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Risk factors for hypotension in regional spinal anesthesia for cesarean section. Role of the Waist-to-Hip Ratio and Body Mass Index

Factores de riesgo para hipotensión en anestesia regional subaracnoidea para cesárea. Papel del Índice Cintura Cadera e Índice de Masa Corporal

Keywords: Anesthesia Spinal, Hypotension, Cesarean Section, Risk Factors, Obesity

Palabras clave: Anestesia Raquídea, Hipotensión, Cesárea, Factores de Riesgo, Obesidad

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Abstract

Introduction: Because of its incidence, hypotension under spinal anesthesia has been the subject of study and debate. Studies have been aimed at defining risk factors, clarifying pathophysiology, and creating prophylaxis and management protocols. There are no studies of anthropometric measurements, such as waist-to-hip ratio (WHR) and body mass index (BMI), associated with maternal hypotension. The higher the content of the abdominal cavity, the greater the likelihood of aorto-caval compression syndrome and the higher the risk of hypotension.

Objective: To determine if the WHR and the BMI correlate with the probability of developing hypotension in pregnant women undergoing cesarean section under subarachnoid anesthetic block.

Materials and methods: A prospective cohort study of 231 women undergoing cesarean section under regional anesthesia. Anthropometric measurements were made before anesthesia, and vital signs were recorded during the procedure at predetermined time points to analyze the hemodynamic status. Hypotension was defined as a systolic blood pressure below 90 mm Hg.

Results: The incidence of hypotension was 38%; 45.8% of the women had a WHR >0.99, with an incidence of 21.7% versus 15.2%, and a nonsignificant risk ratio of 2.12 (95% confidence interval [CI] 1.52–3.54, $P=0.021$). Women with a BMI >29 had an incidence of 42.8% versus 57.14%, without a significant difference ($P=0.576$). There was a significant association between the weight of the newborn >3900g and the risk of hypotension (relative risk 2.12, 95% CI 1.52–3.54, $P=0.021$).

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Conclusion: There was no positive correlation between WHR and BMI, and the risk of developing hypotension. The weight of the newborn must be further analyzed in future studies.

Resumen

Introducción: La hipotensión bajo anestesia regional subaracnoidea ha sido tema de estudio y debate, dada su alta incidencia. Los estudios se han encaminado a encontrar factores de riesgo, estudiar fisiopatología, crear protocolos de manejo y profilaxis. No hay estudios de medidas antropométricas, como el índice de relación cintura-cadera (IRCC) e Índice de masa corporal (IMC) asociados a hipotensión en maternas. A mayor contenido en cavidad abdominal, mayor probabilidad de síndrome de compresión aorto-cava y mayor riesgo de hipotensión.

Objetivo: Determinar si el Índice de Relación Cintura Cadera y el Índice de masa Corporal se correlacionan con la probabilidad de desarrollar hipotensión en gestantes sometidas a Cesárea bajo anestesia subaracnoidea.

Materiales y métodos: Estudio analítico de cohorte prospectivo. 231 maternas sometidas a cesárea bajo anestesia regional; se tomaron medidas antropométricas antes de anestesia, se registraron signos vitales durante el procedimiento en momentos preestablecidos para analizar el comportamiento hemodinámico. Se definió hipotensión como tensión arterial sistólica < 90 mmHg.

Resultados: La incidencia de hipotensión fue 38%. El 45,8% tuvieron IRCC >0,99 con incidencia de hipotensión de 21,7% vs 15,2% y RR no significativo de 2.12 (IC95% 1.52–3.54 p=0.021). Pacientes con IMC >29 la incidencia de hipotensión fue 42,8% versus 57,14%, sin diferencias significativas. (p=0,576). El peso del recién nacido >3.900 gramos se asoció significativamente con riesgo de hipotensión; RR:2.12 (IC95% 1.52–3.54 p=0.021).

Conclusiones: EL Índice Cintura Cadera y el Índice de Masa Corporal no presentaron correlación positiva con el riesgo de presentar hipotensión. El peso del recién nacido debe documentarse en futuros estudios.

