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Preoperative ultrasound guided inferior venacava collapsibility index as a guide to predict hypotension following spinal anaesthesia in patients scheduled for elective surgery

Dr Meghna Mukund
Associate Professor, Department of Anaesthesia, Yenepoya Medical College, Mangalore, Karnataka

Dr. Shilpa G K Bhat
Assistant Professor, Department of Anaesthesia, Yenepoya Medical College, Mangalore, Karnataka

Dr. M Govindraj Bhat
Assistant Professor, Department of Anaesthesia, K S Hegde Medical Academy, Mangalore, Karnataka
Corresponding author email: govindrajbhat@nitte.edu.in

Dr. K G Shivakumar
Senior Resident, Department of Anaesthesia, JSS AHER, Mysore, Karnataka

Dr. Harish Hegde
HOD, Department of Anaesthesia, Yenepoya Medical College, Mangalore, Karnataka

***Abstract*---**Background: Spinal anaesthesia is the most commonly employed anaesthetic technique for infraumbilical surgeries. Post spinal hypotension is a commonly encountered complication which can lead to organ under perfusion and ischemia. Severe episodes of intraoperative hypotension have been proposed as an independent risk factorin the development of postoperative adverse outcomes and prolonged hospital stay. However, there are no reliable methods to determine which patients are at risk for spinal induced hypotension. This study investigated whether preoperative ultrasound guided inferior venacava collapsibility index (IVC-CI) could predict hypotension following spinal anaesthesia. Objectives were to measure

inferior venacava collapsibility index and to compare the incidence of hypotension following spinal anaesthesia among patients with IVC-CI>50% and patients with IVC-CI<50%. Materials and Methods: This prospective observational study was conducted in the department of anaesthesia, Yenepoya Medical College Hospital, Mangalore during the period between October 2016 to October 2018. After ethical committee approval and informed consent, 73 patients belonging to "American society of Anesthesiology" (ASA) grade I & II, aged between 18 to 65 years, scheduled for elective surgeries which require spinal anaesthesia were selected. Preoperative ultrasonography was done to determine the IVC-CI in these patients. All ultrasonographic examinations were performed by the same anaesthesiologist. Baseline HR, SBP, DBP, MAP were recorded prior to spinal anaesthesia and also every 5 minutes following spinal anaesthesia for 30mins. Results: Operative procedures included 52 orthopedic and 22 general surgeries. 53.4% of all patients had significant hypotension post spinal anaesthesia. 100% of patients with a IVC-CI≥50% had significant hypotension compared to 37% with a IVC-CI<50%, p=0.004. IVCCI≥50% has a specificity of 100% (95%CI, 64.29%-90.26%) and sensitivity of 48.72% (95%CI, 52.06%-81.28%) in predicting Post spinal hypotension. Conclusion: Patients with IVC-CI≥50% are more likely to develop significant spinal induced hypotension.

***Keywords*---**spinal induced hypotension, inferior venacava collapsibility index, preoperative ultrasonography.

Introduction

Spinal anaesthesia is a regional anaesthetic technique widely employed in clinical practice. The simplicity, effectiveness and safety profile of regional anaesthesia has added to its popularity. Neuraxial block for infraumbilical surgeries are becoming popular as it has many advantages over general anaesthesia. The common side effects are due to the reduction in systemic vascular resistance, causing systemic hypotension. Post spinal hypotension is a common complication which occurs due to sympathetic blockade leading to peripheral vasodilation and venous pooling of blood.

Hypotension following spinal anaesthesia may lead to organ underperfusion and ischemia.[1] Following spinal anaesthesia, patients are at a risk of developing hypotension because of the cardiovascular depressant and vasodilatory effects of anaesthetic agents. Preexisting hypovolemia due to dehydration, preoperative fasting, bowel preparation and impaired compensatory responses can increase the risk of post spinal hypotension. Severe intraoperative hypotension can lead to the development of postoperative adverse outcomes such as myocardial infarction, acute kidney injury, heart failure, stroke and prolonged hospital stay. (1) However, there are no reliable methods to determine which patients are at risk for spinal induced hypotension. To prevent this complication, prophylactic administration of fluids is usually done on an empirical basis, which can lead to volume overload.

