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Original Research Article

Ultrasound Guided Assessment of Inferior Vena Cava Collapsibility Index and Fluid Optimization to Minimize the Spinal Induced Hypotension in Patients Undergoing Femur Fracture Surgeries

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Abstract:

Hypotension is the most common side effect of spinal anaesthesia. Ultrasonography (USG) being the most reliable diagnostic technique for examination of the inferior vena cava (IVC) and inferior vena cava collapsibility index (IVCCI) in order to estimate the volume status in patients with spontaneous respiration. The aim of present study was to find out ultrasound guided inferior vena cava collapsibility index and fluid optimization to minimize the incidence of spinal induced hypotension in patients undergoing femur fracture surgeries. The study was enrolled as prospective, interventional trial which included 80 patients of American society of Anaesthesiologists grade I and II scheduled for femur fracture surgeries. Eighty patients were divided into 2 groups- case group (IVC group) and control group with 40 patients in each group. In case group IVC ultrasound guided fluid optimization before spinal anaesthesia and in control group, there was no IVC ultrasound assessment. The primary outcome of the study was incidence of spinal induced hypotension (SIH) between the two groups. The secondary outcomes were correlation of collapsibility index with mean arterial blood pressure and pre-spinal fluid, requirement of vasopressor drugs in both groups, changes in haemodynamic parameters after spinal anaesthesia in both groups. The incidence of hypotension after spinal anaesthesia was lower in case group (15%) as compared to control group (42.5%). There was decreased requirement of vasopressors in case group as compared to control group. IVC guided fluid optimization reduces spinal induced hypotension and requirement of vasopressors in patients posted for femur fracture surgeries. Total IV fluid given was more in case group as compared to control group.

Keywords: Spinal anaesthesia, hypotension, IVC collapsibility index.

Introduction

Spinal anaesthesia is a safe and effective technique of providing analgesia during various surgical procedures involving lower abdomen, pelvis, perineum, and lower limb surgeries. The most common haemodynamic disorders of spinal anaesthesia are hypotension and bradycardia. [1] Sympathetic block further leads to decrease in systemic vascular resistance which leads to peripheral vasodilatation and results in decreased myocardial contractility and cardiac output [2] Hypotension can be caused by decreased cardiac output and reduction of systemic vascular resistance. In obstetric anaesthesia to reduce the chances of haemodynamic impairment, prophylactic volume loading is commonly performed before giving spinal anaesthesia. [3] Further studies have been done regarding preloading in obstetric patients which showed inconsistent results. Therefore, to reduce the incidence of spinal induced hypotension fluid co-loading has been proved to be effective and vasopressor requirements significantly decreased. [4] Therefore it become mandatory to search the predictors of spinal induced hypotension so that we can prevent blind volume loading and can reduce the vasopressor requirements.

Various parameters are used for evaluating preoperative intravascular volume status and fluid requirements. Ultrasonography (USG) has been recommended as a noninvasive and reliable diagnostic technique for examination of the inferior vena cava (IVC) and inferior vena cava collapsibility index (IVCCI) in order to estimate the

volume status in patients with spontaneous respiration. [5]

The aim of present study was to find out ultrasound guided inferior vena cava collapsibility index and fluid optimization to minimize the incidence of spinal induced hypotension in patients undergoing femur fracture surgeries.

The primary objective of this study was to compare the incidence of spinal induced hypotension after fluid optimization using ultrasound guided assessment of collapsibility index of inferior vena cava in patients undergoing femur fracture surgeries (neck and shaft). The secondary objectives were correlation of collapsibility index with mean arterial blood pressure and pre-spinal fluid, requirement of vasopressor drugs in both groups, changes in haemodynamic parameters (pulse, blood pressure) after spinal anaesthesia in both groups.

Material And Methods

This prospective randomized interventional study was initiated after seeking clearance from Institutional Ethical Committee SNMC/IEC/2021/1420-1422. In this interventional study, patients aged between 18 to 60 years of ASA (American Society of Anaesthesiologists) grade I and II of either sex scheduled for femur fracture surgeries under spinal anaesthesia with blood pressure between 90/60 mmHg to160/100 mmHg along with patients having IVC collapsibility index >36% at Dr S.N. Medical College and associated group of hospitals in 2021 were included. Patients with absolute and relative contraindications of spinal anaesthesia, allergic to drug administered, uncooperative patients, history of cardiac or respiratory diseases, hepatic failure, neuromuscular disorders, pathology related to spine, coagulopathies were excluded from the study.

Sample size was calculated to be total 80 patients. Eighty patients were divided into 2 groups- case group (IVC group) and control group with 40 patients in each group. Patients were randomly allocated in either of the group by computer generated random number table. All patients were instructed to remain nil per oral for 8 hours.

