Role of Inferior venocaval Ultrasonography Prior to Spinal Anesthesia In Guiding Vasopressor and Fluid administration

Corresponding Author:
Prof. Dr. Jayaraman V
PG, Dept of Anesthesiology and Pain Medicine,
Sri Ramachandra Medical College,
Sri Ramachandra Institute of Higher education and Research,
Porur, Chennai
Tamil Nadu, India

First Author:
Dr. A Benisha Julian
Professor, Dept of Anesthesiology and Pain Medicine,
Sri Ramachandra Medical College,
Sri Ramachandra Institute of Higher education and Research,
Porur, Chennai
Tamil Nadu, India

Affiliations: Department of Anesthesiology and Pain Medicine, Sri Ramachandra Medical College, Sri Ramachandra Institute of Higher education and Research, Porur, Chennai, Tamil Nadu, India

Introduction

Spinal anesthesia is a widely practiced, safe and reliable technique of anesthesia due to its easy predictability, low complication rate, earlier recovery of bowel function and decreased need for systemic Opioids.(1) It involves the injection of a local anesthetic drug in the subarachnoid space containing CSF which enables uptake and distribution of the drug along nerve roots that may need to be blocked to achieve surgical anesthesia.(2)Hence it can be used for surgeries below the umbilicus such as hernia repair, hysterectomy, cesarean section, urological procedures such as lithotripsy, prostate resection, cystoscopy, and orthopedic surgeries of the lower limbs. (3)
Spinal Anesthesia induced hypotension occurs as a result of blockade of the lumbar sympathetic outflow leading to profound systemic venous, arterial and arteriolar vasodilation causing a decrease in cardiac output as a result of the decreased preload.

It has multiple definitions but is more commonly defined as systolic arterial blood pressure less than 80% of the baseline. (4)Major adverse effects following profound and persistent spinal anesthesia induced hypotension results in organ hypoperfusion associated with perioperative morbidity and mortality.(5,6)

Spinal Anesthesia induced hypotension can be prevented by fluid co-loading or preloading and by the use of vasopressors and nonpharmacological methods such as use of compression stockings, inflatable splints/ boots, and trendelenburg tilt and so on.

Fluid responsiveness indicates the inherent ability of an individual to increase their cardiac output following an increase in the preload, which is seen during intravascular volume expansion following fluid administration in some individuals and is reflected in static parameters such as arterial blood pressure, mean arterial pressure, heart rate and so on.

This serves as an indicator and a guidewire to treat a patient either prophylactically or symptomatically in critical care settings, while predicting or managing profound hemodynamic instability, by administering fluids instead of a vasopressor without overloading the patient.

It also helps in predicting the initiation of vasopressor support in individuals who are 'fluid non-responsive,' instead of beginning with fluid administration, that may be futile.

However, static parameters such as blood pressure, heart rate, mean arterial pressure are deemed to be less specific and sensitive, especially in acute perioperative care settings. Hence the need for a dynamic, yet, non-invasive parameter such as theassessment and optimization of the IVC collapsibility index. This can be assessed by abdominal ultrasonography (USG) of the Inferior vena cava (IVC) which is a collapsible major blood vessel with diameters varying during respiration correlating with the intravascular volume status. (7,8)This variability in the diameter of the IVC during respiration is considered to be a valuable predictor of volume responsiveness in cases of circulatory failure in ventilated(9–12)and spontaneously breathing patients(13,14) even in the presence of nonfatal cardiac arrhythmias.(15)

Hence this technique can be employed by anesthesia providers to prevent spinal anesthesia induced hypotension and its related complications index as it is a non-invasive, inexpensive, straightforward and simple technique with good interobserver reliability to determine volume status in spontaneously breathing patients.(5,16,17), thereby raising the quality of perioperative patient care.

Materials and Methodology

This study is a prospective randomised control study conducted in the Department of Anaesthesiology, Critical care and Pain medicine, Sri Ramachandra Institute of Higher Education and Research. The sample size was 76 with 38 samples per group, belonging to ASA 1 or 2 scheduled for urological procedures and lower limb wound debridement surgeries under spinal anesthesia, between the age group of 18-60 years of age.

Randomisation was done by computer generated randomisation and the patients were divided into 2 groups. Group A was the control group, where patients received routine spinal anesthesia and group B was the study group where an ultrasonographic evaluation of the IVC was done prior to spinal anesthesia and fluid was administered according to the IVC Collapsibility index if required.