The role of preoperative assessment of the volume status in the development of hypotension after spinal anaesthesia has not been assessed fully. Assessing intravascular volume status can be extremely challenging for the clinicians. Static parameters such as CVP are invasive and lack accuracy. A number of dynamic parameters like stroke volume variation and pulse pressure variation are now being recommended for volume assessment. Owing to its increased availability, portability and non-invasiveness, ultrasound has now been used to assess volume status by visualization of inferior venacava collapse. The advantages of ultrasound in the emergency department, intensive care unit, for gaining IV access, peripheral nerve blocks, arterial catheterization has already been established. However, diagnostic use of this technology in the field of anaesthesia is still highly limited.

Ultrasound measurements of inferior vena cava collapsibility index (IVC-CI) is a rapid and noninvasive method of estimating intra vascular volume status. It is now popular due to its repeatability and could also be easily performed by operators with little experience in ultrasonography. Ultrasound measurement of the IVC has been studied extensively in different clinical settings. Several studies have demonstrated that IVC-CI is a reliable indicator of intravascular volume status. Vena cava ultrasound has been shown to be an effective method to assess volume status in critical care patients, however this method has not been studied extensively in a non critical population. Therefore, we hypothesized that preoperative IVC-CI, could predict the incidence of post spinal hypotension with a high degree of sensitivity and specificity.

The IVC is a thin-walled compliant vessel that adjusts to the body's volume status by changing its diameter depending on the total body fluid volume. The vessel contracts and expands with each respiration. Negative pressure created by the inspiration of the patient increases venous return to the heart, briefly collapsing the IVC. Expiration decreases venous return and the IVC returns to its baseline diameter. Collapsibility index: IVC expiratory diameter - IVC inspiratory diameter, divided by IVC expiratory diameter × 100. [(2)]

Aims & Objectives

Aim of this study was to determine whether Inferior Vena Cava analyzed by ultrasonography is an effective method to predict hypotension following spinal anaesthesia. Objectives of this study were to measure inferior venacava collapsibility index and to comapare the incidence of hypotension following spinal anaesthesia among patients with IVC-CI>50% and patients with IVC-CI<50%.

Materials and Methods

This prospective observational study was conducted in the department of anaesthesia, Yenepoya Medical College Hospital, Mangalore during the period between October 2016 to October 2018. After ethical committee approval and informed consent, 73 patients belonging to “American society of Anesthesiology” (ASA) grade I & II, aged between 18 to 65 years, scheduled for elective surgeries which require spinal anaesthesia were selected. Exclusion Criteria were patients undergoing emergency surgeries, patients with valvular heart disease and cardiac

failure, patients in whom it was not possible to perform spinal anaesthesia due to patient's refusal, any contraindications to spinal anaesthesia, parturients and pregnant women.

Sample size was calculated using $n=Z^2pq/d^2$,
Where, n= desired sample size
Z=standard normal deviate; set at 1.96(or a~2), which correspond to 95% confidence level.
p=proportion in the target population estimated to have a particular characteristic.
76% of patients with IVC-CI≥50% had significant hypotension [3]
So p=76q=100-p(proportion in the target population not having the particular characteristics)
100-76 = 24
d= degree of accuracy required is 10%
So required sample size was 73

All the patients were kept nil per oral for solids for 8hours and clear liquids for 2hrs, premedicated with oral lorazepam (1mg for patients<50kgs and 2mg for patients>50kgs) and oral ranitidine 150mg on the previous night and 2 hours prior to surgery.

Thorough preanaesthetic evaluation and routine investigations were carried out before taking up the patient for surgery. On the day of the surgery, 45minutes prior to the administration of spinal anaesthesia, the patient were shifted to the anaesthesia procedure room and were positioned in supine position. Standard monitors (electrocardiogram, non-invasive blood pressure, pulse oximeter) were connected, baseline readings were taken and intravenous access was secured. Ultrasonography was performed before spinal anaesthesiato assess the IVC collapsibility index.

All ultrasonographic examinations were done by the same anaesthesiologist who had been trained to perform IVC ultrasound throughout the present study. All the scans were done with sonosite ultrasound using a low frequency probe. The anteroposterior diameter of inferior vena cava (IVCD) was measured using images frozen, at end of inspiration (iIVCD) and end of expiration(eIVCD) in a subxiphoid location in the longitudinal axis 2 cm distal to the IVC-right atrium junction. The IVC-CI was determined as the percentage of the difference between eIVCD and iIVCD divided by the eIVCD as expressed by the following equation: IVC-CI = [(eIVCD-iIVCD)/eIVCD] x 100[2]. The observation of hypotension following spinal anaesthesia was done by a different anaesthesiologist in the operative room to avoid bias.

