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IS CAVAL AORTIC INDEX A GOOD TOOL FOR PREOPERATIVE VOLEMIA ASSESSMENT?

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Introduction: Patient's volemia assessment remains a challenge in anaesthetic management and is one of the causes of lack of control in Spinal Anesthesia Induced Hypotension (SAIH) prediction; however, Caval Aorta Index (IVC/Ao) measurement seems to be simple, fast and high-accuracy tool in evaluation of volemia status in elective orthopaedic surgery.

Methods: Prospective, randomised study, performed on patients scheduled for elective anaesthesia in orthopaedic surgery; randomised into 2 groups: group 1 – patients with routine preloading with crystalloids; group 2 – patients with IVC/Ao evaluated ultrasonographically, and preloading at a Cut-off = 0.8. The outcome was appreciated by the incidence of hypotension after spinal anaesthesia in both groups.

Results: BMI ($p = 0.313$) and age ($p = 0.163$) distribution by groups didn't show a statistically significant difference in hypotension occurrence. Incidence of hypotension in both groups didn't show significant statistical difference ($p = 0.807$). There was lack of association between hypotension occurrence and absence of preloading (Odds Ratio = 0.941, CI 95% 0.575 – 1.538).

Conclusion: Caval Aorta Index represents a simple, fast, non-invasive, cost-effective method for volemia evaluation and it seems to be a good predictor of post-spinal anaesthesia hypotension.

Key words: anesthesia, spinal; aorta, abdominal; vena cava, inferior; hypotension, controlled.

ЧИ Є ПОКАЗНИК CAVAL AORTIC INDEX ЕФЕКТИВНИМ ІНСТРУМЕНТОМ ДЛЯ ПЕРЕДОПЕРАЦІЙНОЇ ОЦІНКИ ОБ'ЄМУ ЦИРКУЛЮЮЧОЇ КРОВІ?

Ольга Герасім

Вступ. Оцінка об'єму циркулюючої крові пацієнта залишається складним завданням в анестезіологічному менеджменті і є однією з причин відсутності передбачуваності гіпотензії, спричиненої спінальною анестезією (SAIH). Проте вимірювання індексу Caval Aorta Index (співвідношення нижньої порожнистої вени до аорти – IVC/Ao) вважається простим, швидким і високоточним методом оцінки вольємічного статусу при планових ортопедичних утручаннях.

Методи. Проспективне, рандомізоване дослідження було проведено серед пацієнтів, які підлягали плановій анестезії в ортопедичній хірургії. Пацієнти були рандомізовані на дві групи:

- група 1 – пацієнти з рутинною переднавантажувальною інфузією кристаллоїдів;
- група 2 – пацієнти, у яких ультразвуково оцінювали показник IVC/Ao і переднавантаження проводили за значення індексу $\leq 0,8$.

Кінцевий результат оцінювався за частотою виникнення гіпотензії після спінальної анестезії в обох групах.

Результати. Розподіл IMT ($p = 0,313$) та віку ($p = 0,163$) між групами не виявив статистично значущих відмінностей у частоті гіпотензії. Частота гіпотензії в обох групах також не показала статистично значущих відмінностей ($p = 0,807$). Зв'язок між виникненням гіпотензії та відсутністю переднавантаження не був виявлений (Odds Ratio = 0,941, 95% ДІ: 0,575–1,538).

Висновок. Індекс Caval Aorta Index є простим, швидким, неінвазивним та економічно ефективним методом оцінки вольємії, що може бути корисним предиктором розвитку гіпотензії після спінальної анестезії.

Ключові слова: анестезія спінальна, аорта черевна, нижня порожниста вена, контрольована гіпотензія.

Relevance and problem statement. Spinal anaesthesia is the standard anaesthetic technique used in orthopaedic surgery due to a number of advantages like rapid onset, cost-effectiveness, ease of administration, postoperative outcome, preservation of respiratory function [1, 2].

Despite that, the most common side effect after induction of spinal anaesthesia is Post Spinal Anaesthesia Hypotension (PSAH), which has an incidence of 5.4%, according to the data of Hartman et al [3] and directly correlate with patient volemic status.

Although the determination of volemia and stabilising the need for preloading could reduce the incidence of PSAH, the difficulty of volemic status determination remains one of the causes for lack of control in PSAH prediction, because despite there are a multitude of methods for assessing circulating blood volume such as central venous pressure (CVP), pulmonary artery catheterization, PiCCO (Pulse index Continuous Cardiac Output), Vigileo, they remains a subject of ongoing debate due to financial restrictions, high complication rates, invasiveness, and the length of time required for application [4].

In that context, ultrasound guided techniques for volume assessment appear to be simple, rapid, non- invasive, cost-effective, and does not require the presence of an imagist.

