrocardiogram, blood pressure readings, pulse oximeter readings, and end-tidal carbon dioxide (EtCO2) measures) was carried out. Before undergoing general anaesthesia, none of the patients received a fluid load. Before anaesthesia, at the beginning of giving the anaesthesia, and three times after induction with a 2-minute gap between measures, heart rate (HR) and mean blood pressure (MBP) were monitored. The average values were then recorded.

Within 15 minutes of the anaesthetic being induced, hypotension episodes were managed with 5 mL/kg of crystalloids. Ephedrine 5 mg, phenylephrine 100 mg, and atropine 0.5 mg were supplied every 2 min depending on the patient's state after 2 min of persistent hypotension or MBP 55 mmHg. All anaesthetics were stopped when the surgery was finished, and the neuromuscular block was then treated with 0.02 mg/kg of neostigmine and 0.01 mg/kg of atropine. The endotracheal tube was removed once the patient was fully conscious, and all patients were then taken to the post-anaesthesia care unit (PACU).

Ethical approval: Study procedures were approved by Misr University of Science and Technology University Ethical Research Committee (ERC) (No. 2022/0008). Every patient signed an informed written consent for acceptance of participation in the study. This work has been carried out in accordance with The Code of Ethics of the World Medical Association (Declaration of Helsinki) for studies involving humans.

Statistical Analysis

Statistical analysis was performed with SPSS statistics software version 28 (SPSS, Inc., Chicago, IL). Kolmogorov-Smirnov test was used to test the normality of quantitative data. All quantitative variables were not-normally distributed, thus they were described in terms of median, minimum, maximum and interquartile range. Non-parametric statistical tests of significance were applied. Mann-Whitney test was used to compare two independent groups, and Kruskall Wallis test was used to compare three independent groups. Qualitative data were expressed by numbers and percent. Spearman Rank Correlation test was used to determine the association between the blood vessels diameters and blood pressure levels. In all other applied statistical tests of significance, P value ≤ 0.05 was considered significant.

RESULTS

Out of 90 participants, 51.1% were males, 48.9% were females (Table 1). The Median age for study participants was 36 years with minimum age of 18 and a maximum age of 72 years. Most of the study participants (62.2%) fell between 20-45 years of age. Whereas 28.9% of them were above 45 years.

Table (1): Sociodemographic data of the study participants

		N= 90 (%)
Sex	Male	46 (51.1%)
	Female	44 (48.9%)
Age (Years)	Median	36
	Min. – Max.	18 -72
	IQR	27 - 47
Age Categories	< 20 Yrs.	8 (8.9 %)
	20 - 45 Yrs.	56 (62.2%)
	> 45 Yrs.	26 (28.9%)
DM Type 2	No	80 (88.9%)
	Yes	10 (11.1%)
Hypertension	No	78 (86.7%)
	Yes	12 (13.3%)

Both vessels were significantly dilated (P<0.001) after induction of anaesthesia in comparison to pre-induction status (table 2). The median IVC diameter before induction was 1.03 cm while it was 1.4 cm post induction. Concerning CFV, the median diameter was 0.76 pre-induction compared to 1.015 cm post induction. P values were calculated using Mann-Whitney test.

Table (2): Comparison of IVC diameter and CFV diameter before and after induction of anesthesia

	Before	After	Statistical Test	*p*
IVC (cm)				
Median	1.03	1.40		
Min. – Max.	0.62 – 2.09	1.09 – 1.75	Z= - 8.242	< 0.001**
IQR	0.87 – 1.30	0.82 – 2.50		
CFV (cm)				
Median	0.76	1.015		
Min. – Max.	0.33 – 1.78	0.48 – 7.20	Z= - 8.240	< 0.001**
IQR	0.60 – 0.90	0.84 – 1.23		

Serial measurements of blood pressure continued to show significant decrease by induction of anesthesia (Table 3) reaching the lowest point 2 mins after induction (P<0.001). P values were calculated using Friedmann test followed by post-hoc pairwise comparison.