On arrival to the operating room, after attaching standard monitors, spinal anaesthesia was achieved with bupivacaine 0.5% 15 mg. Infusion of Ringer lactate or saline was started at the rate of 10ml/kg/hour only after the procedure of spinal anaesthesia was completed. Spinal anaesthesia technique was standardized for every patient. They were positioned in sitting position, L3-L4 space was identified and spinal anaesthesia administered via a 25G spinal needle (quincke's). A standard dose of bupivacaine 0.5% 15 mg is slowly injected. After

injection, patients are immediately positioned supine for the surgery. Height of the blockade will be assessed. NIBP was measured every 5 minutes and recorded in a data collecting form for 30 minutes following spinal anaesthesia. If the patient develops any sign or symptom of hypotension, he/she was treated according to our protocol with crystalloid bolus initially followed by mephentermine bolus of 6 mg i.v. Total quantity of mephentermine used was also recorded. In our study hypotension was taken as blood pressure <20% of the patients baseline value of mean arterial pressure (MAP).

Statistical Analysis

Data so gathered was analyzed using Statistical Package for the Social Sciences (SPSS) Inc., Chicago, USA, Version 22.0. Continuous variables were expressed in the form of means or medians, based on the distribution of the data. Percentages and proportions were used to express categorical variables. Student's t test was applied to find out the difference between 2 means. Non-parametric tests were applied to compare medians. Pearson's correlation was used to find out the relationship between IVC Collapsibility Index and Mean Blood Pressure. Bivariate analysis was conducted by applying Chi-square test for categorical variables. Multiple logistic regression analysis was done on the outcome variables found to be statistically significant in the bivariate analysis and confounding variables were adjusted. A p value of <0.05 was considered as the criteria for statistical significance.

Results

Our study population comprised of 73 patients, out of which 26% of patients had IVC-CI>50% AND 74% had IVC-CI<50%. 52(71.2%) were males and 21 (28.8%) were females. There was no significant difference between the groups. (P = 0.368).

			Sex		
			F	M	Total
IVCCI	<50%	Count	14	40	54
		% within IVC_Grp	25.9%	74.1%	100.0%
	>50%	Count	7	12	19
		% within IVC_Grp	36.8%	63.2%	100.0%
Total		Count	21	52	73
		% within IVC_Grp	28.8%	71.2%	100.0%

Table 1: gender distribution of patients studied

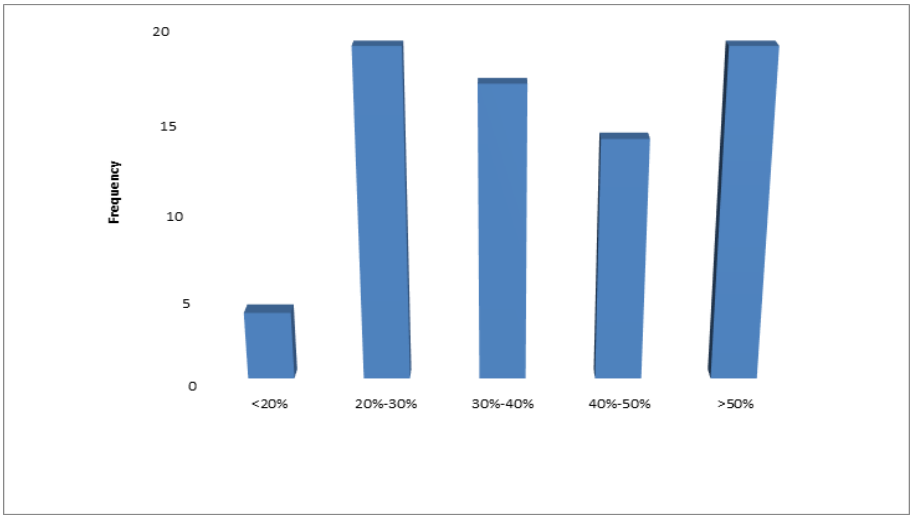
Independent t test was used to compare the age, height and weight between the

IVC groups <50% and >50% and was observed that there was no significant difference in between the groups with p<0.05.

