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Pre-anaesthetic ultrasonographic assessment of neck vessels as predictors of spinal anaesthesia induced hypotension in the elderly: A prospective observational study

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ABSTRACT

Background: Increased age has been linked to the development of spinal anaesthesia induced hypotension (SAIH) and increased the risk of perioperative complications. The internal jugular vein collapsibility index (IJV-CI), rates of change in IJV diameter (ΔIJV-D) and IJV area (ΔIJV-A) in the supine and Trendelenburg positions, and carotid intima-media thickness (CIMT) were evaluated as predictors of SAIH in the senior population.
Materials and methods: This prospective Cohort was conducted at the Cairo University Hospitals. Seventy-one patients scheduled for elective procedures under spinal anaesthesia of ASA I–III, over 60 years and BMI less than 30 kg/m^2. The right IJV was assessed ultrasonographically in supine and Trendelenburg postures, as well as CIMT. The primary outcome was the IJV- CI as predictor of SAIH while ΔIJV-D and ΔIJV-A with posture and CIMT in prediction of SAIH were assigned as secondary outcomes.
Results: SAIH was shown in forty-seven (66.2%) of patients. IJV-CI, ΔIJV-A and ΔIJV-D increased significantly in Hypotensive group (median 38.09, IQR (23.61–50), 0.393 (0.2–0.52) and 0.213 (0.12–0.34) respectively) in comparison to Non-hypotensive group (26.05 (10.32–34.08), 0.167 (0.03–0.48) and 0.074 (0.02–0.29) respectively) (p-value <0.05). IJV-CI showed AUROC of 0.699 and 95% CI of 0.578–0.802 (p-value = 0.002) with cut-off value ≥0.34.4, 61.70% sensitivity, 79.17% specificity, 85.3% PPV and 51.4% NPV.
Conclusions: Preanesthetic IJV-CI and ΔIJV-D from the supine to the Trendelenburg position were moderate predictors of SAIH. Results suggested that IJV-CI is > 34.4% and a ΔIJV-D is of ≥ 0.11 to be the threshold levels, while CMIT could not predict SAIH.

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1. Introduction

Spinal anaesthesia remains the anaesthetic procedure of choice for geriatric patients; however, spinal anaesthesia induced hypotension (SAIH) remains a frequent complication. Increased age was reported to be an independent risk factor for the development of SAIH with subsequent ischemic myocardial, cerebrovascular, and acute kidney injuries. These injuries eventually prolong the hospital stay and increase postoperative morbidity and possible mortality [1,2]. Empirical volume preloading is commonly performed to prevent SAIH, which carries the risk of volume overload, especially in patients with pre-existing cardiac and renal disorders [3].

Spinal anaesthesia induces sympathetic blockade and veno-dilation, reducing the venous return and cardiac output [4]. An assessment of the intravascular volume deficit prior to the spinal anaesthesia conduction may help to predict the occurrence of a critical decrease in blood pressure [5]. For the aforementioned purpose, several indices have been proposed to assess the intravascular volume status depending on either a fluid challenge or an assessment of heart-lung interaction. Heart rate variability, passive leg raise test, and peripheral perfusion index have revealed good abilities to predict SAIH. The inferior vena cava (IVC) collapsibility index provides high diagnostic accuracy in predicting SAIH in general and caesarean sections surgeries [6,7].

IVC visualisation is not feasible in up to 15% of patients due to obesity, intra-abdominal gas distension, intra-abdominal masses, and surgical dressings. So, the internal jugular vein (IJV) was proposed to be a good alternative to IVC. Ultrasonographic evaluation of the IJV has been used to estimate the intravascular volume status and predict hypotension after induction of general anaesthesia, with promising results in some studies [8–11] and conflicting results in other studies [12–15]. The prediction of SAIH in the elderly population, using IJV parameters, has not been previously investigated.

Arterial atherosclerosis increases carotid intima-media thickness (CIMT), which has been previously demonstrated to be an accurate predictor of atherosclerosis-related events, including strokes, myocardial

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infarctions, and peripheral artery disease [16]. Kaydu A et al. [17] concluded a threshold value of CIMT of 0.65 mm that may be used as a predictor of hypotension after the induction of general anaesthesia. Further studies are nevertheless needed to confirm these results.