Table (3): Serial comparison of blood pressure before, during and after induction of anesthesia

	Pre-induction (1)	Zero time (2)	After 2 minutes (3)	After 4 minutes (4)	After 6 minutes (5)	Statistical Test	*p*
SBP (mmHg) Median Min. – Max. IQR	130 100 – 170 120 – 140	107.5 90 – 140 100 – 120	105 90 – 130 100 – 110	110 90 – 130 100 – 110	110 95 – 130 100 – 110	X^2= 160.02	< 0.001**
Pairwise Comparison	*p* (1) – (2)	< 0.001**	*p* (2) – (3)	0.058	*p* (3) – (4)	0.004**	
	p (1) – (3)	< 0.001**	*p* (2) – (4)	0.305	*p* (3) – (5)	0.021*	
	p (1) – (4)	< 0.001**	*p* (2) – (5)	0.677	*p* (4) – (5)	0.504	
	p (1) – (5)	< 0.001**					
DBP (mmHg) Median Min. – Max. IQR	80 60 - 100 78.75 - 90	65 60 - 90 60 - 75	70 65 - 70 65 - 70	70 65 -71.25 55 - 85	70 65 -71.25 60 - 85	X^2= 133.90	< 0.001**
Pairwise Comparison	*p* (1) – (2)	< 0.001**	*p* (2) – (3)	0.510	*p* (3) – (4)	0.227	
	p (1) – (3)	< 0.001**	*p* (2) – (4)	0.425	*p* (3) – (5)	0.229	
	p (1) – (4)	< 0.001**	*p* (2) – (5)	0.623	*p* (4) – (5)	1.00	
	p (1) – (5)	< 0.001**					

Three age groups were included in the study. Among these groups, percentage increase in IVC diameter wasn't significant between the age groups. However, CFV diameter showed significant (P<0.045) variations between age groups. The CFV reached its highest dilation in the age group below 20 years old and its lowest dilation in the age group between 20-45 years old (Table 4).

Table (4): Comparing the percent increase in IVC diameter and CFV diameter in cm pre- and after-induction of anesthesia among the different age groups.

	Age Categories			Statistical Test	*p*
	< 20 Yrs. N=8	20 - 45 Yrs. N=56	> 45 Yrs. N=26		
IVC (% Increase) Median Min. – Max. IQR	31.15% 11% – 56% 26% – 50%	29% 3% – 90% 23% – 37%	34% 12% - 78% 25% - 45%	X^2= 2.772	0.250
CFV (% Increase) Median Min. – Max. IQR	47%^{a} 16% - 90% 28% - 62%	33%$^{a, b}$ 9% – 96% 24% – 4*%	41%^{b} 13% – 90% 28% -53%	X^2= 3.741	0.045*

The age group above 45 years old showed significant (P<0.001) increase in pre-induction blood pressure both systolic and diastolic. This refers to the fact that most hypertensive patients lie in this age group. Moreover, the same group showed significance (P= 0.01) (Table 5).

Table (5): Comparing the blood pressure values pre-induction and after 2 minutes among the different age categories.

	Age Categories			Statistical Test	*p*
	< 20 Yrs. N=8	20 - 45 Yrs. N=56	> 45 Yrs. N=26		
Preinduction SBP				X^2= 32.073	<0.001**
Median	115^{b}	120^{a}	$140^{a,b}$		
Min. – Max.	100 – 130	100 – 140	100 - 170		
IQR	110 – 122.5	120 – 130	140 - 150		
Zero-time SBP				X^2= 9.163	0.010*
Median	110	110^{a}	100^{a}		
Min. – Max.	90 - 120	90 – 135	90 – 140		
IQR	95 - 115	100 – 120	90 - 110		
2-minutes after SBP				X^2= 2.063	0.356
Median	102.5	110	105		
Min. – Max.	95 – 115	90 – 130	90 – 120		
IQR	90 – 112.5	100 - 110	100 - 110		
Preinduction DBP				X^2= 31.135	<0.001**
Median	70^{b}	80^{a}	$90^{a,b}$		
Min. – Max.	60 - 85	60 - 95	60 - 100		
IQR	70 – 80	77.5 – 80	90 - 100		
Zero-time DBP				X^2= 8.554	0.014*
Median	70	70^{a}	60^{a}		
Min. – Max.	60 - 75	60 - 85	60 - 90		
IQR	60 – 72.5	65 - 75	60 - 70		
2-minutes after DBP				X^2= 0.398	0.820
Median	65	70	67.5		
Min. – Max.	60 - 80	60 - 80	60 - 80		
IQR	62.5 – 72.5	65 - 70	65 - 70		

Our study contained a total of 12 (13.3% of population) hypertensive patient (Table 6). Both the PIH and the percentage increase in IVC and CFV were not significant. However, hypertensive patients showed significant (p<0.001) decrease in diastolic blood pressure 2 mins after induction compared to non-hypertensive patients (Table 7).

Table (6): Comparing the percent increase in IVC diameter and CFV diameter in cm pre- and after-induction of anesthesia among hypertensive vs. normal patients.