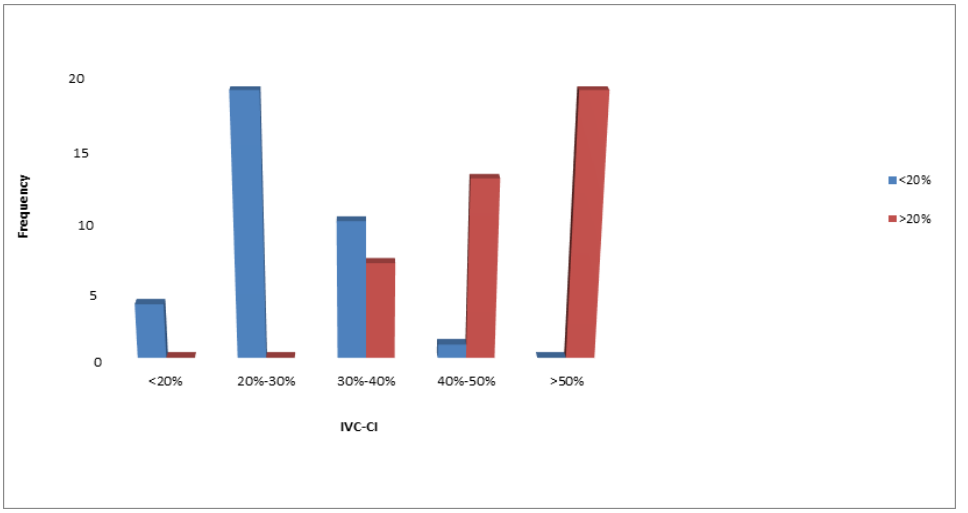
	IVCG	N	Mean	Std. Deviation	p-value
AGE	<50%	54	42.26	10.624	0.837
	>50%	19	42.84	10.474	
HEIGHT	<50%	54	166.26	9.405	0.307
	>50%	19	163.74	8.517	
Weight	<50%	54	71.94	10.525	0.05
	>50%	19	66.53	9.094	

Table 2: Age, Height and Weight Distribution

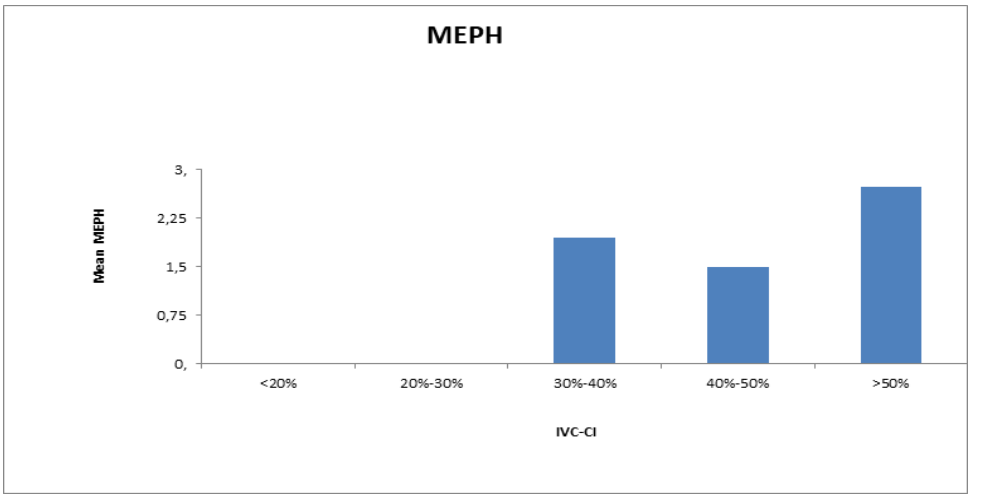
Operative procedures included 52 orthopedic and 22 general surgeries. 53.4% of all patients had significant hypotension post spinal anaesthesia. 39 of these patients were given vasopressors during their procedures. 100% of patients with a IVC-CI≥50% had significant hypotension compared to 37% with a IVC-CI<50%, p=0.004. IVCCI≥50% has a specificity of 100% (95%CI, 64.29%-90.26%) and sensitivity of 48.72% (95%CI, 52.06%-81.28%) in predicting Post spinal hypotension. Positive predictive value of 100% and negative predictive value of 62.96%. The accuracy was 72.6%. In our study, 23 patients had IVCCI <30% and there was no evidence of significant hypotension in this group. 17 patients had IVCCI 30-40%, out of which 7(41.2%) had significant post spinal hypotension.14 patients had IVCCI 40-50%, out of whom 13(92.9%) had significant post spinal hypotension. (P<0.001)