A written informed consent was taken from all the patients included in the study. After taking patient on operating table, all monitoring devices like electrocardiograph (ECG), pulse oximetry (SpO2), non-invasive blood pressure (NIBP) were attached. Base line blood pressure, pulse rate and oxygen saturation were recorded. Intravenous line secured with an 18 G or 20G cannula. All patients were premedicated with inj. Midazolam 0.03mg/kg, given 5 minutes before the procedure to reduce the anxiety.

In 1st group, measurement of inferior vena cava diameter during inspiration (dIVCin) and expiration (dIVCex) was recorded by using M mode of frequency (2-5 MHz) curvilinear probe by keeping the probe in subxiphoid region 1-2cm below the level of the hepatic vein in long axis subcostal view. Collapsibility index > 36% was considered as fluid responders and 10 ml/ kg of ringer lactate (RL) given within 10-15 minutes in these patients before giving spinal anaesthesia. Inferior vena cava collapsibility index was reassessed and the if the collapsibility persist then we will again give the fluid till we achieve collapsibility index of <36%.

Collapsibility index of inferior vena cava was calculated by using this formula

IVC-CI = ((dIVCex – dIVCin) / dIVCex) × 100%. [6]

After recording all these parameters subarachnoid block (SAB) was given in L3-L4 space in midline sitting position using 25 G spinal needle (Quincke needle) with hyperbaric (0.5%) Bupivacaine 3.5 ml. (dose variation was kept as per patient's demographic requirements like weight, height, etc).

For 2nd group (control group) subarachnoid block was performed like group 1st with same drug and dosage but no preloading was done. Instead of that fluid was started while preparing patients for SAB. Measurement of IVC collapsibility and fluid requirement was not assessed preoperatively.

After the SAB, all the patients were kept in supine position, haemodynamic parameters SBP, DBP, MAP, heart rate, Spo2 were recorded immediately after spinal blockade at 1 min after that in every 2 minutes interval till 20 minutes, after that at every 5 minutes interval till 30 minutes and after that interval was increased for 10 minutes and 15 minutes till 120 minutes. Surgery was allowed once adequate level of sensory and motor blockade T6–T8 level achieved by using cold test. Hypotension is defined as decrease in 20% from the baseline mean arterial pressure or MAP < 65 mmHg. Hypotension was treated with repeated doses of vasopressor agents like ephedrine with initial bolus of 5 mg. Following parameters were estimated-IVCCI in case group patients, total amount of vasopressors used in both the groups, total amount of fluids given in both the groups and correlation between collapsibility index versus pre-spinal fluids and collapsibility versus baseline MAP in control group patients during the study period. The following vitals like blood pressure, pulse rate, Spo2, and any other complications were noted. Other complications related to spinal anesthesia like bradycardia, nausea, vomiting etc. noted and managed accordingly during surgery.

All data was analysed using MedCalc for Windows, version 19.3, a statistical software package designed for biomedical sciences. Chi square test was used for comparison of qualitative data. Pearson's

correlation coefficient was used to find correlation. Results were summarized as mean ± standard deviation (SD) or median and as numbers or percentages for categorical variables. The level of significance was set at $p < 0.05$.

Results

All 80 patients of two groups completed the study without any exclusion. Patient demographic data that includes age, sex, and weight of patients between two groups were comparable (table 1).

Table 1: Demographic distribution between the two groups

Characteristics		**Case Group** (n=40)	**Control Group** (n= 40)	**P value**
Age (years)		36.9 ± 13.76	42.0 ± 13.08	0.093
Weight (kg)		67.15 ± 4.40	68.65 ± 4.31	0.127
Gender	Male	33 (82.5%)	30 (75%)	0.412
	Female	7 (17.5%)	10 (25%)	
Duration of surgery (min)		85.3±14.8	85.2±14.8	0.982

Data represented as Mean ± SD, n- number of patients, SD- standard deviation

Table 2: Vasopressors and IV fluids usage between the groups

Parameters	**Case Group** (n=40)	**Control Group** (n=40)	**P value**
Number of times vasopressors given			
First dose	6 (15%)	17 (42.5%)	0.002
Second dose	Nil	6 (15%)	0.001
Pre spinal IV fluids (ml)	562.5±79.0	Nil	
Total IV fluids(ml)	2062.25±222.11	1838.25±203.19	0.0001

Data represented as Mean ± SD, n- number of patients, SD- standard deviation

Table 3: Comparison of hypotension in both groups

Incidence of Hypotesion	**Case Group** (n= 40)	**Control Group** (n= 40)	**P value**
	6 (15%)	17 (42.5%)	0.0299

Table 2 shows iv fluids used and vasopressors required in both the groups. Total iv fluid given in case group was more as compared to control group and results were found to be statistically significant. In case group, only 6 patients out of 40 required vasopressors. In control group, 23 patients out of 40 required vasopressors. The results were statistically significant.