	Hypertension		Statistical Test	*p*
	No N=78	Yes N=12		
IVC (% Increase)			U= 378.00	0.285
Median	30.05%	35.71%		
Min. – Max.	2.86% – 90.48%	21.05% – 77.78%		
IQR	23.76% – 39.06%	26.39% – 41.99%		
CFV (% Increase)			U= 346.00	0.148
Median	34.14%	46.20%		
Min. – Max.	9.28% - 98%	12.92% – 83.3%		
IQR	25.64% - 48.33%	28.87% – 64.29%		

Table (7): Comparing the blood pressure values pre-induction of anesthesia and after 2 minutes among hypertensive vs. normal patients.

	Hypertension		Statistical Test	*p*
	No N=78	Yes N=12		
Preinduction SBP				
Median	125	150		
Min. – Max.	100 – 165	140 – 170	U= 28.50	< 0.001**
IQR	120 – 135	147.50 – 155		
Zero-time SBP				
Median	110	100		
Min. – Max.	90 – 140	90 – 140	U= 314.00	0.064
IQR	100 – 120	90 – 107.5		
2-minutes after SBP				
Median	105	107.5		
Min. – Max.	90 – 130	100 – 120	U= 417.5	0.540
IQR	100 – 110	105 – 110		
Pre-induction DBP				
Median	80	100		
Min. – Max.	60 – 95	90 – 100	U= 279.50	0.022*
IQR	75 – 85	92.5 – 100		
Zero-time DBP				
Median	70	60		
Min. – Max.	60 – 85	60 – 90	U= 352.0	0.154
IQR	65 – 75	60 – 65		
2-minutes after DBP				
Median	70	70		
Min. – Max.	60 – 80	65 – 80	U= 29.50	< 0.001**
IQR	65 – 70	65 – 72.5		

Our study contained a total of 10 (11.1% of population) diabetic patient (Table 8). The percentage increases in IVC and CFV were not significant. Diabetic patients showed significant (p<0.001) increase in pre-induction blood pressure although they were reported non-hypertensive in history collection. Otherwise, they showed non-significant differences in post-induction blood pressures when compared to normal population (Table 9).

Table (8): Comparing the percent increase in IVC diameter and CFV diameter in cm pre- and after-induction of anesthesia among diabetic vs. normal patients.

	Diabetes Mellitus Type 2		Statistical Test	*p*
	No N=80	Yes N=10		
IVC (% Increase)				
Median	29.93%	38.28%		
Min. – Max.	2.86% – 90.48%	24.06% – 67.50%	U= 265.00	0.083
IQR	23.57% – 38.68%	28.86% – 48.08%		
CFV (% Increase)				
Median	34.14%	43.02%		
Min. – Max.	9.28% - 98%	23.71% – 83.02%	U= 295.00	0.178
IQR	25.00% - 48.86%	34.02% – 52.22%		

Table (9): Comparing the blood pressure values pre-induction of anesthesia and after 2 minutes among diabetic vs. normal patients.

	Diabetes Mellites Type 2		Statistical Test	*p*
	No N=80	Yes N=10		
Preinduction SBP				
Median	127.5	140	U= 132.50	< 0.001**
Min. – Max.	100 – 170	130 – 160		
IQR	120 – 137.5	140 – 150		
Zero-time SBP				
Median	110	100	U= 302.00	0.203
Min. – Max.	90 – 140	90 – 120		
IQR	100 – 120	95 – 120		
2-minutes after SBP				
Median	105	107.5	U= 349.5	0.508
Min. – Max.	90 – 130	90 – 110		
IQR	100 – 110	100 – 110		
Preinduction DBP				
Median	80	90	U= 115.00	< 0.001**
Min. – Max.	60 – 100	85 – 100		
IQR	75 – 87.5	90 – 100		
Zero-time DBP				
Median	70	62.5	U= 335.5	0.395
Min. – Max.	60 – 90	60 – 80		
IQR	60 – 75	60 – 80		
2-minutes after DBP				
Median	70	70	U= 367.00	0.661
Min. – Max.	60 – 80	60 – 75		
IQR	65 – 70	65 – 70		

DISCUSSION

It is crucial to keep hemodynamic stability in order to lower the frequency of postoperative problems. Although there is no clear definition of intraoperative hypotension, it seriously affects myocardial injury, acute renal injury, and septic consequences **(6)**. The majority of the prediction models that are currently employed to estimate the risk of hypotension relies on non-modifiable parameters (e.g., age, comorbidities) **(6)**. More specifically, the majority of the prediction models that are now in use to calculate the risk factors for low blood pressure relies on many factors like age > 40, a history of hypertension, a basal reading of the arterial systolic blood pressure of less than 115 mmHg, and emergency surgery **(7)**.