Even if there is a variety of ultrasonographic measurements like the Inferior Vena Cava (IVC) or Superior Vena Cava (SVC) measurement, Inferior Vena Cava Distension Index (IVCDI), Inferior Vena Cava Collapsibility Index (IVCCI), the Abdominal Aorta Index (IVC/Ao) seems to present a much higher accuracy compared to others, because the Aorta is a structure that does not collapse and maintains a relatively constant diameter, regardless of the volume state of the patients. Aortic diameter correlates with body surface area (BSA), patient age, and sex, unlike IVC, which collapses with decreasing intrathoracic pressure during inspiration and re-expands with an increasing pressure during expiration, which reduces its accuracy[5], but there is a small number of patients included in the previous published studies and not sufficient data about the cut-off point.

Materials and methods. Prospective, randomised, non-blinded, comparative study was conducted from November 2021 to August 2022, after obtaining approval from the national ethical committee (no. 4, dated 12 November 2021), that was carried out in accordance with the principles of the Declaration of Helsinki (2013) and good clinical practice. Written and informed consent for participation in the study and use of their data for research and educational purposes was obtained from all patients, after informing them about the ultrasound technique that was going to be used.

The study was performed on patients scheduled for elective anaesthesia in orthopaedic surgery, enrolled based on the following inclusion criteria: hospitalisation for scheduled orthopaedic surgery; preoperative anaesthesia physical status I–III, evaluated according to the Classification of the American Society of Anaesthesia (ASA); scheduled anaesthetic technique: spinal anaesthesia; age between 45–79 years; discontinuation of chronic antihypertensive medication ≥ 12 hours; informed consent obtained.

All patients were subjected to a preanaesthetic evaluation performed based on accepted institutional protocol.

Routine and specific investigations were conducted based on the patient's status.

Randomisation was performed using a computer-generated random number table, where the patients were assigned to one of two preset groups (Group 1 control – patients with routine crystalloids bolus preloading in a volume of 7 ml/kg/IBW; Group 2 studied – patients with IVC/Ao evaluated ultrasonographically, and a preloading at a Cut-off = 0.8[6]).

When the patient arrived at the operating room(OR), the baseline parameters, including heart rate (HR), non-invasive blood pressure, oxygen saturation (SpO₂) and electrocardiogram (ECG), were recorded.

An intravenous (IV) line was secured with an 18G or 20G catheter.

Subsequently, patients from Group 1 received the bolus of Ringer's lactate in a volume of 7 ml/kg/IBW, and then performed spinal anaesthesia; patients from Group 2 had the IVC/Ao Index measured by ultrasound, with the patient in the supine position, on the Anterior Median Line, Long- Axis View, with Inferior Vena Cava(IVC) measured near the hepatic veins confluence, and the abdominal Aorta (Ao) at 1 cm above the celiac trunk; after which the relate of IVC to Ao (IVC/Ao) was made to obtain the IVC/Ao Index.

If the obtained value of the index IVC/Ao was ≤ 0.8 the patient was preloaded with bolus of Ringer's lactate in a volume of 7 ml/kg/IBW, otherwise the spinal anaesthesia was performed.

The measurements were always made by the same anaesthetist, with the same ultrasound machine **HITACHI ARIETTA Precision**, convex probe C251 (1–5 MHZ), in M-Mode.

The spinal anaesthesia was performed in sitting position, under aseptic conditions.

A lumbar puncture was performed initially at L4–L5 and in case of failure after 2 attempts at L3–L4 interspace in all patients with a 25G pencil point spinal needle.

An isobaric solution of Bupivacaine 0.5 % was administered with the calculation of the dose of 0.15–0.17 mg/kg/IBW depending on the type of orthopaedic surgery, and the decrease by 0.5 mg of the obtained dose for every +5 years in patients > 65 years was made.

Monitored parameters: systolic blood pressure (SBP), diastolic blood pressure (DBP), mean arterial pressure (MAP), cardiac rhythm, pulse oximetry on admission and every 5 minutes within 30 minutes after spinal anaesthesia were registered, and the sensory block level was assessed by using a pinprick method.

Adverse effects like hypotension, bradycardia, nausea, vomiting, sweating or others were noted.

Post Spinal Anaesthesia Hypotension (PSAH) was defined as a decrease in MAP >30% from the initial MAP lasting >10 minutes in the first 30 minutes after spinal anaesthesia, with the need for therapeutic involvement for stabilization like the bolus of Ringer's lactate in a volume of 10 ml/kg/IBW administered, and at the persistence of hypotension boluses of 50 mcg of Phenylephrine every 5 minutes given.