Table 3 indicates incidence of hypotension in both groups. In case group, 6 patients out of 40 developed hypotension, whereas in control group 17 out of 40 patients developed hypotension. The results were statistically significant.

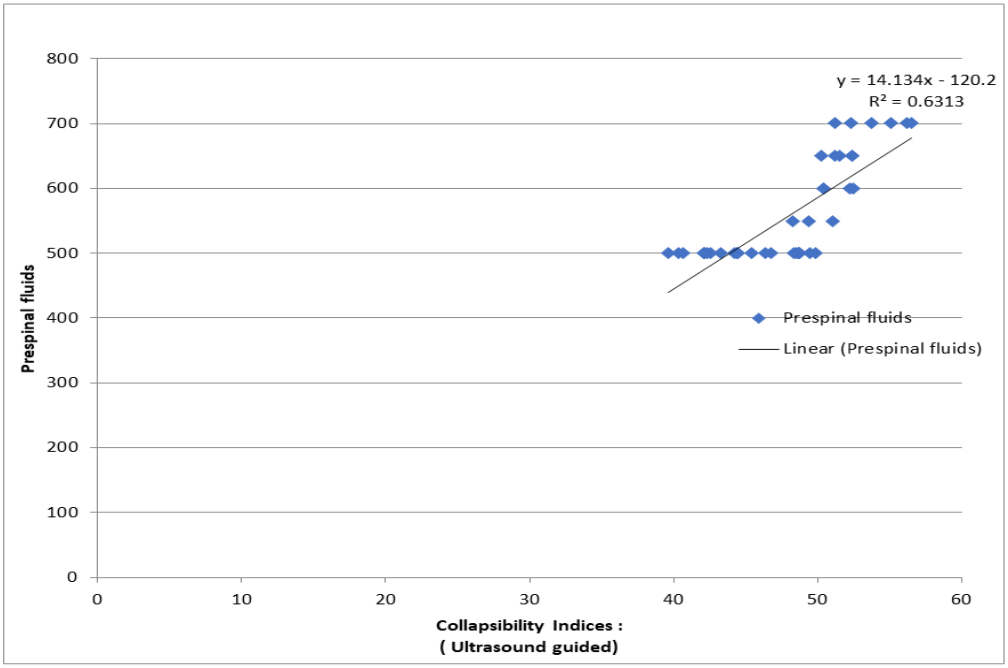

Figure 1: Correlation of pre-spinal fluid and IVCCI.

This graph is showing a positive correlation between collapsibility indices of inferior vena cava and pre spinal fluids ($r^2 = 0.6313$). the result was statistically significant with a p value of <0.0001.

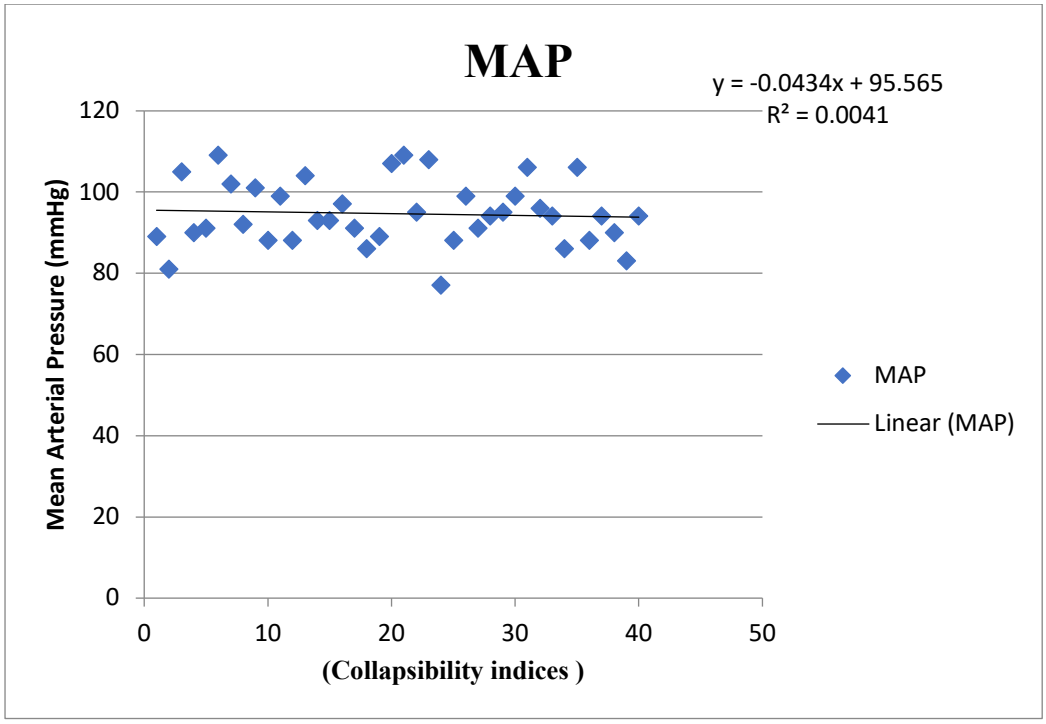

Figure 2: Correlation of mean arterial blood pressure and IVCCI.

