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ACCURACY OF THE TRANSVERSE DIAMETER OF RIGHT COMMON FEMORAL VEIN BY ULTRASOUND IN THE SUPINE POSITION FOR PREDICTING POST-SPINAL HYPOTENSION DURING CESAREAN DELIVERY

Sadaf Arshad[*1], Ashraf Zia[2], Nabila Arshad[3]

[*1]*PG Trainee Anesthesiology, AIMC/ Jinnah Hospital Lahore*
[2]*Professor Anaesthesiology, AIMC/ Jinnah Hospital Lahore*
[3]*PG Trainee General Medicine, Nishter Hospital Multan*

[*1]dr.sadafarshad@gmail.com

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Corresponding Author: *
Sadaf Arshad

Abstract

Objective: *To validate the accuracy of ultrasound measurements of the transverse diameter of the right common femoral vein (RCFV) in the supine position for predicting post-surgical hypotension (PSH) in women undergoing scheduled C-sections with spinal anesthesia.*

Study design: *Cross-sectional validation study.*

Place and duration of the study: *Department of Anesthesia, Jinnah Hospital, Lahore, from 01 August 2024 till 31 January 2025.*

Methodology: *200 multiparous women aged 20-40 years scheduled for elective C-section with spinal anesthesia were enrolled in this study. The researchers collected patient demographics, body mass index and parity on a structured data form before conducting pre-operative ultrasound measurement of the RCFV at approximately 15 minutes prior to initiation of anesthesia. Intra-operative monitoring will be conducted to determine hypotension as defined as blood pressure < 20% from baseline. Statistical evaluation was done with the use of SPSS v.27 using t-test, and chi-square tests.*

Results: *In total, 69.0% (n=138) of the 200 subjects undergoing surgery experienced an intraoperative period of PR (i.e. intraoperative hypotension). The mean RCFV diameter in the hypotensive subjects was significantly greater than that of non-hypotensive subjects (12.97 ± 0.63 vs. 12.31 ± 0.78 respectively; p < 0.001). Ultrasound measurement of RCFV diameter had a sensitivity of 92.0%, PPV of 83.6% and NPV of 77.1%.*

Conclusion: *The transverse diameter of RCFV is a reliable predictor of PSH in patients undergoing cesarean delivery, when the RCFV diameter is > 12.2 mm, the patient is at increased risk for post-spinal hypotension.*

Introduction:

Spinal anesthesia is the preferred technique for delivery because it has been shown to be effective and safe; however, there is still a risk of developing post-spinal hypotension (PSH), which happens in 64% to 78% of patients globally(1). The incidence of PSH in Ethiopia has been 64%; a study done on Somali women revealed that it occurs in 78.1%

of these cases. Contributing factors to the occurrence of PSH include maternal obesity (high body mass index [BMI]) and inadequate preload. In Pakistan, PSH accounts for a large proportion of Mother's anesthesia-related morbidity, with local observational studies indicating that PSH occurs in an estimated 70% to 76% of local cases(2); this puts women at even higher risk in low-resource settings such as Pakistan. PSH occurs due to the combined effects of vasodilation from sympathetic block and the direct aortocaval compression caused by the pregnant uterus; this can lead to maternal nausea, fetal acidosis, and neonatal depression in the mother and child(3).
Ultrasound is now being used to assess vascular parameters non-invasively for the prediction of PSH; inferior vena cava (IVC) collapsibility has proven useful but is limited due to positioning and cardiac artefacts. Other studies have suggested a more reliable measure may be the transverse diameter of the right common femoral vein (RCFV) in the supine position, since the IVC may compress distally to the site of compression.(4,5).
A prospective 2021 investigation of 56 mothers in labor demonstrated an association of an RCFV transverse diameter of more than 12.2 mm and PSH (OR 2.022, 95% CI 1.261-3.243; AUC 0.759) and provided pre-anesthetic stratification.(6).
This cross-sectional validation study will evaluate the RCFV transverse diameter to accurately predict PSH during C/S and incorporate local data from Pakistan. Existing predictors of PSH, such as IVC parameters, are not reliable in the supine position; the RCFV transverse diameter represents an easy and practical way to assess PSH risk pre-operatively with a high degree of accuracy. Validation of the current study will help ensure that the RCFV transverse diameter will be applicable to the greater population, not just to mothers in the two participating hospitals.