This study aimed to evaluate the reliability of three possible predictors of SAIH in the elderly population; (i) the collapsibility index of the IJV (IJV-CI), assessed through a preoperative ultrasonographical study; (ii) the rates of change in IJV diameter (IJV-D) and IJV area (IJV-A), when measured in the supine and Trendelenburg positions; and (iii) CIMT value. Therefore, we hypothesised that the IJV-CI and the rates of change in IJV-D and IJA-A, when measured in the supine and Trendelenburg positions, would be good predictors for SAIH in the elderly population.

2. Materials and methods

This prospective observational study was conducted at the Cairo University Hospitals after approval of the Research Ethics Committee of the Kasr Al-Ainy Faculty of Medicine, Cairo University (email: kasralainirec@gmail.com, ID: MD-152-2020). The study was registered prospectively at clinicaltrials.gov (ID: NCT05078606, date of first registration 10/04/2021). All methods were carried out in accordance with relevant guidelines and regulations. The reporting of this study conformed to the Accurate Reporting of Diagnostic tests (STARD) guidelines. Signed written informed consent was obtained from all patients.

Seventy-one ASA physical status I–III patients, aged > 60 years with BMI < 30 kg/m^2, scheduled for elective surgeries under spinal anaesthesia, were enrolled in the study. Patients with a history of cardiovascular or respiratory disorders, including arrhythmias, heart failure, tricuspid or mitral regurgitation, or dilated right atrium or ventricle, and those who had previously undergone valvular or carotid artery surgeries were excluded from the study.

All patients had nothing by mouth eight hours prior to surgery and were maintained on clear fluids two hours prior to the conduction of anaesthesia. Upon arrival to the operating room, intravenous access was secured, and ringer acetate was administered at a rate of 2 ml/kg/hr. Premedication in the form of 40 mg omeprazole and 4 mg ondansetron was intravenously administered. Each patient was connected to electrocardiography, pulse oximeter, and non-invasive blood pressure monitors. Baseline mean arterial pressure (MAP), heart rate (HR), and arterial oxygen saturation (SaO_2) were all recorded.

3. IJV Ultrasonography

Ultrasonographic examination of the right IJV was conducted with the patient supine while the neck rotated to the left (at only an approximate 40° to avoid venous occlusion at the opposite side). A linear probe with a 7–12 MHz frequency and a depth of 3 cm (Siemens ACUSON X300 Ultrasound Systems) was gently placed over the neck. The sternocleidomastoid muscle was used as an external landmark. The right IJV was identified just below the bifurcation of the sternal and clavicular heads of the muscle. The right JIV was examined over three full respiratory cycles using the M- mode in the transverse axis. The maximum IJV-D and IJV-A were recorded during each cycle, and the averages were computed. Then, using a protractor set on the operating table, the patient was placed at a 10° Trendelenburg position, and the same ultrasonographic measurements were repeated [18]. (Figure 1).

During the statistical analysis, the rate of change in IJV-D with the change in posture (ΔIJV-D) was calculated as follow: [ΔIJV-D = IJV-D in Trendelenburg