According to this figure there is no positive correlation between collapsibility indices and baseline mean arterial pressure. (r^2= 0.0041)
P value (0.979) is statistically insignificant.

Discussion

In our study, we have seen that IVC-guided fluid optimization with the help of ultrasound machine before giving spinal anaesthesia leads to 47% reduction in the incidence of spinal induced hypotension as well as requirement of vasopressors. Sub arachnoid block provide good operating conditions with drier surgical field, less incidence of deep vein thrombosis and pulmonary embolism, and also good for postoperative analgesia. Above all mental function of the patient does not hamper as seen in general anaesthesia. [7] As we all know that risk of hypotension and bradycardia are more in spinal anaesthesia cases. Hypotension further may lead to several adverse effects such as coronary ischemia and delirium. [8,9]. However, healthy patients generally well tolerate the hypotension by leading only to light headedness, nausea and vomiting. [10] Ting Ni T. et.al. [11] concluded that IVCCI significantly reduce the incidence of hypotension in patients undergoing non cardiac and non-obstetric surgery. IVCCI had a sensitivity of 83.9% and specificity of 76.3% for predicting post spinal anaesthesia hypotension at a cut off point of >42%. It also concluded that use of vasopressors and total amount of IV fluid given was significantly lower in IVC guided group as compared to control group. Similarly, Ceruti S. et.al. [12] conducted a prospective, randomized, cohort study among 160 patients scheduled for surgery under spinal anaesthesia. It concluded that IVC-US as an effective method to prevent post spinal anaesthesia hypotension by IVC-US guided fluid administration before spinal anaesthesia. Relative risk reduction of hypotension between the two groups was 35%. The need of vasoactive drugs was significantly lower in IVC-US group, whereas total amount of fluid given was higher in IVC-US group as compared to control group. Zhang et.al[5] in his prospective study done on 100 patients, investigated the prediction of hypotension after induction of general anaesthesia by preoperative IVCUS. Maximum IVC diameter and IVCCI were measured preoperatively. After regression analysis, they found that IVCCI was an independent predictor of hypotension with odds ratio 1.17 (1.09–1.26). They concluded that preoperative IVCCI measurement was a reliable predictor of hypotension after induction of general anaesthesia with a sensitivity of 78.6% and a specificity of 91.7% at a cut-off value of 43% and an AUC of 0.90. Another study done by Ayyanagouda B et.al. [13] in which role of IVCUS was seen in everting spinal induced hypotension in 80 patients undergoing hernia and hydrocele surgeries. They found that ultrasound guided fluid optimization has reduced the chances of SIH up to 40% in spinal anaesthesia and also reduced the use of vasopressor drugs. Zhang et.al [14] in a systematic review where a total of eight studies involving 235 patients were

analysed. The cut-off values of IVCCI varied across studies ranging from 12 to 40%. The sensitivity and specificity in the overall population were 0.76 and 0.86 respectively. It concluded that IVCCI was of great value in predicting fluid responsiveness. Salam ER. et al. [15] in his study concluded that preoperative IVCCI is better predictor of occurrence of post-spinal arterial hypotension as compared to IVC: Ao index. Szabo et al [16] have studied the role of IVCCI in the prediction of hypotension associated with general anaesthesia in spontaneously breathing noncardiac surgical patients. It concluded that ultrasound-guided IVC fluid optimization before giving spinal anaesthesia led to 47% reduction in the incidence of SIH. Singh Y. et. al. [17] did a prospective observational study among 45 pregnant patients undergoing elective caesarian section. They concluded that IVC-CI is not a predictor of post spinal hypotension. Studies done by Pinsky et al. and Maciuliene et al. [18,19] reduction in IVC diameters and increase in IVCCI do not predict hypotension and bradycardia during spinal anaesthesia in spontaneously breathing patients undergoing elective knee joint replacement surgery.

Acknowledgements: Nil

Conclusion:

The incidence of spinal induced hypotension and the use of vasopressors during spinal anaesthesia can be reduced by using IVC-guided fluid optimization by using USG preoperatively before giving spinal anaesthesia. There is a positive correlation between IVCCI and pre spinal fluid which prevents SIH in patients posted for femur fracture surgeries.

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