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REVIEW ARTICLE

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Hypotension in spinal anesthesia: predictive factors, prevention and volemia's non-invasive estimation methods

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ABSTRACT

Introduction. Evaluation of patient volemia arriving at a medical service today still represents a challenge for specialists, especially in those who need surgical and anesthetic intervention. One of the most common systemic side effect to anesthesia is hypotension. Spinal Anesthesia-Induced Hypotension (SAIH) because of sympathetic blockade is most frequently cited as a complication of subarachnoid anesthesia, its severity being influenced by the patient's volemic state. The aim of this literature review is to analyze if „routine" preanesthetic preloading reduces the incidence of SAIH in patients undergoing spinal anesthesia, also to emphasize the efficacy of preanesthetic assessment of the IVC/Ao (Inferior Vena Cava/Abdominal Aorta) Index measured by ultrasound in determination of patients' volemia.

Material and methods. Narrative literature review. Bibliographic search in the PubMed, NCBI and Google Academic databases, using the keywords: „hypotension inferior vena cava", „hypotension spinal anesthesia", „inferior vena cava/aorta diameter", „preloading hypotension", which were combined with each other. The final bibliography included 40 references.

Results. The principles of perianesthetic volemia management and prevention of arterial hypotension after the administration of the spinal block were detected in different groups of patients: the elderly, adult patients, anesthesiologic assistance in obstetrics and in various types of surgical interventions. Hypotension incidence data in patients with and without preanesthetic volume repletion were detected. At the same time, the effectiveness of the ultrasonographic assessment of IVC/Ao index in assessing patient's volume status was determined. The information was analyzed and synthesized in the article.

Conclusions. The effectiveness of routine preloading in reducing the incidence of arterial hypotension after spinal anesthesia did not prove its benefits in normovolemic patients, and 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 specialized imagist, being practically devoid of contraindications.

Keywords: hypotension in spinal anesthesia, preanesthetic volume repletion, volume in spinal anesthesia, assessment of volume status, Inferior Vena Cava/Aorta Index.

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Key messages

What is not yet known on the issue addressed in the submitted manuscript?

Currently, there is no consensus on the methods of estimating the circulating volume and the need for preanesthetic preloading in patients scheduled for spinal anesthesia, arterial hypotension being one of the most frequent adverse reactions, and its severity correlates directly with the patient's volemia.

The research hypothesis

Analysis and synthesis of the available literature for elaboration of perianesthetic management recommendations and their effectiveness in order to reduce arterial hypotension and diminish adverse effects after spinal block administration.

The novelty added by manuscript to the already published scientific literature

To evaluate the efficacy of ultrasonographic assessment of volume status in optimization of need for preanesthetic volume repletion in patients for elective spinal anesthesia, in order to avoid hypovolemia and hypervolemia, resulting in early and late complications.

Introduction

Spinal anesthesia, frequently used in daily clinical practice, is a safe and reliable method used in various orthopedic, lower abdominal and obstetric interventions.

Although this type of anesthesia is very advantageous due to a number of considerations (rapid onset, cost-effectiveness, ease of administration, postoperative outcome, preservation of respiratory function) [1, 2], arterial hypotension and bradycardia are the most common side effects after induction of spinal anesthesia, with an incidence of PSAH 33% and bradycardia - 13% according to the data given by Carpenter et al. in 1992 [3], and a PSAH about 5.4% according to the data of Hartman et al. [4]; with a higher risk at those with age 50 or more, a sensory level block above Th6, bupivacaine use as a local anesthetic, body mass index (BMI) 30 or more, and those receiving opiate as a premedication [5].

Rachianesthesia also can cause several adverse effects, such as coronary ischemia and delirium [6, 7], directly correlating with the increased mortality rate of patients who developed such intra anesthetic events, according to the data given by Sanborn et al. [8].

Various strategies for the prevention of relative hypovolemia caused by spinal anesthesia, such as empiric preanesthetic volume loading, prophylactic intramuscular or intravenous vasopressors have not proven to be plausible and applicable to all patients [9, 10], cardiac arrest representing the most serious intra anesthetic complication.

High variation in the incidence rate of hypotension and bradycardia after anesthesia is due to different definitions for „hypotension" and „bradycardia", and the various methods of measuring blood pressure and HR (heart rate). In most studies, blood pressure readings were documented manually. However, some authors have shown that automated on-line variable collection, together with an accurate definition of hypotension, can result in more accurate and comprehensive documentation of adverse events compared to manual documentation. This is also true for intraoperative hypotension [11].