Introduction

Hypotension in regional subarachnoid blocks has been defined as the most important and most deleterious side effect for the well-being of the mother and the fetus. Studies have focused on identifying the most relevant risk factors, including pathophysiology, early and effective prevention, and the creation of management protocols.

The definition of hypotension has varied among authors over the years, making it difficult to estimate its incidence. Studies have shown that reported incidences range between 1.9%¹ and 71%.² More recent studies came to greater agreement and proposed proportional reduction of systolic blood pressure (SBP) to a value lower than 70%–80% of baseline, or a reduction of the SBP value under 90 and 100 mm Hg.^{3–5} With the use of these definitions, the incidence of hypotension rose to 70%–80% of the pregnant women,

despite fluid preloading or the use of nonpharmacological measures such as uterine displacement.^{4,6}

Obesity and increased abdominal content because of the pregnant uterus are an additional risk factor for the occurrence of hypotension under regional anesthesia, as a result of a greater displacement of the intra-abdominal content, and vascular compression that aggravate the aorto-caval compression syndrome. This variable determined by waist-to-hip ratio (WHR) is an attractive predictor for hypotension that could be even better than body mass index (BMI). The objective was to determine if there is a positive correlation between anthropometric variables and the presence of hypotension in pregnant women taken to cesarean section under spinal anesthesia.

Materials and methods

This is a prospective analytical cohort study of 236 patients undergoing regional subarachnoid anesthetic block for cesarean section at Hospital Universitario de Santander and Clínica Materno Infantil San Luis, during the time period between July, 2014 and December, 2015. Patients over 18 with an ASA classification of 1, 2, and 3, taken to urgent or elective surgery, were included. Patients given epidural or spinal analgesia were excluded. The study was approved by the Scientific Research Ethics Committee of Universidad Industrial de Santander (Number 7083) and the Ethics Committee of Clínica Materno Infantil San Luis (Code DM-0076–14), and classified as minimum risk, because it did not propose any form of intervention. All patients signed an informed consent for anthropometric measurements.

A pilot test was conducted with 50 patients to determine sample size, and the incidence of hypotension in the group with WHR >0.99 was 19% versus 8%, with a 95% confidence interval (CI) and a 5% accuracy, for an estimated number of 236 patients.

Weight, height, and waist and hip circumference were measured initially. Basic monitoring was then initiated and vital signs were recorded (SBP, diastolic blood pressure and mean arterial pressure, heart rate, and pulse oximetry). The anesthetic procedure was then started according to the choice of the specialist, using a mix of local anesthetic with opioid (bupivacaine 0.5% 8–10 mg + fentanyl 15–20 µg + morphine 60–100 µg), and technique specifics were documented in the collection tool (position, puncture site, needle type, sensory level reached). Having verified the sensory level reached with the anesthetic block, the surgical procedure was then started and vital signs were recorded at predetermined intervals until the end of the procedure. The patients who developed hypotension were managed as judged by the anesthetist in charge, in accordance with the protocol of each institution. Management was documented in the tool, as was also the case with intraoperative signs and symptoms such as nausea,

Table 1. Baseline characteristics

Variable	Mean	SD	Minimum	Maximum
Age, yr	28.64	5.68	18	43
Weight, kg	74.19	11.35	53	112
Size, m	1.59	0.06	1.47	1.8
BMI	28.7	3.93	21	42
Gestational age, wk	38.23	1.01	34	41
Parity	2.43	1.16	1	8
Uterine height, cm	35.26	2.52	27	44
Waist circumference, cm	105.87	9.47	87	142
Hip circumference, cm	107.64	10.83	85	175
Waist-to-hip ratio	0.99	0.07	0.8	1.23

BMI=body mass index, SD=standard deviation.
Source: Authors.

vomiting, and dyspnea. Data regarding the newborn were also recorded.

Population characteristics were described using means, ratios, and proportions with their respective CIs. The outcome variable was classified in accordance with the prior description, and it was used to estimate incidence, expressed in percentages.