Methodology:
After approval from the Institutional Review Board this cross-sectional study validation study was conducted at Department of Anesthesia at Jinnah Hospital / Allama Iqbal Medical College (Lahore) over 6 months (from 01 August 2024 till 31 January 2025) .
This study was conducted on 200 patients selected using simple random sampling. The sample size was determined using a sensitivity and specificity calculator using the following parameters: 95% confidence interval, hypotension prevalence of 33%, femoral vein diameter (sensitivity 62.5%, margin of error 12%), and femoral vein diameter (specificity 78.1%, margin of error 7.5%)(6).

Inclusion criteria: Pregnant women between the ages of 20 and 40 years, who are multiparous (having 5 or fewer babies), have been gestationally functional for > 37 weeks (by LMP), and will be undergoing elective cesarean section (under spinal anesthesia), will be included.

Exclusion criteria: Liver dysfunction (ALT/AST greater than 40 IU), kidney disease (creatinine greater than 2 mg/dL), malnutrition (Hb less than 10 g/dL), underactive thyroid (TSH level greater than 5 IU), bleeding disorder (PT greater than 15 seconds, INR greater than 2) and/or any known form of an allergy to the procedure itself.
The data was collected through a structured proforma instrument (Proforma) for the purpose of creating an accurate assessment and analyzing the likelihood of the occurrence of hypotension during the intraoperative period. The assessment consisted of three sections. The first section included baseline demographic variables such as age, height, weight, BMI, gestational age, parity, ASA status, and comorbidities (anemia, hypertension, diabetes). All subjects received pre-operative ultrasound imaging of their right common femoral vein at 15-minute intervals prior to the administration of an anesthetic, utilizing a high-frequency linear probe to measure the transverse diameter of the vein.
The second section included the administration of spinal anesthesia utilizing standard aseptic practices in the operating room. Subjects were monitored during surgery for signs and symptoms of hypotension, which was defined as a decrease in blood pressure from baseline of greater than 20%. Surgical time and intraoperative blood loss were

also recorded. From the results of these assessments, subjects were classified as true positive, true negative, false positive, or false negative based upon their femoral vein diameter (> 12.2 mm or ≤ 12.2 mm) and the occurrence of hypotension.

The analysis for this data was performed using Statistical Package for Social Sciences (SPSS) version 27. The Shapiro–Wilk test was used to assess the normality of height (p-value = 0.661), weight (p-value = 0.171), and femoral vein transverse diameter (p-value = 0.835), duration of operation time (in minutes) (p-value = 0.057), and blood loss after delivery during uterine involution (p-value = 0.573). Therefore, these variables were normally distributed ($p > 0.05$). Conversely, age ($p < 0.001$), BMI ($p = 0.002$), and gestational age ($p < 0.001$) were determined to be non-normally distributed ($p < 0.05$). Normal Quantitative parameters were reported as the mean ± SD (age, duration of operation time (in minutes), blood loss after delivery during uterine involution, and diameter of the right femoral vein). Non-normal variables, such as Body Mass Index (BMI) and gestational age, were reported as median (interquartile range). Qualitative data were reported by frequency/percent of the whole sample for ASA classifications, the presence of comorbidities, and the presence of hypotension. An independent sample t-test was performed to compare the means of femoral vein diameter between the positive and negative intraoperative post spinal hypotension. Use of 2 × 2 contingency tables to calculate sensitivity and specificity, PPV, NPV, and overall accuracy for the diagnosis of the transverse diameter of the right femoral vein.

Results:

A total of 200 patients participated, with a mean age of 30.15 ± 6.42 years, and a median age was 30.50 (IQR 12.00). All participants' mean height, weight, and BMI were 159.25 ± 6.24cm, 69.76 ± 8.51kg, and 27.66 ± 4.21 kg/m², respectively. The mean gestation was determined as 38.55 ± 1.13 weeks (median 39.00, IQR 2.00), and condyle diameters of the femoral vein were considered to be 12.77 ± 0.74mm (median 12.80mm, IQR 0.97mm). Operative times and blood loss means were 81.01 ± 14.54 minutes (median 81.35 minutes, IQR 20.25 minutes), 394.34 ± 100.73 ml (median 394.05 ml, IQR 140.08 ml).