At the same time, the definition of arterial hypotension as an absolute value of systemic blood pressure lower than 90/60 mmHg seems to be no longer valid, that being later classified by biometric parameters of blood pressure measurement. Some authors define it as an absolute change in systolic blood pressure less than 90 mmHg or mean blood pressure less than 65 mmHg, others as a relative change, with a decrease in diastolic blood pressure less than 40 mmHg. It may be orthostatic with a drop in systolic pressure of 20 mmHg or more, or a drop in diastolic pressure of 10 mmHg or more at patient's position change [12].

Cardiac arrest (CA) appears as the most serious complication of spinal anesthesia (SA), with the incidence and causes in the perioperative period studied over the years. Most of the literature involves retrospective studies or case reports. Few prospective studies evaluating large numbers of patients have been published [13]. The incidence of CA during regional anesthesia varies in different studies from 1.5-6.4/10000 [14, 15]. Charuluxananan et al. reported an incidence of CA following spinal anesthesia of 2.73/10000 [16].

Theories regarding the mechanism of cardiac arrest after neuraxial block involve a vascular etiology. Initially, it was speculated that sedation caused many of the cardiac arrests during spinal anesthesia [17]. Another reason could be the decreased preload after neuraxial block, resulting in a deviation in cardiac autonomic balance, with subsequent predominance of the parasympathetic system, leading to bradycardia.

Finally, three mechanisms have been proposed: the activation of low-pressure baroreceptors in the right atrium and inferior vena cava, autoregulatory reflexes that involves pacemaker cells of the myocardium, in which the heart rate is proportional to the degree of stretch of these cells [18] and the paradoxical Bezold-Jarisch response, in which mechanoreceptors located in the inferoposterior wall of the left ventricle, when stimulated, can cause bradycardia.

In addition, such conditions as a high level of sympathetic block, sedation, hypoxemia, hypercarbia, and chronic medications (such as beta-adrenergic antagonists) can directly activate vagal tone and contribute to the development and severity of bradycardia. Administration of intravascular fluids, alpha and beta agonists, and vagolytic therapy seems to decrease the frequency and improve survival in cardiac arrest due to neuraxial block [19].

Despite numerous studies have failed to demonstrate a reduction in the occurrence of low blood pressure following spinal anesthesia induction in individuals who have received preoperative volume replenishment [20], preloading still remains a widely used strategy. On the other hand, rapid preloading creates a major risk for cardiac compromised patients due to fluid overload and damage of the endothelium and endothelial glycocalyx [21]. Thus, fluids should be prescribed with the same care as any other medication, and avoid unnecessary administration [22].

Although the determination of volemia is an acceptable and salutary practice in anesthetic management, the difficulty of volume status determination affects the control and prediction of SAIH.

Despite the existence of a wide number of methods for assessing circulating blood volume, none of them is entirely plausible for the requirements imposed by contemporary medicine. Various techniques, such as central venous pressure (CVP) measurement, pulmonary artery catheterization, PiCCO (Pulse index Continuous Cardiac Output), Vigileo are capable of assessing preload as a component of hemodynamic status. However, their use remains a subject of ongoing debate due to financial restrictions, high complication rates, invasiveness, and the length of time required for application [23].

Recent publications in international specialized journals note the interest in studying ultrasound diagnostic methods in volume assessment is of major importance in patients of all age groups, which appear to be simple, rapid, non-invasive, cost-effective, and does not require the presence of a specialized imagist, thus having no contraindications.

Material and methods

In order to obtain the expected results, an initial search of specialized scientific publications was carried out. These were identified through the Google search engine: PubMed, NCBI, SpringerLink, Google Scholar. Articles selection was based on contemporary data regarding the monitoring of patient's hemodynamic and volemic status in perianesthetic period, applying the keywords: „hypotension inferior vena cava", „hypotension spinal anesthesia", „inferior vena cava/ aorta diameter", „preloading hypotension". These keywords were employed in various combinations to optimize search efficiency.

For the advanced selection of bibliographic sources, the following filters were used: full-text articles, articles in English, published in recognized journals, published from 1990 to 2022.

After a preliminary analysis of the relevance of the topic, original articles, randomized clinical trials, meta-analyses and review articles which contained up-to-date information and contemporary concepts regarding patient's volemic status measure and management for elective spinal anesthesia were selected.