Patients who belonged to ASA PS III and above, or those with contraindications for spinal anesthesia (such as Infection at the site of injection, Increased intracranial pressure, Coagulopathy, Sepsis, Fixed cardiac output states, Ischemic heart disease, Indeterminate neurological disease, Hypersensitivity to local anesthetic drugs) and emergency, obstetric and cardiovascular surgeries were excluded from this study

While monitoring baseline NIBP, pulse oximetry and ECG, USG guided measurement of the Inferior vena caval diameter was obtained in participants belonging to group B in the supine position before spinal anesthesia. During spontaenous tidal breathing, using a Subcostal approach, M-mode trans abdominal ultrasonography was used to measure the variation in the diameter of the IVC, that is, the maximum diameter (IVC_{max}) during inspiration and minimum (IVC_{min})diameters during expiration.

Based on these measurements the IVC Collapsibility Index was derived using the following formula,

$IVCCI = (IVC_{max} - IVC_{min}) / IVC_{max}$

Individuals with an IVC collapsibility index >36% were considered to be fluid responders. These individuals were then pre-loaded with 10 ml/kg of crystalloids (0.9% Normal Saline or Ringer's lactate solution) After 15 minutes, variations in the IVC diameter were reassessed under Ultrasound guidance. If these individuals continued to have an IVC collapsibility index >36% they received another fluid bolus of 10 ml/kg crystalloids. They were reassessed and the above steps were repeated till the IVC collapsibility index becomes <36%, indicative of a fluid non-responder pattern.Individuals with an IVC collapsibility index <36% were then administered spinal anesthesia under strict sterile aseptic precautions.