Table I: Descriptive statistics of continuous variables (n = 200)

Variable	Mean ± SD
Age (years)*	30.50 (12.00)
Height (cm)	159.25 ± 6.24
Weight (kg)	69.76 ± 8.51
BMI (kg/m²)*	27.60 (5.28)
Gestational Age (weeks)*	39.00 (2.00)
Femoral Vein Diameter (mm)	12.77 ± 0.74
Operative Time (min)	81.01 ± 14.54
Blood Loss (ml)	394.34 ± 100.73

**Non-normal variables reported as median (IQR)*

In comparison to parity, 0 children were born to 20.0% of mothers; 1 to 21.0%; 2 to 16.5%, 3 to 24.5%, and 4 to 18.0% of mothers. Seventy-six percent of all patients had ultrasound-detectable post-spinal hypotension, while 69.0% of all patients had intraoperative post spinal hypotension recorded. Patients with comorbidities included 11.5% with anemia, 16.0% diabetes; 18.0% hypertension; 9.5% multiple illnesses, and no illness was present in 45.0% of the total number of patients. ASA class I 61.0% and class II, 39.0% of patients received classifications based on physical status during surgery.

Table II: Frequency distribution of categorical variables (n = 200)

Variable	Category	n (%)
Parity	0	40 (20.0)
	1	42 (21.0)
	2	33 (16.5)
	3	49 (24.5)
	4	36 (18.0)
Ultrasound Post-Spinal Hypotension	Negative	48 (24.0)
	Positive	152 (76.0)
Intraoperative Post-Spinal Hypotension	Negative	62 (31.0)
	Positive	138 (69.0)
Comorbidities	1	90 (45.0)
	Anemia	23 (11.5)
	Diabetes	32 (16.0)
	Hypertension	36 (18.0)
	Multiple	19 (9.5)
ASA Class	I	122 (61.0)
	II	78 (39.0)

Using an independent sample t-test, femoral vein diameter showed statistically significant differences (12.97 ± 0.63 vs 12.31 ± 0.78mm; $p<0.001$) between patients with vs without intraoperative post-spinal hypotension.

Table III: Comparison of femoral vein diameter with intraoperative post-spinal hypotension using independent sample t-test

	Intraoperative Post-spinal Hypotension		
Parameter	**Negative**	**Positive**	**p-value**
Femoral Vein Diameter (mm)	12.31 ± 0.78	12.97 ± 0.63	<0.001

Statistical significance was set at $p < 0.05$.

The contingency table (2×2) used to analyze these data indicated a strong association between ultrasound-measured post-spinal hypotension and intraoperative hypotension. With respect to predictor variables, of the 48 patients with negative ultrasound (FN), 11 developed hypotension (FN), and 37 did not develop hypotension (TN). In contrast, of the 152 patients with positive ultrasound (TP), 127 developed hypotension (TP), and 25 did not develop hypotension (FP). This association was statistically significant as indicated by the chi-square statistic ($\chi^2 = 62.705$, dfs = 1; $p<0.001$).

Table IV: 2×2 contingency table of ultrasound-detected post-spinal hypotension versus intraoperative hypotension

Ultrasound Post-Spinal Hypotension	Intraoperative Post-spinal Hypotension		Total
	Negative	**Positive**	
Negative	TN = 37	FN = 11	48
Positive	FP = 25	TP = 127	152
Total	62	138	200

TP: True positive, FP: False positive, TN: True negative, FN: False negative

The ability of ultrasound to diagnose post-anesthesia hypotension before intra-operative hypotension was assessed. The ultrasound had a sensitivity of 92.0%, indicating that it was able to accurately detect most patients who experienced intra-operative hypotension; however, its ability to accurately detect patients who did not experience intra-operative hypotension was moderate and therefore not as conclusive. The positive predictive value (PPV) of ultrasound was 83.6%, while the negative predictive value (NPV) was 77.1%. This shows that a positive ultrasound indicates a high likelihood of developing intra-operative hypotension; however, a negative result may not be as reliable to exclude the possibility of developing intra-operative hypotension.