The information from the publications included in the bibliography was submitted for analysis, synthesis, systematization, description, and comparative analysis of the results, to emphasize the importance of correct management of patients' volemic status during elective neuraxial blockades.

Only studies that satisfy validity criteria were evaluated and a comprehensive review was based on both: positive outcome studies and those that did not highlight the repletion's benefits.

After excluding duplicate publications and articles that did not meet the purpose of the article, the final bibliography included 40 references.

Results

Carpenter et al. [3] described hypotension with an incidence of 33% in their study. They defined hypotension as systolic blood pressure (SBP) <90 mmHg or, alternatively, as a 10% decrease from baseline in patients with baseline SBP <90 mmHg. Tarkkila and Isola [5] defined hypotension as a drop in SBP of more than 30% of the preanesthetic value or a drop in SBP less than 85 mmHg. They detected episodes of hypotension in 15.3% of patients.

The relatively low incidence of arterial hypotension observed in the study by Hartman et al. (5.4%) may be explained by their strict definition to detect episodes of hypotension with high specificity and, at the same time, an effect of reduced artifacts. Thus, according to their data, an episode of arterial hypotension after spinal anesthesia is defined as a decrease in mean arterial pressure (MAP) of 30% or more from the initial MAP at admission, within 10 minutes after the administration of the spinal block, requiring therapeutic intervention until 20 min after the onset of the decrease [4].

The basic effects of blocking the autonomic nervous system determine the physiological mechanism of action of the neuraxial block on cardiovascular activity. These effects generally increase with involvement of more afferent dermatomes (cephalad) and more extensive sympathectomy and may explain the sudden cardiac arrest sometimes seen during spinal anesthesia [24].

However, the variations in the response of the autonomic nervous system regulatory mechanisms in different patients can explain the different hemodynamic responses occurring after the application of spinal anesthesia [25].

Once analyzed, the risk factors that can cause the occurrence of post spinal anesthesia hypotension (SAIH) showed different precipitating values.

Hartman et al., in their study published in 2002 [4], analyzed the predictive power of hypotension of 13 patient-related variables, 4 directly related to surgery, and 12 anesthesia-related variables (8 variables related to regional anesthesia) as follows:

- variables related to the patient: age, height, weight, body mass index (BMI), sex, physical status of the patient according to the ASA score [26], active cigarette consumption, chronic alcohol consumption (defined as more than three alcoholic drinks per day), chronic heart failure (classification given by the New York Heart Association I-IV), history of preoperative hypertension or hypotension, vascular diseases, endocrine diseases and chronic preoperative antihypertensive treatment (with angiotensin-converting enzyme inhibitors, beta-adrenergic blockers, calcium channel antagonists, diuretics);
- surgical variables: admission status (inpatient/outpatient), emergency or elective surgery, surgical department (orthopedic and trauma surgery, general surgery, urology, gynecology and others) and type of surgical procedure according to the International Classification of Medical Procedures, given by WHO (World Health Organization);
- anesthesia-related variables: oral premedication with 3.8 or 7.5 mg midazolam (yes/no), amount of volume preload with intravenous crystalloid/colloid

given before Spinal Anesthesia (SpA), intravenous sedation after SpA (midazolam, propofol or both) and time interval between SpA puncture and start of surgery;

- variables directly related to spinal anesthesia: type of needle used for spinal puncture (Atraucan, Quincke, Whitacre, Sprotte), spinal needle size (22 to 29 Gauge), spinal anesthesia(SA) puncture site (L1-2 to L5 -S1), number of scoring attempts (from 1 to 4, ≥5), type and dose of local anesthetic (plain bupivacaine 0.5% or hyperbaric mepivacaine 4%), height of sensory block measured 10 minutes after application block by thermal stimulation with cold alcohol spray and local complications after SA puncture (bleeding, paresthesia).

Analysis of the results in Hartman's study revealed the following: a decrease in MAP within 30 minutes after SA induction was recorded in 3074 (99.2%) of 3098 patients. In 46.8% (n = 1450), MAP decreased by 10% to 20%, and therapeutic intervention occurred in 52.9% (n = 767) of this group. In 19.8% (n = 613) of all cases, there was a decrease in MAP of 20% to 30%; 50.4% (n = 309) of these patients underwent therapeutic intervention. In 8.2% (n = 254) of all cases, MAP decreased by more than 30%, but underwent therapeutic intervention 5.4% (n = 166) of these cases. These patients (n = 166) with relevant hypotension, by the definition, were included in the analysis. Evaluation of the samples to determine accuracy revealed no artifacts among the automatically detected events [4].