Data was tabulated and introduced into Microsoft Excel. The results were analysed using Statistical Package for the Social Sciences (SPSS) statistics software version 20.0 (IBM Corporation).

Descriptive statistics were presented in terms of numbers. Categorical variables like ASA and gender were expressed in frequency and percentage. The comparison of categorical variables between the groups was carried out by using the Chi-square test.

The indicators of central tendency for distribution of age, gender and IBW were made by Skewness and Kurtosis measures.

The distributions of continuous and discrete variables like height, weight, duration of time from patient admission to anaesthesia administration, MAP, sensory block level were expressed in terms of mean (standard deviation) [95% confidence interval (CI)].

They were compared using an independent Mann-Whitney test. Results were statistically significant if the P value was <0.05.

Results. The study enrolled totally 521 patients, 22 patients were excluded from the study due to incomplete information regarding intra anaesthetic haemodynamics during entering the data from forms in Microsoft Excel, as result 499 patients were analysed, 253 in Group 1 and 246 in Group 2 [Figure 1].

Both groups were compared in terms of a normal distribution of age variable (mode = 68 years, Skewness = -0.333, Kurtosis = -0.417, SE Kurtosis = 0.218, CI 95%), with an average age 64.22 years (CI 95% 63.65–64.79) [Figure 2] and Body Mass Index (BMI) variable calc by World Health Organization (WHO) Classification [7], with mean value of 32.07 and SD = 5.22 [Figure 3].

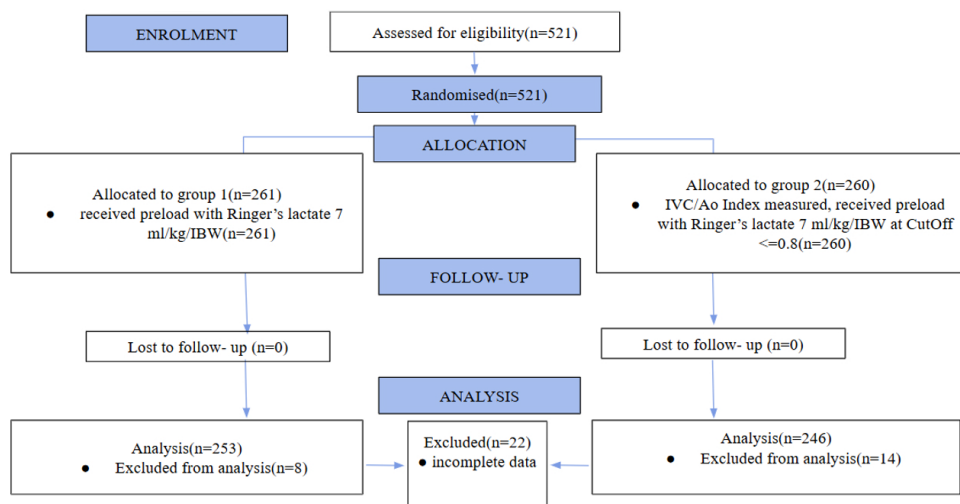


Fig. 1. CONSORT flow chart of the study groups. CONSORT = Consolidated Standards of Reporting Trials, n = number of patients

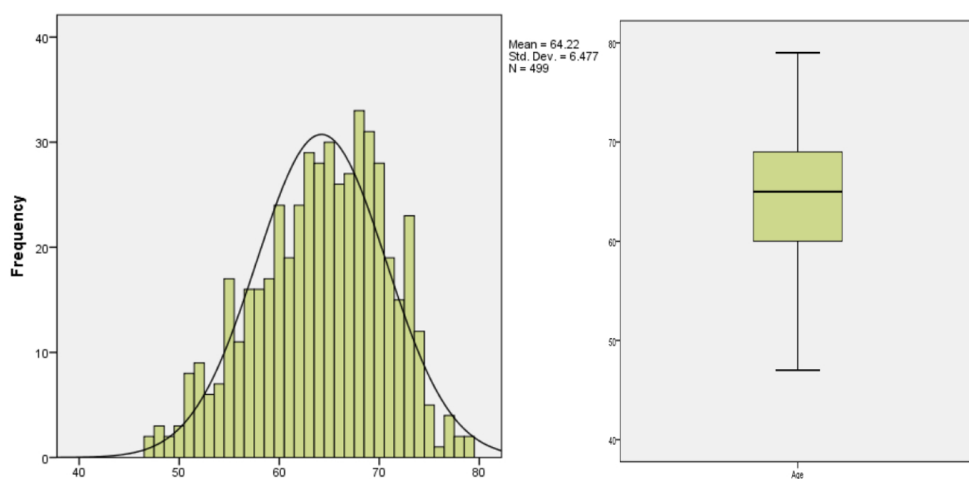


Fig. 2. Histogram with age variable distribution, N= number of patients

Incidence of PSAH between the groups was: 7.8 % (39) in Group 1 and 7.2% (36) in Group 2, that means that there is no significant statistical difference between the groups ($p = 0.808$) [Table 1], and at the same time there is lack of association between hypotension occurrence and absence of preloading (Odds Ratio = 0.941, CI 95% 0.575–1.538).