Discussion:

We recently conducted a validation study at a single site that measured the transverse diameter of the right common femoral vein (RCFV) with ultrasound in supine individuals and evaluated how well this measurement predicts hypotension post-spinal anesthesia for cesarean deliveries. Among the 200 patients enrolled, those who experienced hypotension (mean diameter = 12.97 mm) had significantly larger diameters than those without hypotension (mean diameter = 12.31 mm) ($P < 0.001$). In addition, when hypotension was predicted by the ultrasound measurement, it was associated with actual intraoperative hypotension ($\chi^2 = 62.705$, $P < 0.001$). The sensitivity of the ultrasound was 92.0%, the positive predictive value (PPV) was 83.6%, and the negative predictive value (NPV) was 77.1%. Thus, a positive ultrasound measurement of RCFV diameter provides very useful information to identify women at risk for developing hypotension, while a negative measurement will not exclude subsequent hemodynamic instability.

Our findings are consistent with results reported by Yao et al., who found that increased transverse RCFV diameter was independently associated with hypotension following spinal anesthesia among women undergoing elective cesarean deliveries. In a cohort of 56 women, they determined a cut-off value of approximately 12.2 mm; when this value was exceeded, good discrimination between those who did or did not develop hypotension occurred(6). They concluded that using RCFV measurement obtained by ultrasound provides an excellent opportunity for pharmacy personnel to identify women at significant risk for developing hypotension. Our data for RCFV diameter (≈12.30 mm in normotensive and 13.00 mm in hypotensive patients) is consistent with Yao et al's established threshold levels and supports the hypothesis that the larger the RCFV size, the IVC will result in greater the risk of post-sympathectomy induced hypotensive events.

More recently, clinical studies have also supported the concept of using the femoral vein to provide predictive modeling for obstetric neuraxial anesthesia. A recent clinical study published in 2025 utilized a cohort of women who underwent cesarean delivery to evaluate transverse femoral vein diameter. That study demonstrated that women who had longer right-sided transverse femoral vein diameters (>11.80 mm to 12.20 mm) had larger odds ratios for developing post-spinal hypotension and indicated that, depending on the results of those measurements, could be utilized routinely during their pre-anesthetic evaluations for obstetrics.(7). The odds ratio for larger right femoral vein circumference at the time of spinal anesthesia reported by these authors is comparable to the magnitude and direction of the odds ratio identified by us in this study; although the size of their sample population was smaller and utilized slightly different exclusion criteria.

Several studies have examined various indices that derive from ultrasound and are helpful in predicting hypotension related to spinal anaesthesia besides the RCFV. One observational study evaluated ultrasound measurements (of the femoral venous and inferior vena caval diameters) preoperatively to identify patients at risk of developing spinal hypotension (non-obstetric surgery). The authors concluded that due to the heterogeneous performance across studies and populations, these variables could not be reliably used for pre-operative screening, and therefore, should not be routinely included in clinical

practice when screening patients for spinal anaesthesia-related hypotension. Similarly, systematic reviews also indicated that while there is evidence to support the use of femoral venous or inferior vena cava ultrasound parameters as screening tools for spinal anaesthesia-related hypotension in a general surgical population, the current level of evidence remains limited and inconsistent to use these parameters as stand-alone tools across surgery populations.(8–10).

Other ultrasound modalities have also focused on arterial, rather than venous, variables in evaluating spinal anaesthesia induced hypotension. A study conducted by Helmy et al. in 2025 was able to successfully use femoral artery Doppler indices and their agreement to detect differences in pulsatility and resistive indices in females undergoing elective caesarean sections to relatively accurately predict the patient's risk of becoming hypotensive after receiving spinal anaesthesia.(11). A further analysis of the predictive ability of some Doppler indices yielded favourable results, including NPV estimates of 100%.