Graph 1: Distribution of Patients among Various Groups of IVC-CI



Graph 2: Percentage fall in MAP among the subgroups of IVC-CI within 30mins



Graph 3: Requirement of Mephentermine among Sub Groups of IVC-CI

Here we observe that there is significant difference in mean requirement of mephentermine between the groups with $p<0.001$. The amount of mephentermine used to treat hypotension was significantly higher in group with IVC-CI>50%.

Discussion

This study investigated the association of preoperative IVC-CI as measured by bedside ultrasonography with incidence of intraoperative post spinal hypotension. We observed that a preoperative IVC-CI≥50% was associated with a higher incidence of post spinal hypotension. Having a predictive tool to determine whether an individual is likely to become hypotensive could be useful in framing the plan of anaesthesia for that particular patient. Spinal anaesthesia is a commonly employed anaesthetic techquine for infraumbilical surgeries. A commonly encountered complication following spinal anaesthesia is post spinal

hypotension. In the present study,53.4% patients had significant hypotension post spinal anaesthesia. Additionally, it has been demonstrated that hypotensive events are associated with increased mortality during hospitalization. [4]

During spinal anaesthesia, cardiovascular response is individual and depends on the height of sympathetic block. The hemodynamic changes are minimal if the block height is below L3.[5] In our study, the sensory block reached Th8-10 and does not differ between the groups. Administration of intravenous fluid, addition of vasopressors are required following spinal anaesthesia in case of hypotension with their inherent side effects. Attempts have been made to prevent spinal induced hypotension by volume loading or premedicating with ephedrine, with varying amounts of success. Though premedicating with ephedrine or fluid loading could be beneficial, it has not been universally recommended.

Although preoperative HR, MAP, clinical methods of determining hydration status can predict intraoperative hypotension, they are not definitive. Kambiz Kalantari et al studied various static and dynamic parameters for the assessment of intravascular volume status, and have concluded that Static pressure measurements such as the CVP and PCWP have little utility due to their invasiveness and should not be routinely used to assess volume status. Newer dynamic measurements hold great promise for determining fluid status such as IVC ultrasonography.[6] We observed that the development of hypotension following SA might be related to increased collapsibility of IVC which could be due to decreased intravascular volume caused by vasodilatation.

Ultrasound of the IVC has been shown to correlate with central venous pressure and assist with determining a patient's overall volume status. Nagdev et al reported a 50%collapse of the IVC diameter during a respiratory cycle as being strongly associated with a low CVP [7] Guidelines from the American Society of Echocardiography support the use of IVC size and collapsibility in the assessment of volume status.[8] In the present study, we observed that ultrasound evaluation of the IVC is a potential method to determine which individual patients are more likely to develop hypotension following spinal anaesthesia.

The use of Inferior venacava collapsibility index as a tool to measure intravascular volume status and fluid responsiveness in ICU settings has already been established. However, this method has not been studied extensively in a non critical population. Different methodologies are reported in the literature to measure IVC diameters, depending on probe selection (convex or sector), orientation (longitudinal or transversal) and measurement site along the vessel (proximal, mean or distal sub-xyphoid scan)[9]. In our study, we performed a longitudinal scan in a subxiphoid location 2 cm distal to the IVC-right atrium junction where the anterior and posterior wall of the IVC are easily visualized and lie parallel to each other.

N kent wise et al compared the M mode ultrasonography of IVC with the two dimensional mode. The results of this study indicate that M-mode ultrasonography can be used in most patients to inspect the inferior vena cava. In agreement with this study, inferior venacava measurements in our study was done using M mode.[10] In this present study, a total of 73 patients were enrolled.

IVC ultrasounds were performed by the same anaesthetist. In our study population, mean age was 42 years, (95%CI, 39.96- 44.86) with 28.8% females. There were no differences in age, sex, BMI or preoperative vital signs between the two groups.