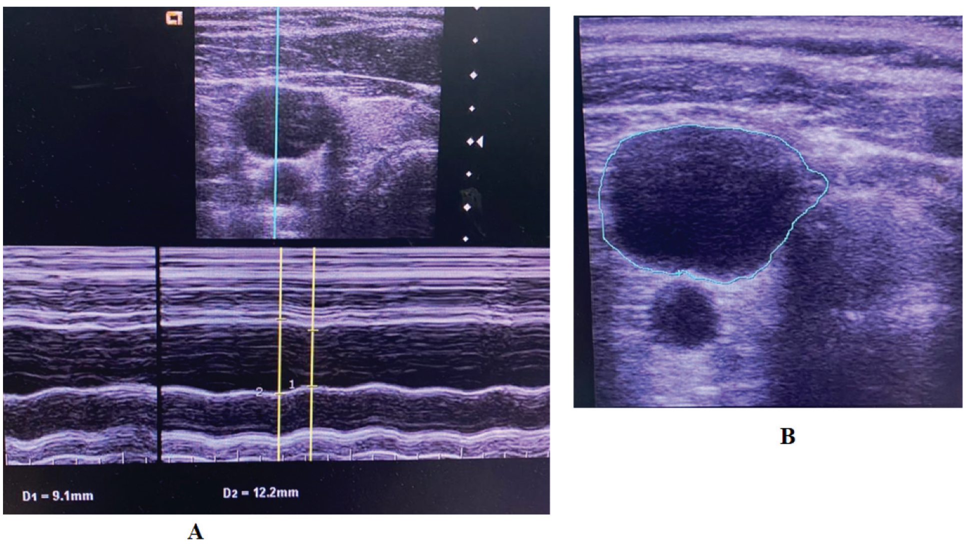

Figure 1. IJV ultrasonography showing: A: The right internal jugular vein showing the maximum and minimum diameters. Using M mode, 1 = minimum diameter (9.1 mm), 2 = maximum diameter(12.2 mm). collapsibility (%) = (max diameter − min diameter)/max diameter x100 **B: The right internal jugular vein showing the IJV-area = 2.07 cm^2.**

position – IJV-D in supine position/IJV-D in Trendelenburg position]. The rate of change in IJV-A with the change in posture (ΔIJV-A) was calculated using the same previous equation. Finally, the IJV-CI was calculated while the patient was in the supine position as the percentage decrease in IJV-D during inspiration compared with its value during expiration as follow: [IJV-CI (%) = (maximum IJV diameter – minimum IJV diameter)/maximum diameter x100].

4. Carotid intima-media thickness (CIMT)

Using the B-mode with a linear probe on the right carotid artery, a cross-sectional view was attained by pointing the arrowhead on the side of the probe towards the midline of the patient's neck, allowing for concurrent viewing of the IJV. The probe was then turned by 90° for a longitudinal view with the arrowhead pointing cranially. The probe was moved alternatingly in the caudal and cranial directions to zero-in on the bifurcation of the common carotid artery, which would eventually appear on the left side of the screen as the carotid bulb. This view represented the ideal vantage point for the desired imaging and conducting the CIMT measurements. Taking a longitudinal view of the far wall of the carotid artery, the CIMT appeared as two parallel lines, the lumen-intima and media-adventitia interfaces perpendicular to ultrasound beams. The CIMT was taken from the point just medial to the right carotid bifurcation. The distance between the lumen-intima and the media-adventitia was determined. A pre-defined window of the bifurcation of the right carotid artery, distal common carotid artery, and carotid bulb were all scanned for plaques. The plaques were identified as focal thickenings of the arterial wall (> 1.2 mm) [17]. The atherosclerotic segments were not included in these measurements. The distance between lumen-intima and media-adventitia was computed manually. (Figure 2) Two independent investigators examined the IJV and CIMT separately; then, a mean was taken for both measurements.

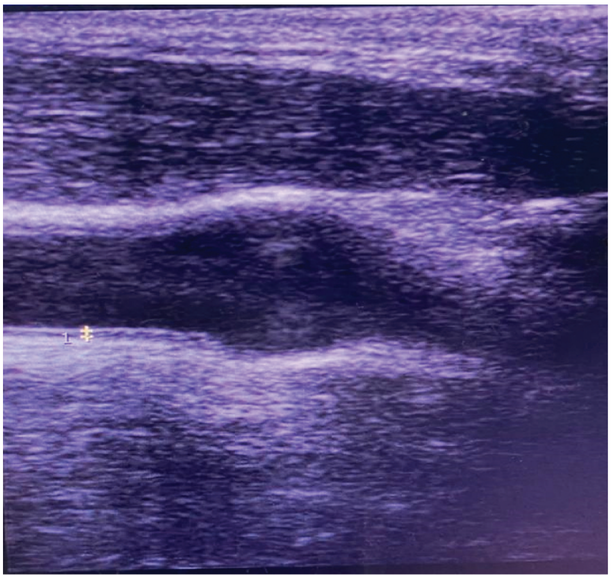

Figure 2. The right carotid artery ultrasonography image showing the Carotid intima-media thickness (distance 1 represents the maximum intima-media thickness of each Segment = 0.4 mm).