In order to identify patients who have modifiable risk levels, such as patients suffering from hemodynamic derangement, it is vital to identify readily available characteristics **(8)**. Yet, it can be challenging for anesthesiologists to assess the intravascular fluid condition. Preload and other aspects of hemodynamic states have been assessed using several techniques, including the pulmonary artery wedge pressure measurement, PiCCO, and Vigileo. Due to cost limitations and high incidences of major complications in many of the cases, their general usage is still up for debate **(9)**.

Hypovolemia is the most prevalent cause of postinduction hypotension (PIH). Even with global improvements in preoperative management and preparation that encourage avoiding non-essential fasting and aggressive bowel preparation, tailored fluid management continues to be the cornerstone of treatment for maximum effectiveness **(6)**. To reduce the possibility of hypotension after general anesthesia, a variety of techniques have been employed, such as prophylactic vasopressors or preventive empirical volume loading **(10)**.

Nevertheless, especially in patients with heart illness, intravenous volume preload entails the threat of volume overload **(11)**. The impact of volume preload on the avoidance of PIH is still debatable as a result of various hypotension definitions and varying patient demographics. Sadly, even in critical population of patients, great number of anesthesiologists continue to employ measurement of arterial blood pressure and pulse waveform as the main parameters for monitoring hemodynamics during anesthesia **(12)**.

It is much preferable to use preventative medication solely for individuals who have a high chance of acquiring PIH rather than a one-size-fits-all management strategy. Yet, finding noninvasive, simple-to-use, affordable screening techniques is necessary to find these patients. Also, finding patients who are latently hypovolemic gives doctors the opportunity to restore the lost fluids before administering general anesthesia. We define quiescent hypovolemia, which is a syndrome marked by a reduction in fluid load in circulation with no evidence of hemodynamic abnormalities and/or organ dysfunction, as a condition that raises the risk of developing hypoperfusion as a result of external insults, such as anesthesia and surgical operations. Because general anesthesia and the ensuing inhibition of the sympathetic compensation may have significant impacts, we take data suggesting excessive collapsibility evaluated in normo-tensive or hypertensive patients as an indication of quiescent volume depletion.

For the reasons mentioned above, anesthesiologists frequently and effectively use noninvasive ultrasound evaluation as a tool in the safe administration of anesthetic. **Albuquerque *et al.*** **(13)** found a 31% shift in anesthetic management following the use of ultrasonography in a recent meta-analysis. ICV diameter varies with the respiratory cycle. Such variation can be used as a useful tool to predict fluid responsiveness in non-spontaneously breathing patients **(14)**. IVC diameter is a simple, non-invasive, and appealing approach for identifying patients who are at risk for postinduction hypotension **(15)**. IVC diameter has become increasingly clear as a useful volume status measure, according to accumulating evidence **(16)**.

At a cut-off value of 43%, **Zhang and Critchley** **(3)** reported that preoperative ultrasonographic IVC-CI readings might anticipate the development of hypotension following the onset of general anesthesia. Similar ideal cut-off values of 44.7% were discovered by **Salama and Elkashlan** **(17)** for anticipating hypotension following spinal anesthesia. IVCCI was demonstrated by **Ni *et al.*** **(8)** to be a significant determinant of hypotension after spinal anesthesia. Moreover, a study by **Saranteas *et al.*** **(18)** compared spinal anesthesia with no fluid preload infusion versus IVCCI-guided fluid delivery. In the group receiving fluid administration under IVCCI guidance, they observed a decreased incidence of hypotension.

Our results expanded on the evidence of IVC measurements utility in managing patient fluid status. In the current study, IVC diameters showed significant dilatation upon induction of general anesthesia (P<0.001). Along with that, patients suffered from significant (P<0.001) post-induction hypotension compared to their pre-induction systolic and diastolic blood pressure.

IVC measurement has certain drawbacks, though, including the fact that it can be impacted by a variety of personal and environmental factors, such as intra-abdominal pressure, morbid obesity, pregnancy, cirrhosis, and intestinal gas **(19)**. These issues have motivated academics to look for new methods of assessing blood volume status. Hence, investigations have focused on more accessible veins, such as the femoral vein (FV), internal jugular vein, and subclavian vein **(20)**. There are now just a few contradictory research looking into the usefulness of CFV measures in determining blood volume status. Our research sought to determine whether CFV diameter was more predictable in regulating fluid status than IVC diameter.