The following variables were identified by univariate analysis as having an association with a higher incidence of hypotension:

- variables related to the patient: age, weight, height, BMI, chronic alcohol consumption (due to neuropathy due to alcohol, the sympathetic nervous system is affected), the physical status of the patient according to the ASA score (ASA II patients presenting an incidence of 5, 9%, and ASA III of 8% in the univariate analysis, compared to the 3% in patients evaluated ASA I), preoperative history of arterial hypertension (increases the risk 2 times), long-term antihypertensive therapy;
- variables related to surgical intervention: emergency surgical interventions (due to the impossibility of qualitative and detailed assessment of patients), the operating department (general surgery and gynecology interventions presenting a much higher rate of intraoperative hypotension);
- variables related to anesthesia: the colloids administered before the puncture (with significant statistical data in the univariate analysis, but without significance in the multivariate analysis; it is important to note that the administration or not of crystalloids as preanesthetic volume repletion did not in any way influence the incidence of hypotension after spinal anesthesia , similar to the study carried out by Rout et al. back in 1993 [27]), the height of the sensory block above Th6 at 10 minutes after the application of the local anesthetic (due to the risk of blocking the cardioaccelerator fibers in case of advancement) and the frequency of punctures [4].

The association of one of the precipitating factors listed above increases 2-3 times the risk of developing episodes of hypotension after induction of spinal anesthesia.

In contrast, Kyokong et al. 4 years later published a study, where factors associated with hypotension and bradycardia after spinal anesthesia was analyzed, and SAIH was defined as a drop in SBP more than 30% of the initial value and bradycardia as a decrease in HR below 60 beats/min. As a result, he obtained an incidence of hypotension and bradycardia of 36.8% and 4.9%, respectively, the incidence of hypotension in this case being about 4.4 times higher than that of Hartman's study.

The following precipitating factors were detected:

- related to the patient: age and body mass index ≥30;
- related to anesthesia: analgesic level ≥dermatome T4, a prehydration volume less than 500 ml (controversial event by a lot of other recent studies);
- related to surgical intervention: cesarean section [28].

In this context, it is very difficult to determine the definition of SAIH, which will correlate most closely with the real situation of the patient.

Anesthetists consider that the mean, systolic, and diastolic pressure provides valuable information. However, according to Mascha et al. in their study „Intraoperative Mean Arterial Pressure Variability and 30-day Mortality in Patients Having Noncardiac Surgery" [29], diastolic and especially systolic pressures are subject to a considerable distortion depending on the vasomotor state, the measurement site and the type of anesthesia. In contrast, MAP is generally close to aortic pressure in a wide variety of clinical conditions, and close to oscillometric and radial artery measurements. Thus, in the results of his study, MAP values were essentially unchanged when the analysis was limited to radial arterial pressures versus pressures given by noninvasive arterial measurements.

Finally, they found that through SBP that was sustained for more than 10 minutes was associated with a higher 30-day mortality rate when SBP was less than 70 mmHg, but has no association with increased mortality when MAP is greater than 70 mmHg [29].

In the case of the correlation of intra anesthetic hypotension and organ injury (the development of Acute Kidney Injury or Acute Myocardial Infarction), Wasselink et al. in 2018 did a systematic review based on 42 studies, where they tried to highlight the intra anesthetic blood pressure values that create a risk for the postoperative outcome, in the context of the development of organ injury [30].

Based on their results, the reported risks of any end-organ injury after noncardiac surgery began to increase with prolonged exposure (≥10 min) to an SBP <80 mmHg, resulting in a slightly increased risk, with Odds Ratio between 1.0 and 1.4. For shorter durations (<10 min), slightly increased risks were reported for MAP thresholds of 70 mmHg and lower. The reported risks increased to moderate (OR 1.4 to 2.0) with exposures to MAP <65–60 mmHg for ≥5 min, or any exposure <55–50 mmHg of MAP. High risks (OR > 2.0) were reported for SBP <65 mmHg for ≥20 min, SBP <50 mmHg for ≥5 min, or any exposure <40 mmHg [30].