5. Anaesthetic management

Spinal anaesthesia was performed while the patient was in a sitting position. The patient was co-loaded with 10–12 ml/kg ringer acetate over 10–15 minutes. A 25-gauge spinal needle was introduced at either the level of L3–4 or L4–5 interspaces, 10 mg of 0.5% hyperbaric bupivacaine plus 25 µg of fentanyl were injected, the patient was then turned and maintained in a supine position. A cold test using an alcohol gauze was conducted to assess the degree of sensory block, with a desired T8 dermatomal level block. Maintenance fluid 2 ml/kg/hour of ringer acetate was then commenced. MAP was measured every 2 minutes after administering the anaesthesia for a total of 20 minutes. Any episode of hypotension, defined as a decline in MAP to less than 75% of the preoperative baseline reading, was recorded and managed by administering five µg of norepinephrine. If the hypotensive episode persisted for two minutes, another bolus of norepinephrine was administered. Any episodes of bradycardia were managed by administering 0.01 mg/kg of atropine.

The reliability of the IJV-CI as a predictor of SAIH (assessed by the area under the receiver-operating characteristic "AUROC" curve) was set as the primary outcome. The secondary outcomes were the reliability of the ΔIJV-D, ΔIJV-A, and CIMT as additional predictors of SAIH.

6. Statistical analysis

The Medcalc program (version 18) was used for sample size calculation. The primary outcome was the accuracy of the IJV-CI in the prediction of SAIH. An initial pilot study revealed an AUROC curve of 0.7 and a null hypothesis of 0.50, taking into consideration that the incidence of SAIH in the elderly had stood at 62% [19], with a power of 0.8, and an alpha error of 0.05, we calculated a minimum number of 71 patients (with at least 38 patients developing post-spinal hypotension).

Data were analysed using the Statistical Package of Social Science Software program, version 23 (IBM SPSS Statistics for Windows, Version 23.0. Armonk, NY: IBM Corp.). The normality of data distribution was assessed using the Kolmogorov-Smirnov and the Shapiro-Wilk tests. Categorical data were presented as frequencies (%) and analysed using the Chi-Square test. Continuous data were presented as means (standard deviations) or medians (Inter-quartiles range IQR). As appropriate, these data were analysed using the unpaired t-test or the Mann Whitney test. Repeated measures were analysed using the two-way analysis of variance (ANOVA) test. A P-value less than 0.05 was considered statistically significant.

7. Results

Seventy-one patients were enrolled and completed the study. Patient demographics and baseline data are presented in Table 1. Forty-seven patients (66.2%) developed SAIH, so patients were divided into two groups, hypotensive and non-hypotensive. Comparable BMI, ASA class, and baseline MAP values were found between the two groups, with more frequent hypotensive episodes noted among female patients and patients with a high baseline HR. (Table 1)

Analysis of ultrasonographic data revealed that the maximum and minimum IJV-D and IJV-A in the supine position were all significantly lower in the hypotensive group (0.82 ± 0.34 cm, 0.53 ± 0.32 cm, and 1.12 ± 0.71 cm2 respectively) compared with the non-hypotensive group (1.03 ± 0.43 cm, 0.83 ± 0.42 cm, and 1.5 ± 0.77 cm2 respectively) with p-value <0.05. (Table 2)

Four patients (one in the hypotensive group and three in the non-hypotensive group) showed a smaller IJV-D and IJV-A in Trendelenburg than in the supine position. In addition, another patient in the non-hypotensive group showed a smaller IJV-A in Trendelenburg than in the supine position. These paradoxical changes resulted in negative values of ΔIJV-A and ΔIJV-D.

IJV-CI, ΔIJV-D, and ΔIJV-A were significantly higher in the hypotensive group (median 38.09, IQR (23.61–50), 0.213 (0.12–0.34), and 0.393 (0.2–0.52), respectively) compared with the non-hypotensive group (median 26.05, IQR (10.32–34.08), 0.074 (0.02–0.29), and 0.167 (0.03–0.48), respectively). There were no significant differences between the two groups regarding IJV-D in the supine position, the IJV-D and the IJV-A in the Trendelenburg position, or CEMT. (Table 2).

The multiple logistic regression analysis of the variables with statistical significance upon the univariant analysis revealed that female gender, the IJV-CI, ΔIJV-D were independent predictors of SAIH ($p < 0.05$). (Table 3).