Variables which, according to the literature, could behave as risk factors for hypotension were identified. A

linear regression analysis was performed to assess the behavior of WHR and BMI as predictors of hypotension. This was followed by univariate and bivariate analyses to select the variables with sufficiently large statistical significance that would be included in the model. A $P < 0.2$ was selected, but only those variables with values < 0.05 were considered significant. Finally, binomial logistic regression was used for modeling.

Results

Overall, data for 231 pregnant women were collected (98% of the calculated sample). Mean age was 28 years, and mean gestational age was 38.2 weeks. Mean WHR was 0.99. **Table 1** shows the information regarding anthropometric measurements and other general characteristics of the patients and the procedure.

Of the pregnant women, 90% belonged to the white race, and 82.6% had no comorbidities, the most frequent pregnancy-associated disorder being hypertension (10%). The main indication for cesarean section was a previous history of this surgical procedure (61%), followed by fetal macrosomia (7.3%).

The anesthetic technique in the sitting position was the most frequent (64%), with the use of the No. 25 pencil-tip needle in 99.1% of cases. The most common access was the L3 to L4 space (86.5%), achieving sensory levels between T2 and T5, the most frequent being T4 (53.2%). Of the anesthetic mix used, 59.74% consisted of bupivacaine 8mg, fentanyl 20µg, and morphine 80µg. The average amount of intravenous fluids was 1668mL, and blood loss was 565mL. The lowest birth weight was 1655g and the highest was 5690g.

All patients were followed through to the end of the surgical and anesthetic procedures. The time period

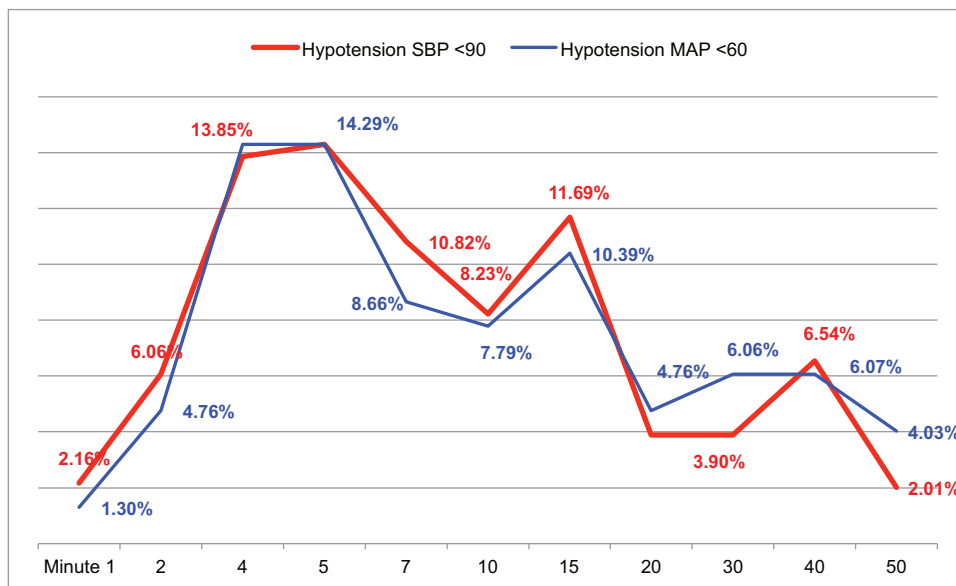


Figure 1. Incidence of hypotension according to time and variable assessed.
Source: Authors.

Table 2. Incidence, absolute, and relative risk of hypotension according to time and variable assessed

Variable	Hypotension (SBP <90mm Hg)	
	No. patients	Cumulative incidence (95% CI)
At 30min	231	37.66% (31.37–43.96)
At 40min	214	38.79% (32.20–45.37)
At 50min	149	37.58% (29.72–45.45)
General	231	38% (28.71–45.67)

	Cut-off point	Absolute risk	Relative risk	P
WHR	≤0.99	15.20%	1	
	>0.99	21.70%	1.25 (0.90–1.71)	0.202
BMI	≤29	57.14%	1	
	>29	42.86%	0.74 (0.42–1.27)	0.265

BMI = body mass index, SBP = systolic blood pressure, WHR = waist-to-hip ratio. Source: Authors.

between 4 and 7 minutes after anesthesia induction was the most hemodynamically labile.