Although the determination of volume in the patient to be anesthetized would be an acceptable and welcome stage of anesthetic management, the difficulty of determining the volume status in daily clinical practice is one of the causes that we lack control and SAIH prediction.

The use of central venous pressure (CVP) as a measure of patient's volemic status demonstrated a very weak relationship between CVP and circulating blood volume, as well as the inability of the ratio of CVP assessment before and after fluid administration (CVP/ ΔCVP) to predict hemodynamic response to fluid challenge. Therefore, CVP should not be used to make clinical decisions about volume management [31].

The use of other invasive methods of monitoring the hemodynamic status are not suitable in spinal anesthesia, for well-determined reasons previously reported, therefore non-invasive, fast, efficient monitoring methods with an increased degree of sensitivity and specificity are available. One of them would be the determination of the Perfusion Index (PI) by registration of pulse oximetry.

The determinants of the PI are complex and interconnected, involving and reflecting the interaction between peripheral and central hemodynamic parameters, such as vascular tone and stroke volume [32], although it appears to be a useful additional and non-invasive tool for anesthesia monitoring, perioperative and critical care for clinicians, is influenced by too many factors, such as preexisting cardiac arrhythmias, obesity, peripheral perfusion disorders, diabetic angiopathy and neuropathy, etc. The results of several studies support the use of this dynamic plethysmographic index also in the cephalic region when the finger is inaccessible or during states of low peripheral perfusion, and report its clearly superior efficacy compared to the Inferior Vena Cava Distension Index [33]. Toyama et al. in their study „Perfusion index derived from a pulse oximeter can predict the incidence of hypotension during spinal anesthesia for Cesarean delivery", reports that the initial baseline PI value correlated directly with the degree of decrease in systolic and mean arterial pressure (r=0.664, P<0.0001 and r=0.491, respectively P=0.0029). The cutoff PI value of 3.5 identified a risk of spinal anesthesia-induced hypotension with a sensitivity of 81% and a specificity of 86% (P<0.001) [34].

Recent publications in international specialized journals note the interest in studying ultrasound diagnostic methods.

These include the measurement of the Inferior Vena Cava Collapsibility Index (IVCCI) and the Inferior Vena Cava related to the diameter of the Abdominal Aorta Index (IVC/Ao).

The measurement of the Collapsibility Index of the Inferior Vena Cava (IVCCI) is very simple to use, it represents the measurement of the diameter of the Inferior Vena Cava at the end of expiration and the end of inspiration, with the subsequent calculation of the collapsibility index by the following formula:

$$IVCCI = \frac{IVCmax - IVCmin}{IVCmax}$$

Patient being evaluated as hypovolemic when IVCCI > 40%, according to the data given by Davi et al. in 2020 in a study of 100 patients requiring orthopedic surgery and receiving spinal anesthesia, and demonstrated that preanesthetic assessment of IVCCI to optimize fluid therapy can reduce the incidence of SAIH in orthopedic surgery and the need for vasopressors, and, therefore, the association of an IVCCI of over 40% with the development of SAIH [35]. Another study conducted in 2022 by Ting-ting Ni et al. on 90 patients requiring spinal anesthesia, revealed 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%[36]. Likewise Szabo et al. in his study analyzed the predictive value for SAIH of IVCCI at the 50% limit with a low sensitivity of 45.5% but a very high specificity of 90% [37]. The results of the study by Zhang et al. in 2016 on a batch of 90 patients showed the IVCCI cut-off value of 43% and had a sensitivity and specificity of 78.6% and 64.8% [38].

All these studies reveal a very high variability of the results obtained, and small groups of patients included in the study, as well as the need to delimit the patient's inspiration and expiration peak, or other conditions that change the pulmonary pressures during the act of breathing, in order to collect truthful data.

In this context, an alternative is the calculation of the Inferior Vena Cava related to the diameter of the Abdominal Aorta Index (IVC/Ao), in which the inferior vena cava is measured in the subxiphoid region, immediately caudal to the confluence of the hepatic veins with the inferior vena cava (IVC), the anteroposterior diameter is measured longitudinally in M-Mode, while the Aorta is visualized by sliding left, opposite to IVC, and the anteroposterior diameter is measured in M-Mode. The ratio of these 2 measurements represents the IVC/Ao Index, according to the data given by the study of Sridhar et al. performed on 170 patients and published in 2012 [39]. Based on this study, IVC/Ao seems to present a much higher accuracy compared to IVCCI 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. Research study states that IVC/Ao is more specific in assessing body fluid status [39].