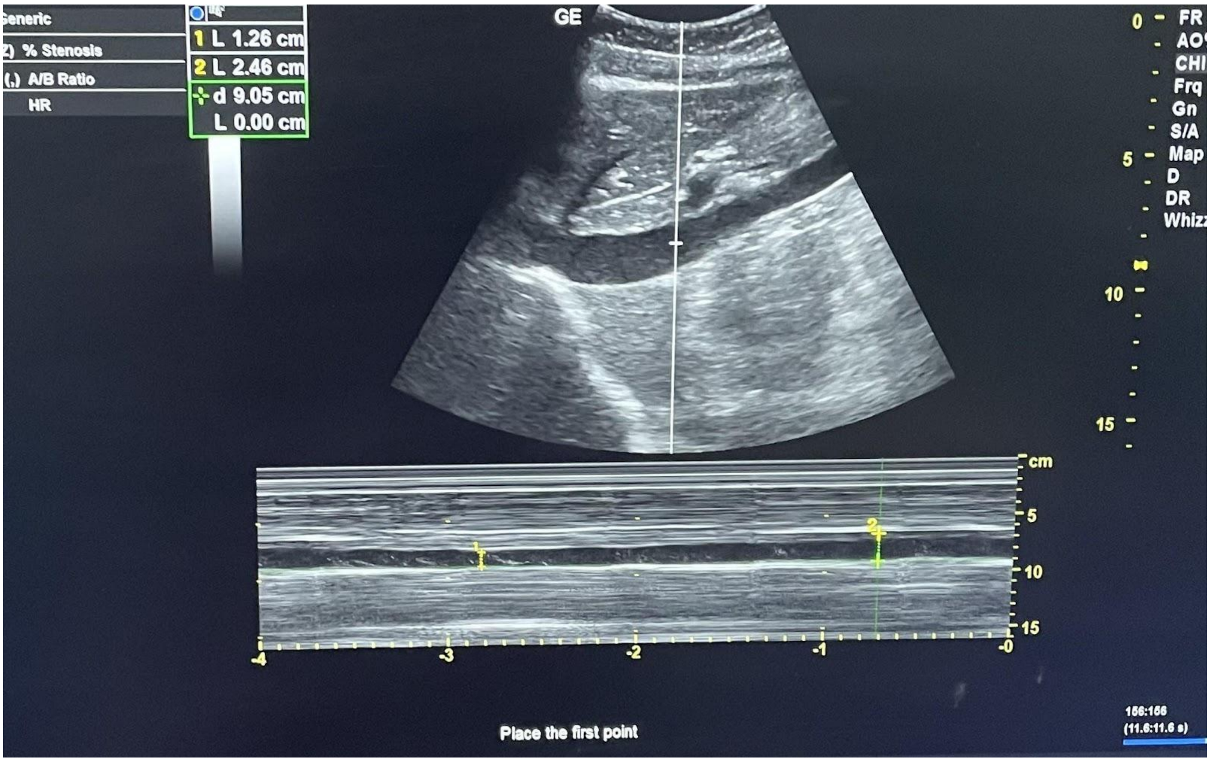

Figure 1 M-mode USG of the IVCCI

Individuals belonging to group A (the control group) did not undergo the ultrasound guided inferior venocaval volume optimization and were directly administered spinal anesthesia.

During spinal anesthesia, individuals were made to sit and using a median approach 0.5% of Bupivacaine of appropriate dosage was slowly infiltrated in the L3-L4 interspace in the subarachnoid space using a 27G Pencan needle. The individuals were continuously monitored throughout the duration of the procedure and were treated and managed according to the group they belonged to in case of any intraoperative hypotension.

Significant intraoperative hypotension was defined as a fall in systolic arterial blood pressure of 20% from the initially measured baseline values.Individuals belonging to group B were treated with the appropriate vasopressor drug (0.1-0.2mg/kg of Ephedrine or 20mcg of Phenylephrine) with no bolus administration of IV Crystalloids.However individuals belonging to group A were treated initially with a bolus administration of IV crystalloids at 10 ml/kg over 15 minutes. Following which if the BP continued to fall persistently 5 minutes after the fluid bolus, they were treated with an appropriate vasopressor drug (0.1-0.2mg/kg of Ephedrine or 20mcg of Phenylephrine.) Both groups were supplemented with maintenance fluid therapy based on the Holiday-Segar formula and replaced adequately according to the loss encountered.

European Journal of Molecular & Clinical Medicine
ISSN 2515-8260 Volume 10, Issue 06, 2023

Results:

76 patients were enrolled for statistical analysis with 38 belonging to each group, A and B. Patients in both the groups were of comparable demographic variables such as age, sexand weight.

There was no statistically significant difference between both groups while comparing the use of Ephedrine administration between both groups (p=0.206) calculated based on Pearson's Chi-squared test. Most individuals who received a 6 mg bolus of Ephedrine in group A were 23.7% and 17.1% in group B. The comparison of Phenylephrine use between both showed that there is no statistically significant difference, with p value= 0.430 based on Fisher's Exact test. Only 13.2% individuals belonging to group A and 5.3% individuals belonging to group B required Phenylephrine administration in both groups. However the amount of fluid used intraoperatively (p value=<0.0001 with a mean of 457.89 ml in group A and 99.21 ml in group) and the total amount of fluid administered (p value= <0.007 with a mean of 451.35 ml in group A and 299.21 ml Whitney U test.) between groups A and B were highly statistically significant between both groups. However there was no positive correlation between the fluid administration and the IVC collapsibility index. (p value= 0.966, r value= -0.015)

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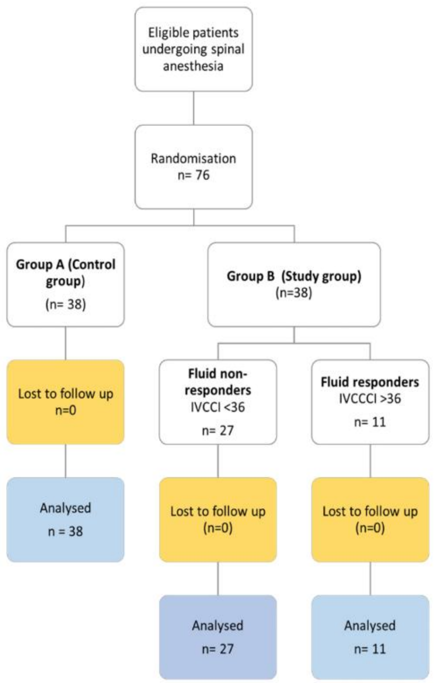