Incidence of hypotension

The incidence of SBP <90mm Hg was 38.01% ($P=0.000$). The highest incidence of 13.85% and 14.29%, respectively, was recorded on minutes 4 and 5. There were 90 episodes of hypotension during the first 30 minutes; 18.18% of the women had at least 1 episode, and 3.8% had more than 3.³ A single vasopressor was used in 79% of the cases, and phenylephrine was the agent most frequently employed (see Fig. 1 and Table 2).

Anthropometric variables and arterial hypotension

The mean WHR was 0.99; 45.89% of the patients had a WHR ratio >0.99, and the incidence of hypotension in this group of patients was 21.7%, with a relative risk (RR) of 1.25 (95% CI 0.90–1.71), and no statistically significant difference ($P=0.2020$). In patients with an above-average BMI (28.71), the incidence of hypotension was 42.86%, a lower and nonsignificant value ($P=0.265$) when compared with patients with a lower BMI (see Table 2).

Correlation between arterial hypotension, and body mass index and waist-to-hip ratio

A linear assessment of WHR (as a continuous variable) did not show a significant regression value that could point to the probability of developing arterial hypotension. More-

over, the assessment of each variable of the WHR did not show a positive trend for predicting hypotension. The greater the diameter of the 2 variables, the lower the probability of developing hypotension. The value was plotted against BP at each time point, and there was never a linear correlation; on the contrary, there was great scatter with negative values as well. BMI behaved the same as WHR when assessed continuously in a linear regression. No predictable behavior was observed (Fig. 2 and Table 3).

Bivariate model and arterial hypotension

The remaining variables were evaluated, either baseline or related to the anesthetic technique and intraoperative events. Variables related to sociodemographic characteristics did not behave as risk factors for hypotension, and those related to the anesthetic technique had the greatest influence on the development of hypotension. Variables with a P value <0.20 or for which clinical evidence has shown association were included in the model: birth weight percentile 90 (RR 1.8, 95% CI 0.9–3.5, $P=0.108$), age >29 years (RR 1.31, 95% CI 0.75–2.26, $P=0.33$), bupivacaine >10 mg (RR 1.01, 95% CI 0.48–2.11, $P=0.966$), blockade above T4 (RR 1.14, 95% CI 0.65–1.97, $P=0.637$), among others.

Once the binomial regression model was applied, the only variables remaining in the final model ($P < 0.05$) were: black race, birth weight of the newborn (>R 3900 g), and hip circumference (greater than 113 cm). The model yielded an area under the ROC curve (AROC) of 0.6415 (Table 4).

Regarding the newborn, there were no adverse effects based on the APGAR score at 1 minute and at 10 minutes. Nausea was the most frequent adverse effect in terms of intraoperative symptoms (19.5%). The incidence of vomiting, yawning, and dyspnea was low.

Discussion

The research design and analyses confer validity to the outcomes. There are no studies in the literature reporting the relation between WHR and hypotension in pregnant women subjected to subarachnoid regional anesthesia. A limit value of 90 was selected for SBP, considering that it is the most frequently used in various studies, as recommended by Liu et al.⁵

Results showed a totally negative or inverse, although nonsignificant, trend: the greater the WHR, the lower the probability of developing hypotension. This is contrary to the pathophysiological mechanism leading to the development of hypotension where the mechanical effect of aorto-caval compression is added to reduced arteriolar tone due to sympathectomy.⁷ It would have been expected that the higher the WHR, the greater the visceral abdominal content, and, consequently, the greater the hypotension due to mechanical compression.