In addition to RCFV, numerous recent investigations have also looked at additional ultrasound-derived measurements for predicting hypotension due to spinal anesthesia. For example, an observational investigation of non-obstetric procedures revealed that pre-operative ultrasound measurements of the femoral vein and inferior vena cava dimensions were not reliably trustworthy enough to suggest their use as a routine screening tool for predicting hypotension due to spinal anesthesia; heterogeneous performance across populations and study designs was identified(12,13). In keeping with these disparate findings, concluded that further studies are still necessary before femoral veins or inferior vena cava parameters can be endorsed as stand-alone screening methods for predicting hypotension due to spinal anesthesia in larger surgical patient populations(14–16). Contrary to these inconsistent findings, our findings in the more homogenous cesarean population suggest that the RCFV diameter performs better when the underlying pathophysiology is primarily driven by pressure from a pregnant uterus onto the inferior vena cava, which exerts a direct effect on the femoral venous system.

Several studies using ultrasound have focused on arterial rather than venous parameters. In 2025, Helmy et al. evaluated the ability of Doppler indices measured from the femoral artery to predict spinal hypotension during elective cesarean section, with some indices demonstrating an NPV of 100%. While moderate sensitivity and specificity are commonly seen with various perfusion index-based and IVC-based techniques, the reported predictive performance of the current study would suggest that the sensitivity of the RCFV is greater than that of some IVC-based and perfusion index-based prediction models(17). While the NPV is set at a moderate level (77.1%), this indicates that a negative ultrasound examination will not allow the provider to exclude the diagnosis of hypotension reliably in a patient with severe spinal anesthesia based on the absence of femoral artery Doppler changes.

In contrast to using arterial Doppler examinations as the exclusion method for hypotension, the RCFV appears to function more reliably as a “rule in” test for identifying parturients at high risk for developing hypotension, rather than as a definitive exclusionary tool. A clinically relevant PPV (83.6%) can be derived from the current study due to the high baseline incidence (69%) of hypotension in our cohort, which indicates that a positive RCFV test result will substantially increase the pre-test probability of hypotension. In addition, a similar PPV was established in the original RCFV study examining patients at risk for hypotension, where a threshold of approximately 12.2 mm improved the population with respect to the risk for hypotension but with an emphasis on the area under the ROC curve rather than conventional predictive values.(18). To conclude, these findings indicate that RCFV measurement should be considered as part of multimodal risk assessment algorithms, perhaps in conjunction with other dynamic measures (e.g., perfusion index, arterial Doppler, or clinical risk factors) to develop individualised prophylaxis strategies.

Limitations of Study:

The methodology of our study needs to be carefully reviewed against current literature; specifically, the limitations of using an observational, single-centre (as opposed to randomised controlled trial) design, as well as the significant operator dependence with ultrasound-based measurements of RCFV and IVC. Previous reports have strongly supported the technical feasibility of RCFV and IVC measurements in the majority of parturients (to be honest, there really is no need to worry about the technical feasibility of these methods), but inter-operator variability could significantly attenuate diagnostic accuracy, especially when performed by less-experienced operators. Although we did not formally test intra- and inter-observer variability in this relation, many of the recent studies about standardising ultrasound training and protocols have attempted to do so, in order to increase reproducibility.

In our study, we did not adjust for all potential confounding variables, such as the use of prophylactic vasopressor agents; strategies used to manage intra-operative fluid volume, or differences between patients in dosing spinal anaesthetics. These 3 variables have been previously identified as having the ability to modify both the occurrence and severity of hypotension in the setting of a cesarean delivery. To further assess the role of RCFV measurement in helping predict the risk of post-spinal hypotension in obstetric anaesthesia, multicentre studies need to be designed using standardised anaesthetic/prophylactic protocols; defined RCFV cut-off values; and an approach to both venous and arterial ultrasound measurement indices.

Conclusions:

The right common femoral vein (RCFV) transverse diameter is an effective non-invasive predictor of post-spinal hypotension (PSH) in elective cesarean section patients. The results support the notion that RCFV diameters greater than 12.2 mm are strongly associated with increased risk of hemodynamic instability following spinal anesthesia. The 92% sensitivity and high positive predictive value for using RCFV measurement make it an ideal "rule in" test during pre-anesthetic evaluations. Use of this US-guided measurement will allow providers to recognize at-risk patients and implement appropriate prophylactic vasopressor therapy during labor, thereby reducing anesthesia-related maternal morbidity.

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