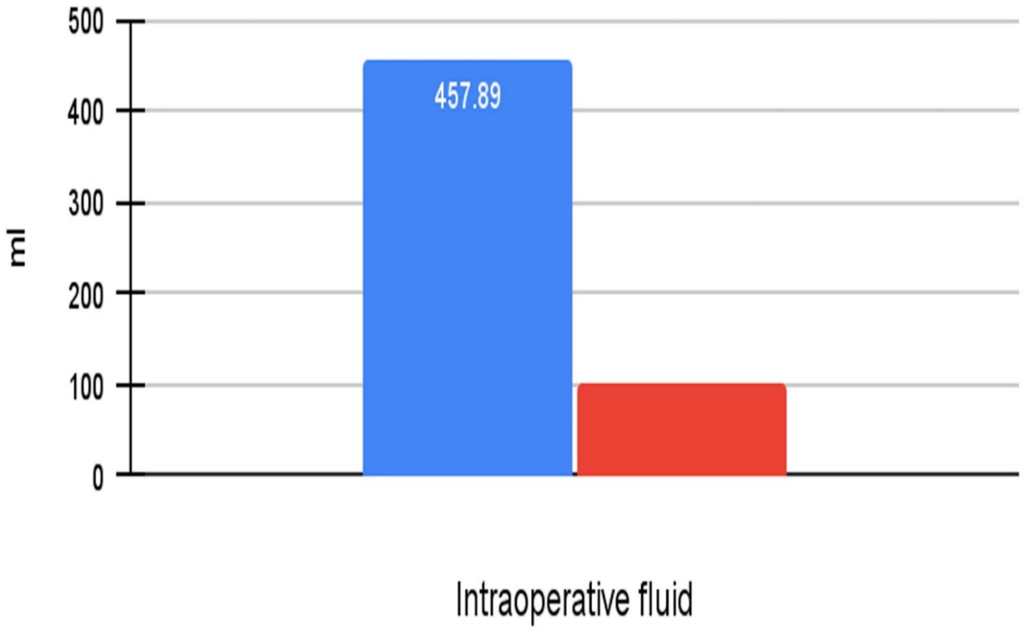

Fig.2 Comparison of intraoperative fluid between both groups.