As the type of the surgery could alter the outcome of our study, we chose to conduct the study on patients scheduled for minor and intermediate surgeries of duration less than 2hours. Operative procedures included 52 orthopedic and 22 general surgeries. None of these procedures resulted in significant blood loss and no other reasons attributable to hypotension were observed. The end point of our study was 30mins following spinal anaesthesia to avoid possible major fluid shifts. Thereby the hypotension caused could be solely induced by SA.

Muller et al.[11]found that a IVC-CI of more than 40% was predictive of fluid responsiveness. Likewise, Jie Zhang et al,[1] in their study concluded that IVC CI greater than 43% was the threshold to predict hypotension following general anaesthesia. This is in accordance with the study conducted by Au AKet al[3] which showed that patients with IVC-CI≥50% were more likely to develop significant hypotension from propofol. Similarly, in the present study we observed that IVC-CI>50% was associated with significant post spinal hypotension.

Interestingly, Asta Maciuliene et al[12]concluded that reduction in IVC diameters and increase in IVC-CI do not predict hypotension following SA in spontaneously breathing patients. In contrary, Our results indicate that patients with an IVC-CI≥50% prior to spinal anaesthesia are more likely to become hypotensive. In our present study,19 patients had IVCCI>50%. All of these patients with a IVC-CI≥50% had significant hypotension compared to 37% with a IVC-CI<50%, p=0.004. The accuracy of IVC-CI in predicting post spinal hypotension was found to be 72.96%. IVCCI≥50% has a specificity of 100% (95%CI, 64.29%-90.26%) and sensitivity of 48.72% (95%CI,52.06%-81.28%) in predicting Post spinal hypotension with a PPV of 100% and NPV 0f 63%. However, differences in patient population, nulla per os (NPO) status and type of surgery among the studies may have resulted in the discrepancy.

AU A Ketal[3]noted a sensitivity of 66.67% (95%CI, 52.06%-81.28%) in predicting PIH which is similar to our study which shows a NPV of 63% and a sensitivity of 48.72% (95%CI,52.06%-81.28%) in predicting spinal induced hypotension. In our study, we also observed that 23 patients had IVCCI <30% and there was no evidence of significant hypotension in this group. 17 patients had IVCCI 30-40%, out of which 7(41.2%) had significant post spinal hypotension.14 patients had IVCCI 40-50%, out of whom 13(92.9%) had significant post spinal hypotension. (P<0.001). Even if it was not the primary objective of this study, this suggests that patients with IVVCI >40% could predict post spinal hypotension. This hypothesis needs to be tested in further studies.

53.4% patients had significant hypotension post spinal anaesthesia. 95% of these patients with hypotension were given vasopressors during their procedures. The amount of mephentermine used was maximum in the group of patients with IVC-CI>50% which was also statistically significant, suggesting that there was probably a greater fall in MAP compared to other patients with IVC-CI<50%. More

precisely, a IVC-CI value < 50% cannot exclude spinal induced hypotension while patients with IVC-CI >50% are more likely to have post spinal hypotension.

Preoperative bedside IVC-CI may help to identify the patients that are likely to become hypotensive and could be used to assist the provider with decisions on the usage of vasopressors and prophylactic intravenous fluids without the concern of overloading the patient or causing acute pulmonary edema. Future studies must be done to determine the effectiveness of volume loading patients with IVC-CI≥50%, to see if this significantly reduces spinal induced hypotension in them. Clinically, preoperative inferior venacava collapsibility index measurements were easy and rapid to perform and point-of-care ultrasound is becoming more-and-more readily available in every set up.

Limitations

The current study had few limitations.

1. IVC collapsibility index following spinal anaesthesia was not measured.
2. Fluid responsiveness was not assessed in patients with IVC-CI>50%.
3. IVC measurements were performed by an anaesthesiology resident with basic level of experience in echocardiography.

Conclusion

The threshold for predicting hypotension was a IVC-CI greater than 50%. IVC-CI was also positively associated with a significant decrease in mean arterial blood pressure post spinal anaesthesia. We conclude that IVC-CI>50% patients with IVC-CI≥50% are more likely to develop significant spinal induced hypotension. In patients at high risk of complications resulting from intraoperative hypovolemia and hypotension, measurement of IVC-CI may provide clinically useful information. Future studies based on IVC-CI measurements are required to determine the best intravenous fluid strategies to reduce post spinal hypotension.

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