ROC curves were constructed using IJV-CI, ΔIJV-D, ΔIJV-A to assess their ability to predict SAIH. (Figure 3). Both IJV-CI and ΔIJV-D revealed a moderate predictive ability with an AUROC of 0.69 and 0.67 at a cut-off value > 34.4 and ≥ 0.11, respectively. On the other hand, Carotid intima media thickness diagnostic accuracy did not attain statistical significance (p-value = 0.482) and

Table 1. Demographic data and baseline characteristics of the studied patients.

		All patients (n = 71)	Hypotensive group (n = 47)	Non-hypotensive group (n = 24)	P value
Age (years)		66.49 ± 6.66	66.98 ± 7.00	65.54 ± 5.96	0.394
Sex (female)		28 (39.4%)	23 (48.9%)	5 (20.8%)	**0.039***
BMI (kg/m^2)		29.09 ± 5.19	29.37 ± 5.75	28.53 ± 3.95	0.527
ASA		1 (1–2)	1 (1–2)	1 (1–2)	0.457
Surgery	Orthopaedic	53 (74.65%)	38 (80.85%)	15 (62.5%)	0.093
	General	18 (25.35%)	9 (19.15%)	9 (37.5%)	
Time to skin incision (min)		18.34 ± 4.15	18.38 ± 4.61	18.25 ± 3.17	0.887
Baseline mean arterial pressure		107.24 ± 17.106	107.85 ± 17.49	106.04 ± 16.63	0.676
Baseline heart rate (bpm)		88.17 ± 14.75	91.34 ± 15.88	82 ± 9.86	**0.003***
Total dose of norepinephrine (µg)		15 (0–30)	25 (15–40)	0 (0)	**<0.001***
Number of norepinephrine boluses		3 (0–6)	5 (3–7)	0 (0)	**<0.001***

Data of age, weight, BMI, HR, systolic, diastolic and mean arterial pressure are presented as mean (standard deviation). Data of sex and ASA and norepinephrine dose are presented as median (IQR). sex and type of surgery are presented as number (percentage). *Statistically significant as p < 0.05, BMI: Body mass index.

Table 2. Ultrasonographic data (all patients, hypotensive and non-hypotensive groups).

	All patients (n = 71)	Hypotensive group (n = 47)	Non hypotensive group (n = 24)	P value
Maximum IJV-D in supine (cm)	0.89 ± 0.38	0.82 ± 0.34	1.03 ± 0.43	**0.026***
Minimum IJV-D in supine (cm)	0.63 ± 0.38	0.53 ± 0.32	0.83 ± 0.42	**<0.001***
IJV-CI	33.07 (20.98–45.52)	38.09 (23.61–50)	26.05 (10.32–34.08)	**0.006***
Δ-IJV-D	0.19 (0.06–0.33)	0.213 (0.12–0.34)	0.074 (0.02–0.29)	**0.019***
ΔIJV-A	0.33 (0.14–0.51)	0.393 (0.2–0.52)	0.167 (0.03–0.48)	**0.044***
CIMT (cm)	0.07 ± 0.03	0.070 ± 0.034	0.066 ± 0.026	0.588

*Statistically significant as p < 0.05, IJV-CI; internal jugular vein collapsibility index, IJV-D; internal jugular vein IJV diameter, IJV-A; internal jugular vein area, ΔIJV-D = rate of change in IJV-D with position, ΔIJV-A = rate of change in IJV-A with position CIMT; carotid intima-media thickness.

Table 3. Logistic regression of various variables for prediction of SAIH.