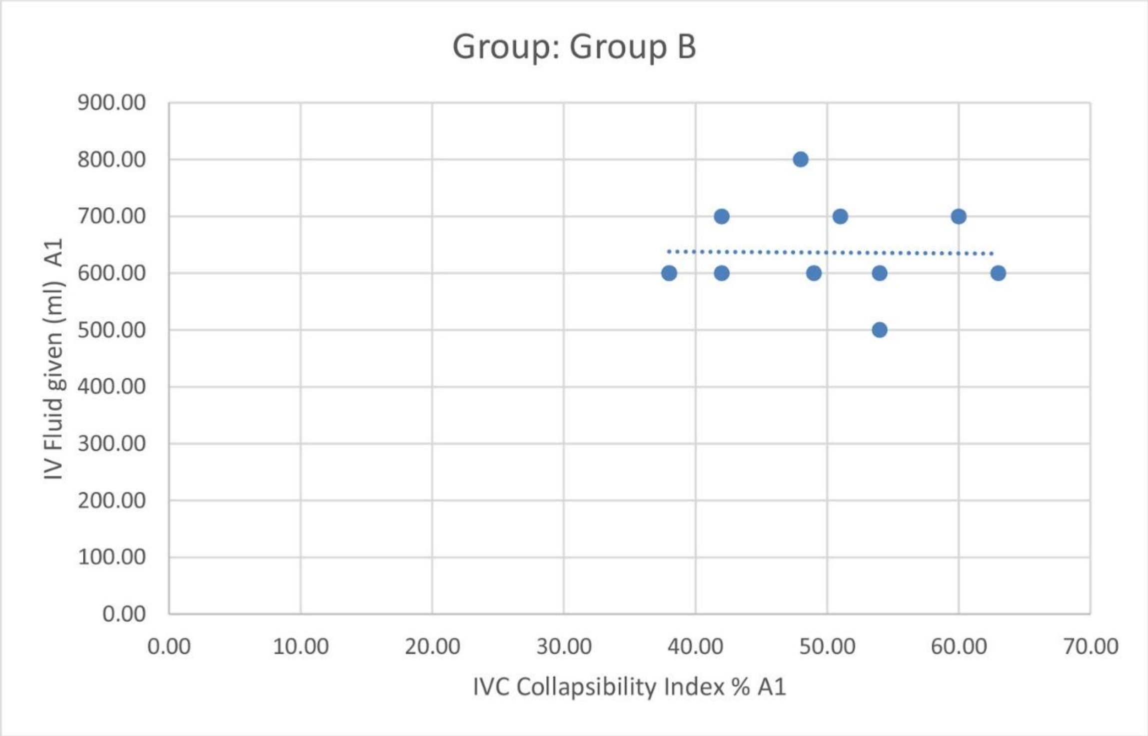

Figure 14 Correlation between Fluid administration and IVCCI in the study group

Figure 4 Correlation between fluid administration and IVCCI in the study group

Table 1 Comparison of Demographic variables between both groups

Demographic variables	Group	n	Mean	SD	P value
Age	Group A Group B	38 38	46.07 46.76	14.13 12.03	0.663
Sex	Group A Group B	38 38	27.6% (females in both groups) 72.4% (males in both groups)		0.442
Weight	Group A Group B	38 38	67.6 64.47	10.54 10.50	0.198

Table 2 Comparison of incidence of vasopressor administration and fluid administration

Parameters	Group A (n=38)	Group B (n=38)	P value
Ephedrine administration	11/ 38	6/38	0.206
Phenylephrine administration	5/ 38	2/ 38	0.430
Intraoperative fluids (ml)	457.89 +/- 227.36	99.21 +/- 4.87	<0.0001

Total IV fluids	451.35. +/- 226.84	299.21 +/- 332.59	<0.007

Discussion:

The main aim of our study was to determine the efficiency of preoperative USG guided IVC diameter optimisation prior to spinal anesthesia by correlating it with the amount of intraoperative IV fluids and vasopressors used and the correlation between them. Baseline characteristics such as age, weight and sex were comparable between both groups. In our study we were able to conclude that with IVC collapsibility assessment prior to spinal anesthesia played a significant role in guiding intraoperative fluid and vasopressor administration to manage spinal induced hypotension.

This is similarto another study by Devi. et al(19) who were able to demonstrate a significantly higher fluid administration in the control group when compared with the study group.In the study by Ni et al, the study group required less fluid administration than the control group preoperatively of 0ml vs 335ml which was similar to the findings of our study.(4) In a study by Ayyangouda et al.(20) there was a positive correlation between the IVCCI and pre-spinal fluid administration (p value= 0.001) with no fluids administered in the IVCCI group and 425+/- 241.53ml in the control group. However in a study by Chowdhary et al, who compared IVCCI and variations in carotid artery peak systolic velocity among 50 patients undergoing elective lower abdominal surgeries concluded that IVCCI and CAPV were poor predictors of post spinal hypotension but a composite model including the ultrasound parameters and baseline MBP could be more efficient.(8)

Zhang et al. in their meta-analysis of eight studies with 235 patients, studied cut-off values of IVCCI varying across studies, ranging from 12 to 40%, while observing the respiratory variation of the IVC diameter to predict fluid responsiveness in critically ill patients. This was the basis of the cut off value of 36% in our study similar to that of employed in the study of Ayyangouda et al. The sensitivity and specificity in the overall population were 0.76 [95% confidence interval (CI): 0.61-0.86] and 0.86 (95% CI: 0.69- 0.95), respectively.(18)

Other parameters using abdominal ultrasonography include aortic peak flow velocity and aortic velocity time integral which were employed in the study by Achar et al, for 42 children under general Anesthesia between ages 1-14 years and proved aortic peak flow velocity and IVC distensibilty index to be reliable indices for fluid responsiveness in children.(21)

In this study we used randomisation to recruit patients into their respective groups but were unable to blind them due to obvious performance of an ultrasonography preoperatively. In this study we have only included patients belonging to ASA 1 or 2, further studies are required on patients belonging to ASA grade 3 and above to assess the efficacy in critically ill patients. The IVCCI of patients belonging to the study group were measured and was hence not comparable with that of those belonging to the control group, IVCCI was not measured during the hypotension and after the spinal anesthesia, there was no comparison of the IVC measurements with dynamic tests such as CVP, PPV or cardiac output. These fallacies can be overcome in future studies with further in depth analyses.

Conclusion:

Based on this study we can conclude that the use of a preoperative ultrasonographic assessment of the IVC and optimisation of the intravascular volume status based on the IVC collapsibility index can aid in the intraoperative administration of IV crystalloids and vasopressors.

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