Also, the risk of hypotension at $IVC/Ao < 0.8$ corrected with crystalloids and $IVC/Ao \geq 0.8$ doesn't vary significantly (Odds Ratio = 1.08, CI 95% 0.305–3.881).

Conclusions. In our study, we demonstrate that the patients coming for elective surgery most often are normovolemic and don't need supplementary preloading before the spinal block is performed, and the IVC/Ao Index is a good tool for patient's volemia assessment.

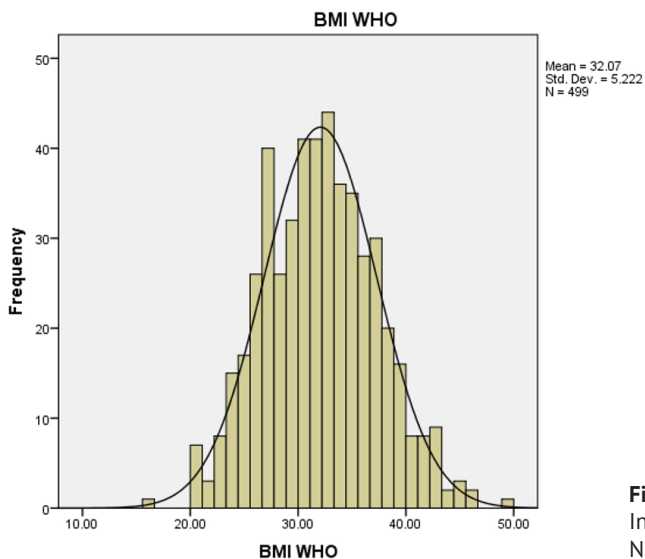


Fig. 3. Histogram with Body Mass Index (BMI) variable distribution, N = number of patients

Table 1

Incidence of Post Spinal Anaesthesia Hypotension(PSAH) between the groups

		Group Type		Total
		Group 1	Studied	
PSAH	No	214	210	424
	Yes	39	36	75
Total		253	246	499

		Group Type	PSAH
Group Type	Pearson Correlation	1	-.011
	Sig. (2-tailed)		.808
	N	499	499
PSAH	Pearson Correlation	-.011	1
	Sig. (2-tailed)	.808	
	N	499	499

Of course, there are other measures made by ultrasound that are used in the evaluation of patient volemic status like measurement of the Inferior Vena Cava Collapsibility Index (IVCCI), Inferior Vena Cava Distension Index (IVCDI), Inferior vena Cava(IVC) diameter or Superior Vena Cava (SVC) diameter that are used for PSAH prediction.

Unfortunately, literature reveals that the IVCCI's specificity and sensitivity is reduced regarding the PSAH prognosis. In a study conducted in 2022 by Ting-ting Ni et al. on 90 patients requiring spinal anaesthesia IVCCI has a sensitivity of 83.9%, a specificity of 76.3%, and a positive predictive value of IVCCI of 84% for predicting SAIH at a cutoff value >42% [8]. The results of the study made by Zhang et al. in 2016 on a batch of 90 patients

were more dramatic and showed a sensitivity and specificity of 78.6% and 64.8% of the IVCCI measurement in hypotension prediction at a cut-off value of 43% [9].

All these studies reveal a high variability of the results, and insufficient number of patients involved in the study, as well as the need to control the patient's inspiration and expiration peak, or other causes of pulmonary pressure modifications, in order to collect truthful data.

On the other hand, IVC/Ao Index present a much higher accuracy compared to IVCCI because the aorta does not collapse and maintains a relatively constant diameter, even if there is significant change in the patient's volume state. Aortic diameter correlates with body surface area (BSA), patient age, and sex, unlike IVC, which collapses with decreasing intrathoracic pressure during inspiration and re-expands with an increasing pressure during expiration, which reduces its accuracy [5].

Research study states that IVC/Ao is more specific in assessing body fluid status, and doesn't need a specialised imagist to perform the measurements [10].

In the end, we can conclude that "ultrasonographic assessment of the IVC/Ao Index in assessing the volume status appears to be a simple, rapid, non-invasive, cost-effective volume assessment, which does not require the presence of a specialised imagist, being practically devoid of contraindications." [11].

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