	Odds ratio	95% CI	P value
Sex (female)	3.56	1.01–12.55	**0.048***
IJV-CI	1.04	1.01–1.08	**0.012***
ΔIJV-D	4540.29	1.19–17,282,093.8	**0.045***
Rate of change in IJV-A with position	0.041	0.0002 to 8.4386	0.240

*Statistically significant as $p < 0.05$. IJV-CI; internal jugular vein collapsibility index, IJV-D; internal jugular vein IJV diameter, IJV-A; internal jugular vein area. ΔIJV-D = Rate of change in IJV-D with position

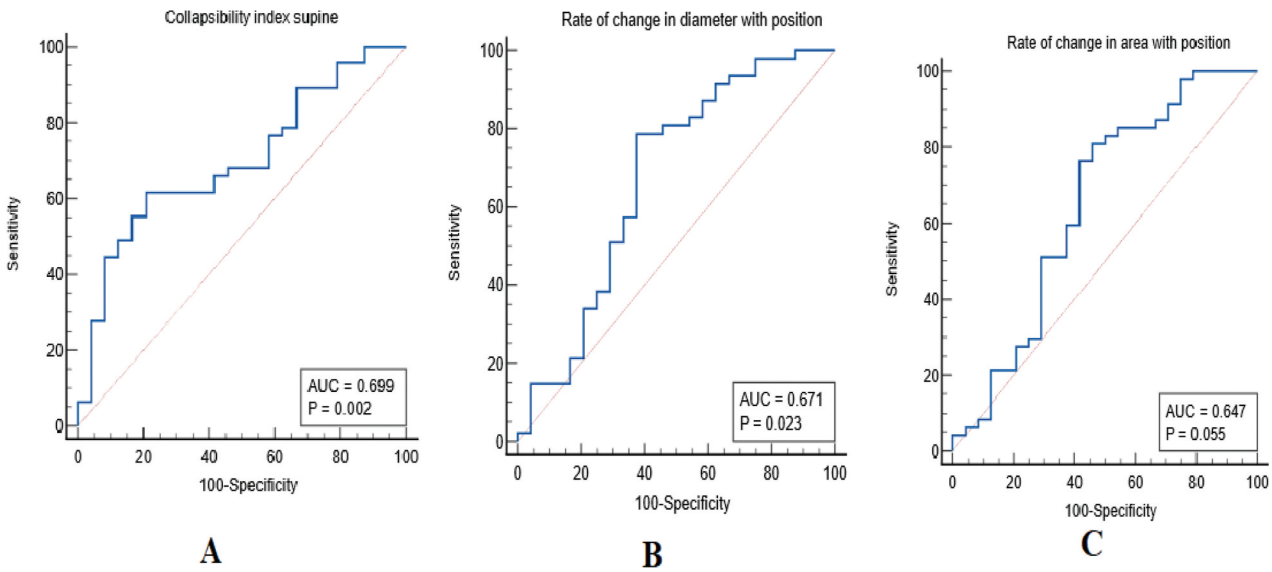

Figure 3. ROC curves of collapsibility index of IJV (IJV-CI), the rate of change in diameter and area of IJV with change in position for prediction of SAIH. A: Collapsibility index of IJV (IJV-CI). B: The rate of change in diameter (ΔIJV-D) with position. C: The rate of change in area (IJV-A) with position.

Table 4. Diagnostic accuracy of various variables for prediction of SAIH.

	Cut-off value	Sensitivity	Specificity	PPV	NPV	Youden index accuracy	AUC	95% Confidence Interval	P value
Maximum IJV-D in supine (cm)	≤0.91	65.96%	62.50%	77.5%	48.4%	0.2846	0.642	0.519–0.752	0.051
Minimum IJV-D in supine (cm)	≤0.59	63.83%	79.17%	85.7%	52.8%	0.4300	0.715	0.595–0.816	**0.001***
IJV-CI	>34.4	61.70%	79.17%	85.3%	51.4%	0.4087	0.699	0.578–0.802	**0.002***
ΔIJV-D	≥0.11	78.72%	62.50%	80.4%	60.0%	0.4122	0.671	0.549–0.778	**0.022***
ΔIJV-A	≥0.17	80.85%	54.17%	77.6%	59.1%	0.3502	0.647	0.525 – 0.757	0.055
CIMT	>0.04	95.74%	16.67%	69.2%	66.7%	0.1241	0.551	0.429–0.670	0.482

*Statistically significant as $p < 0.05$. AUC: area under the curve; 95%, IJV-CI; internal jugular vein collapsibility index, IJV-D; internal jugular vein IJV diameter, IJV-A; ΔIJV-D = rate of change in IJV-D with position, ΔIJV-A = rate of change in IJV-A with position internal jugular vein area, CIMT; carotid intima-media thickness.

