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Prediction of spinal anesthesia-induced hypotension in cesarian section with focus on carotid doppler ultrasound and cardiometry

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Abstract
The occurrence of hypotension following spinal anaesthesia has been seen in a significant number of elective instances when a comprehensive strategy for preventing and treating it was not implemented. Carotid corrected flow time changes provide a straightforward, dependable, and non-intrusive approach to anticipate blood volume without the need for arterial cannulation. Impedance cardiography has the ability to identify little variations in stroke volume that occur when the pregnant woman shifts her posture. Impedance cardiography tests indicated that there was a peak in cardiac contractility during the antepartum period. However, during the postpartum phase, there was a decline in contractility and a rise in thoracic fluid content.

Keywords: Spinal anesthesia-induced hypotension, cesarian section, focus, carotid doppler ultrasound and cardiometry

Introduction

Spinal anaesthesia is the preferred method for elective caesarean section (CS) because to its ability to safeguard against the usual negative consequences associated with general anaesthesia, including the potential for aspiration, difficulties with the airway, and the adverse impact of iv anaesthetic medicines on the foetus. Additionally, it offers efficient pain management, rapid resumption of daily activities, and enhances quality of life [1, 2].

Despite the implementation of several strategies including IV fluid administration, prophylactic vasopressor medication, and patient positioning, hypotension may still occur, with incidences as high as 30% despite these interventions [3, 4]. When vasopressors are administered as a preventive measure, around 30% of women experience reactive hypertension [5]. Hypotension is observed in at least 40% of patients following the administration of fluids. It is important to take into account the potential rare adverse consequences of anaphylaxis, volume overload, and coagulopathy [5].

Variable hemodynamic monitoring modalities had been utilised in the anticipation of post-spinal hypotension. pulse oximetry variables, including the perfusion index and pulse variability index, Ultrasound assessment of fluid status and non-invasive cardiometry were used [6]. Pre-anesthetic carotid artery corrected flow time (FTc) had been shown to be a reliable indicator of post-spinal hypotension in cesarean section [7]. The baseline data acquired using the bioreactance-based technology can potentially function as a prognosticator for post-spinal anaesthesia hypotension in pregnant women [8].

Predictors of post-spinal hypotension

Precise anticipation of post-spinal hypotension during CS could improve clinical decision-making, alter therapeutic management, and lead to appropriate early interventions. over 30 predictors of post-spinal hypotension were investigated. These predictors can be classified into seven categories: demographic features, baseline hemodynamic parameters, baseline sympatho-vagal balance, postural stress testing, peripheral perfusion indices, blood volume and fluid responsiveness indicators, and genetic polymorphism [9].

Consequences of post-spinal hypotension

Acute low blood pressure decreases blood flow to the brain, causes transient ischemia to the brainstem, and triggers the vomiting centre, leading to vomiting and nausea. The utilisation of near-infrared spectroscopy demonstrates that hypotension is correlated with a substantial reduction in maternal regional cerebral blood volume, cerebral oxygen saturation, and oxygenation [10]. This aligns with the finding that providing additional oxygen may alleviate the sensation of nausea [11].

Intraoperative nausea and vomiting (IONV) occur more frequently throughout spinal anaesthesia for CS compared to non-obstetric surgery. The cause of this is influenced by multiple factors. Possible causes of anaesthesia include low blood pressure, raised activity of the vagus nerve, and the consumption of opioids through parenteral or neuraxial routs. Non-anesthetic factors that can cause it includes surgical stimulation, surgical bleeding, drugs like antibiotics and uterotonic agents, and mobility near the end of surgery. Both anaesthetic and non-anesthetic factors can independently or cumulatively contribute to the occurrence of IONV [12, 13].

High dose of intrathecal morphine (>100-250 µg) prolongs analgesia after CS compared with lower doses (50-100 µg) but with higher incidence of IONV. So, clinicians should weigh the advantages and possible adverse effects of using high dose of intrathecal morphine for CS [14].

while intrathecal fentanyl was correlated with a significant reduction in vomiting and nausea. Manipulation of the intra-abdominal organs and peritoneal traction throughout CS cause intraoperative visceral pain, leading to complaints of vomiting and nausea from the pregnant women. Including intrathecal fentanyl with the local anaesthetic eliminates visceral discomfort and reduces the occurrence of vomiting and nausea [15, 16].

Neuraxial anesthesia-induced hypotension is a significant contributing factor to the development of IONV. The use of prophylactic vasopressors was found to significantly reduces the incidence of IONV during CS [17].

Management of post-spinal hypotension

The combined application of low-dose spinal anaesthesia, appropriate hydration therapy, and vasopressor medication is employed to treat maternal hypotension caused by spinal anaesthesia. Since none of the vasopressors currently available have been found to cause significant harm to both the mother and the foetus, it is not recommended to exclude any of them from obstetric practice. Rapid crystalloid co-loading is just as effective as colloids and ought to be chosen due to its lower risk profile [18]. Ondansetron, while not typically used for hypotension, has been found to effectively decrease the occurrence of hypotension and bradycardia. These effects are mild and are particularly notable in the subset of subjects having CS. Further investigation is required to definitively determine its role [19].