The primary outgrowth of the CFV, is a sub-branch of the internal jugular vein. Being close to body surface, a high-frequency probe can easily find the CFV. In a research by **Yao *et al.*** **(5)**, ultrasound assisted measurement of the CFV diameter was linked to the incidence of PIH in elective Caesarean delivery. Another study discovered that the IVC diameter's accuracy at predicting central venous pressure was equivalent to that of the CFV diameter's accuracy **(21)**. In contrast, **Yılmaz et *al.*** **(20)** concluded that CFV measurements were not useful for estimating post-spinal anesthesia hypotension.

The objective of the current prospective observational study was to assess the reliability of CFV diameter measurements taken prior to and post-induction of general anesthesia in comparison with IVC diameter in predicting the incidence of hypotension. Our study compared the hemodynamic consequences of the initiating general anesthesia in paralyzed ventilated patients. We identified a significant association between a high IVC diameter value and a more significant reduction in both systolic and diastolic blood pressure. In accordance, high CFV diameters were also associated with significant reductions in systolic and diastolic blood pressures. In fact, CFV showed significant (P<0.001) dilation post-induction compared to pre-induction. In accordance, both systolic and diastolic blood pressures of subjects showed significant reduction upon receiving general anaesthesia. Our results showed comparable predictability of CFV diameter to IVC diameter ultrasonographic measurements in anticipating post-induction hypotension in generally anesthetized patients.

Unique to our current work, we performed IVC and CFV measurements in a general anesthesiologic setting. Several previous studies were exclusive to in-shock patients held in intensive care units **(22, 23)**. In addition, we investigated deeper in special populations as hypertensive and diabetic patients. Compared to patients with normotension, those with hypertension had a greater likelihood of developing PIH. In patients with hypertension, the incidence of hypotension was reported to be nearly 65%, compared to 54.7% in patients with normotension **(24)**. Because that hypertensive individuals are more inclined to undergo organ damage as a result of hypotension, accurate PIH prediction is very crucial **(25)**.

Age, the degree of high blood pressure before surgery, and type II diabetes were all found as risk factors in a previous multicenter observational trial **(6)**. Another study by **Zhang *et al.*** **(26)** reported that hypertensive patients undergoing non-cardiac surgery to have higher incidence of PIH. Several causes could account for this outcome. Hypertensive patients have more tendency to develop hypotension during surgeries with general anesthesia because they have poor automatic blood pressure management **(27)**. Second, compared to people with normal blood pressure, hypertensive patients have greatly diminished venous compliance **(28)**. The inferior vena cava's volume can fluctuate due to a decline in capacity, a shift in venous compliance, or even both. The inferior vena cava's ability to adjust volume decreases as venous compliance does. IVC-CI therefore indicates the preexisting volume status to a lesser extent than in patients with normal blood pressure.

IVC and CFV predictability in the current study was non-significant. Hypertensive group showed only significant reduction in diastolic blood pressure upon induction of anesthesia. However, we observed more profound PIH in hypertensive and diabetic patients in clinical setting. The lack of result significance might be due the small sample size. Otherwise, our results were consistent with the previously reported literature. Variations in CFV and IVC diameters are insignificant in different age categories, which indicate the reliability of both vessels regardless of age group.

CONCLUSION

Our results showed comparable predictability of CFV diameter to IVC diameter ultrasonographic measurements in anticipating post induction hypotension in generally anesthetized patients. Therefore, the CFV offers a reliable alternative in cases where the IVC cannot be visualized or had limited accuracy such as previous abdominal surgery, pregnancy where the uterus compresses the IVC, and obesity. Variations in CFV and IVC diameters are insignificant in different age categories, which indicate the reliability of both vessels regardless of age group. However, in some chronic diseases such as hypertension, patients suffer more PIH and the predictability of IVC and/or CFV is still questionable. Hence, we recommend titrating general anaesthesia doses to minimize PIH, administering pre-load fluids, and employment of vasopressors if needed during surgery. However, more future multi-centre studies might be needed to generalize these findings. Additionally, the presented results only represent ASA- I and ASA- II populations and more studies are needed to reflect the predictability of IVC and CFV diameters in ASA-III, ASA- IV populations, hypovolemic, and/or in-shock patients. However, we hypothesize that both IVC and CFV diameters will be invaluable in predicting PIH. Hence, our recommendations for future studies include recruiting sub-categories of these patient populations.

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