AUROC of 0.551. The corresponding sensitivity, specificity, positive and negative predictive values are presented in Table 4.

8. Discussion

The main finding of this study was that an IJV-CI and ΔIJV-D and ΔIJV-A with position were significantly higher in the elderly surgical patients who developed SAIH. The IJV-CI and ΔIJV-D were the independent predictors for SAIH with a moderate predictive ability when their baseline values were >34.4 for the CI and >0.11 for the ΔJV-D. CMIT is not a predictor for PSAH.

Increased basal sympathetic tone in the elderly results in a profound sympathetic block. The administration of spinal anaesthesia to this age group adds to any existent decline in central venous pressure (CVP), left ventricular end-diastolic volume, cardiac output and/or systemic vascular resistance. Consequently, there is an increased incidence of SAIH in geriatric patients subjecting this vulnerable age group to the risk of postoperative multi-organ dysfunction [19,20].

In the current study, hypotension was defined as a MAP <75% of the baseline reading starting from anaesthesia induction until a skin incision was made. This definition excludes confounding factors such as surgical stimulation, patient positioning, and/or blood loss. Many studies reported that an intraoperative decline in MAP is an independent risk factor for developing impaired organ perfusion and adverse postoperative outcomes, including myocardial infarctions, heart failure, cerebrovascular stroke, and acute kidney injury, with prolonged hospital stay and potentially higher postoperative mortality rates [6,21,22].

Before anaesthesia induction, the intravascular volume status assessment using IJV related parameters can represent a non-invasive tool for estimating CVP [8,10]. Avcil M. et al. [9] have reported both minimum and maximum IJV-D to be moderately correlated with CVP. They demonstrated an increase in the maximum IJV-D to more than 1.01 cm and a decrease in the minimum IJV-D to less than 0.71 cm as possible sensitive predictors of a CVP value equivalent to 5 mmHg. These cut-off values can be tuned to those from this study (table 4), where the maximum and minimum IJV-D and IJV-A showed moderate predictive abilities for SAIH, with cut-off values of 0.91 cm and 0.59 cm, respectively.

Bauman Z et al. [23] demonstrated a significant correlation between IJV-CI and IVC-CI during spontaneous ventilation. At the same time, it was nonsignificant with increased thoracic or intra-abdominal pressure. The authors denoted that an increased intra-abdominal pressure up to 15 mmHg by gas insufflation during laparoscopic surgeries was associated with a 24% decrease in the IVC-D. Therefore, IJV measurements can represent an alternative when the visualisation of the IVC is difficult, or its measurement is influenced.

The IJV-CI simulates the respiratory variations in the CVP waveform, which increases in hypovolemia. Killu, K. et al.; demonstrated that increasing the IJV-CI by more than 39% predicts hypovolemia in ICU patients [24]. It was also reported that a significant negative correlation was found between compression IJV-CI (performed by manual compression of IJV) and both mean right atrial pressure (Spearman: – 0.43; p-value = 0.0002) and pulmonary artery occlusion pressure (Spearman: −0.35; p-value = 0.0027). Also, there was a negative correlation between the respiratory IJV-CI and mean right atrial pressure and pulmonary artery occlusion pressure, but it did not reach a statistical significance [25].

Kılıç Y et al. [26] investigated the reliability of the IJV-CI as a predictor of PSAH in 47 patients aged between 18 and 65 years. In this study, 22 patients (46.8%) developed hypotension. The authors concluded that the IJV-CI was a moderate predictor of PSAH. They reported an AUROC curve of 0.709, a sensitivity of 64% and a specificity of 63.6%, with a cut-off point of 22.6%. However, the small sample size hinders the generalizability of their findings. In addition, the differences in population age between the current work and the aforementioned study may explain differences in their results compared to ours.

The ΔIJV-D, which represents the rate of change of the IJV-D when a position is changed from supine to Trendelenburg, possibly reflects a change in the intravascular volume similar to the effect of the passive leg raising in the shocked patients [11]. Our study demonstrated that the patients who developed SAIH revealed more decreased IJV-D and IJV-A in both the supine and Trendelenburg positions and, consequently, a greater ΔIJV-D and ΔIJV-A compared to those who did not develop SAIH. This change can be an indicator of decreased intravascular volume and, subsequently, SAIH, as was suggested by Avcil et al. [9]

Significantly, the IJV-D and IJV-A may be affected by some confounders in addition to venous pressure. These cofounders include venous wall compliance, pressure from surrounding tissues, the action of jugular vein valve, and venous contraction due to sympathetic stimulation [11]. These cofounders may also explain the paradoxical changes in IJV-D and IJV-A observed in some patients from the current study, with unexpectedly smaller IJV-D and IJV-A recorded in the Trendelenburg position compared with their values in the supine position.