There is a wide range of hemodynamic monitoring tools available. Various non-invasive monitoring approaches have been developed to achieve precise and consistent measurements, while reducing the potential difficulties associated with invasive methods. Ultrasound is highly recommended for determining volume status due to its non-invasive nature, straightforward acquisition, and the ability to provide consistent results. Therefore, spectral carotid Doppler ultrasound (CDU), a non-invasive method for monitoring blood flow, has become become increasingly popular [20].

Predictors of spinal anesthesia-induced hypotension

There were >30 predictors which were categorized into seven domains [21]

1. Demographic features
2. Baseline hemodynamic parameters
3. Baseline sympatho-vagal balance
4. Postural stress testing
5. Peripheral perfusion indices
6. Blood volume and fluid responsiveness indices
7. Genetic polymorphism

CDU for assessment of hemodynamic parameters

Several investigations were conducted to compare the efficacy of common carotid artery (CCA) sonography with transthoracic echocardiography (TTE) in measuring cardiac output (CO). A study was undertaken to assess the relationship between CO and several hemodynamic variables in the carotid artery among subjects who were stable in terms of their blood flow. It was discovered that changes in preload of the heart and the resulting changes in cardiac output directly corresponded to changes in carotid blood flow. This indicates the possibility of utilising carotid flow as a substitute for cardiac output. The most favourable metrics were systolic carotid flow, corrected flow time, and total carotid flow [22].

No notable disparity existed in carotid and TTE cardiac output among all genders, age groups, and individuals with or without mechanical ventilation. Carotid artery Doppler can be used as a substitute for assessing cardiac output in emergency situations and when it is not possible to estimate cardiac output using TTE [23].

Various research have investigated the utilisation of CDU for evaluating fluid responsiveness and volume status, which indicates the precise measurement of the amount of blood circulating in the body. Based on the findings, the changes in FTc generated by passive leg raise (PLR-ΔFTc) seem to be a reliable indicator for hypovolemia [24].

CDU-derived characteristics are utilised for the prediction of fluid responsiveness, which refers to a patient's capacity to exhibit a favourable response to a preload challenge. This study examines the relationship between the diameter of the CCA and hemodynamic parameters for individuals who have undergone cardiac operations and were placed on mechanical ventilation. Ultrasound was used to visualise the CCA, and the percentage rise in the diameter during diastole was determined by measuring it before and after administering a crystalloid infusion solution. At the same time, pulse pressure variation and invasive arterial blood pressure were evaluated. A notable correlation was seen between the alteration in CCA diameter and the hemodynamic response. Moreover, the carotid diameter evaluated prior to volume expansion exhibited a substantial correlation with the change in pulse pressure variation following fluid delivery [25].

Fluid responsiveness in various clinical situations has been determined using FTc [26]. The hemodynamic variables in the carotid artery can accurately indicate volume responsiveness throughout both spontaneous breathing and mechanical ventilation owing to its superficial location, straightforward measurement, and minimal interference from respiration [26].

The pilot study [27] found that flow measures of the CCA accurately represented temporary variations in stroke volume and velocity time integral (VTI) in the descending aorta throughout simulated end-inspiratory/end-expiratory occlusion tests (sEIOT/sEEOT) performed on healthy participants. Aya *et al*. [28]discovered that changes in FTc caused by recruitment manoeuvres conducted by anesthesiologists throughout surgery can be used as markers to evaluate the fluid responsiveness of patients throughout the operation.

Cardiometry in obstetrics

The use of impedance cardiography to detect heart function throughout pregnancy and in various maternal postures has been documented. Impedance cardiography can accurately identify slight variations in stroke volume (SV) that occur due to alterations to maternal position. Impedance cardiography tests indicated that there was a high level of cardiac contractility during the antepartum period. However, after childbirth, there was a reduction in contractility and a rise in thoracic fluid content (TFC) [29].

Electrical cardiometry (EC) was utilised to determine standard impedance cardiography measurements during the latter half of pregnancy and within 48 hours following delivery, whether through vaginal or caesarean delivery. The values of EC can be utilised to interpret and evaluate individuals who have had similar tests and have hypertensive or otherwise difficult pregnancies [30].

Whole-body impedance cardiography has the potential to be a valuable noninvasive method for monitoring hemodynamics during CS. Upon reaching the destination, there was a significant 47% rise in CI and a notable 39% decline in SVRI, although the mean arterial blood pressure remained constant. The aforementioned alterations took place within a time frame of 2 minutes following the delivery of the newborn and remained in effect for an average duration of 10 minutes [31].

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