To reduce doubts about the need for a specialized imagist to perform such measurements as mentioned previously, Durajska et al. in 2014 published the results of a study, where they demonstrate that a 4-hour training is more than enough to make IVC/Ao measurements of a similar quality to a qualified imagist [40].

However, to determine which assessment method IVCCI or IVC/Ao more accurately predicts SAIH, Salama et al. in 2019, European Journal of Anesthesiology (EJA) published the results of a study conducted on 100 patients who benefited from spinal anesthesia, in which both methods were compared simultaneously. According to the study results, the ROC curve revealed that IVC/Ao had a sensitivity of 96%, a specificity of 88%, and a precision prediction power for SAIH of 95% at a cutoff point of less than 1.2, while IVCCI had a sensitivity of 84%, a specificity of 77%, and an accuracy of 84% to predict SAIH at a cutoff point greater than 44.7% [41].

Discussions

The definitions of hypotension used in the previously cited studies are questionable because the authors define hypotension as exceeding a lower safety limit or, choosing the first measure of blood pressure value as the baseline value. Thus, an episode of arterial hypotension after spinal anesthesia defined as a decrease in mean arterial pressure (MAP) of 30% or more from the initial MAP at admission and based on MAP instead of SBP criteria seems to be more accuracy, as MAP is the most important blood pressure variable related to organ perfusion [4].

However, this approach does not take into account individual patient processes. Many variations in the response of the autonomic nervous system regulatory mechanisms in different patients can explain the different hemodynamic responses occurring after induction in spinal anesthesia [25].

There are 3 types of variables that seems to precipitate 2-3 times the risk of development of SAIH after induction of spinal anesthesia:

- patient related: age, weight, height, BMI (≥30) [28], chronic alcohol consumption, patient's ASA score, presence of chronic arterial hypertension with long-term antihypertensive therapy;
- surgical intervention related: the emergency and type of surgical interventions;
- anesthesia related: sensory block level (above T4 dermatome) [28] and the frequency of punctures [4].

In this context, it is very difficult to determine a strong definition of SAIH, which will correlate most closely with the real situation of the patient.

Preloading did not prove its effectiveness in SAIH incidence reduction and could worsen the patient's physical status.

Although the determination of circulating blood volume in patients will significantly simplify anesthetic management, the difficulty of its measurement results in poor prediction of SAIH.

Therefore, CVP measurement cannot be used to make clinical decisions about volume management [31], as well as other invasive monitoring.

Ultrasound diagnostic methods, of major importance in patients of all age groups, appear to be simple to use, fast, non-invasive, cost-effective, free of adverse reactions, and did not need a specialized imagist to perform the measurements [40].

The echographic measurement of IVC/Ao Index instead IVCCI has a greater sensitivity, specificity, and predictive power for SAIH, based on relative constant properties of aorta as structure.

However, there are some limitations in mentioned studies, probably determined by lack of homogeneity and small samples that lead to great variations in results.

Conclusions

Following the literature review carried out on the basis of all the mentioned studies, we can conclude that there are a series of factors with predictive value increasing the risk for SAIH, whether they are related to the patient, the surgical intervention, or the anesthetic management. Some of them can be influenced, and others cannot,at the same time, there are minimally invasive methods, easy to implement, with very high accuracy, which can evaluate the patient's volemic status immediately before the application of anesthesia, and as a result considerably reduce the adverse reactions related to an empirical preloading.

Moreover, the IVC/Ao Index evaluated ultrasonographically seems to be a simple, fast, non-invasive, cost-effective method for volemia evaluation, which determines the patient's volume status with high accuracy and does not require the presence of a specialized imagist, being free of contraindications.

Competing interests

None declared.

Authors' contribution

The authors contributed equally to the search of the scientific literature, the selection of the bibliography, the reading, and analysis of biographical references, the writing of the manuscript and its peer review. All authors have read and approved the final version of the article.

Abbreviations

SAIH - Post Spinal Anesthesia Hypotension; CVP - central venous pressure; PiCCO - Pulse index Continuous Cardiac Output; IVCCI - Inferior Vena Cava Collapsibility Index; IVC/Ao - Inferior Vena Cava related to the diameter of the Abdominal Aorta Index; SBP - Systolic Blood Pressure; MAP - Mean Arterial Pressure.

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