Assessing the CIMT has been demonstrated to be a reliable method of predicting atherosclerosis-related complications [16]. Simon A et al. [27] concluded a CIMT of 0.9–1 mm to indicate an increased risk of coronary artery disease. Rodeghiero et al. [28] reported a similar increased risk of coronary heart disease with CIMTs of 0.88 mm for men and 0.89 mm for women. The correlation between increased CIMT and anaesthesia induced hypotension could be explained by the processes inherent in atherosclerotic disease, which affect arterial compliance, arterial stiffening, and cardiac autonomic dysfunction [29]. They may also be attributable to age-related changes. Stein et al. [30] reported an increase in CIMT of ≥ 0.010 mm per year, which may explain the increased incidence of SAIH in the elderly population.

Kaydu A et al. [17] concluded a threshold value of 0.65 mm to be a moderate predictor of hypotension after induction of general anaesthesia, with an AUC of 0.753, a cut-off value of 0.65 mm, a sensitivity of 75.6%, and a specificity of 74.4%. In our study, despite a finding of higher CIMTs among patients of the hypotensive group compared with the non-hypotensive group, diagnostic accuracy was low and did not attain statistical significance. This may be attributable to the high values of CIMT in both the hypotensive and non-hypotensive groups of the current study, in comparison with the findings of the Kaydu et al. study [17]. In addition, the sample size calculation was not adjusted for this outcome

Our study had some limitations. One important limitation was the relatively good health of patients included in the study. We recommend that future studies include patients with such chronic disorders as cardiac disease. In addition, we did not compare the reliability of IJV measurements with those of the IVC. We recommend such a comparison be the subject of future studie

9. Conclusions

Conclusions: Preanesthetic IJV-CI and ΔIJV-D from the supine to the Trendelenburg position were moderate predictors of SAIH. Results suggested that IJV-CI is > 34.4% and a ΔIJV-D is of ≥ 0.11 to be the threshold levels, while CMIT could not predict SAIH.

Abbreviations

SAIH: spinal anaesthesia induced hypotension
IVC: The inferior vena cava
IJV: internal jugular vein,
IJV-CI: internal jugular vein collapsibility index
IJV-D: internal jugular vein IJV diameter
IJV-A: internal jugular vein area
ΔIJV-D: rate of change in IJV-D with the change in posture
ΔIJV-A: rate of change in IJV-A with the change in posture
CIMT: carotid intima-media thickness
MAP: Baseline mean arterial pressure
HR: heart rate
SaO2: arterial oxygen saturation
AUROC: area under the receiver-operating characteris tic curve
CVP: central venous pressure

Authors contributions

BA was responsible for idea conception and study design, analysis of the data, and writing the manuscript. MR, HH and BA performed the Ultrasonographic assessment. BA and AA participated in the Data analysis. BA, AR, AA and MR shared in writing the manuscript. All authors read, revised and approved the final manuscript.

Data Availability

The datasets used and analyzed during this study are available from the corresponding author upon reasonable request.

Disclosure statement

No potential conflict of interest was reported by the author(s).

Clinical trial registration number

The study was registered prospectively at clinicaltrials.gov (ID: NCT05078606), date of first registration 10/04/2021.

Ethical approval and consent to participate

- The study is approved by the Research Ethics Committee of Kasr Alainy Faculty of Medicine, Cairo University (email: kasralainirec@gmail.com ID: MD-152-2020).
- The study was registered on ClinicalTrials.gov identifier: ID: ID: NCT05078606.
- All methods were performed according to relevant guidelines and regulations. The reporting of this study conformed to the Accurate Reporting of Diagnostic tests (STARD) guidelines.
- Written informed consent was obtained from all patients before they joined the study.

IRB number

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