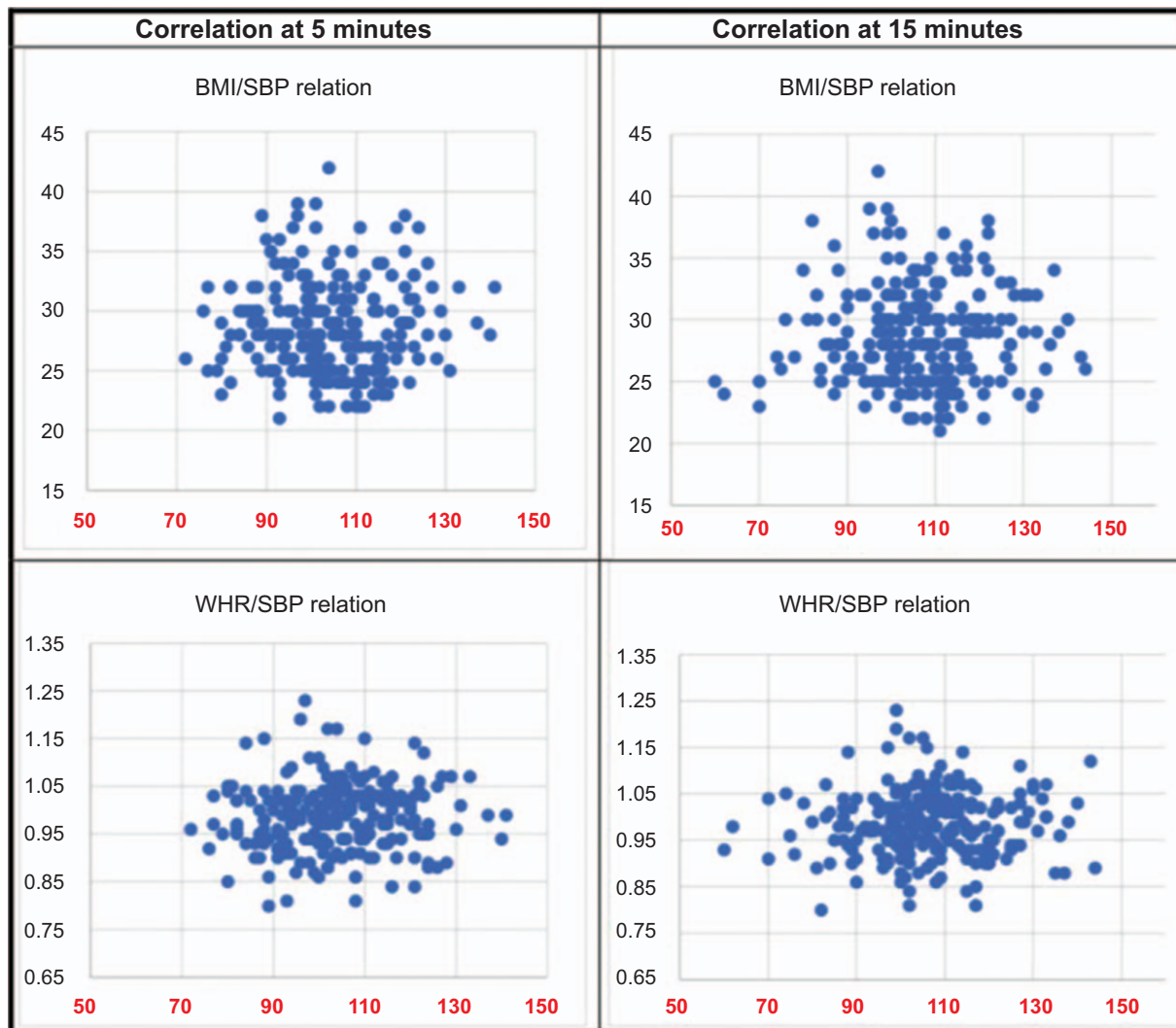


Figure 2. Correlation between systolic blood pressure, and waist-to-hip ratio and body mass index. Source: Authors.

If aorto-caval compression by the pregnant uterus is a known factor for hypotension, this variable could be selected as a surrogate predictor and estimated on the basis of the WHR. However, our hypothesis was not

proven. The sole significant risk factor was fetal birth weight greater than 3900g, a variable that was also included in the final model. Although its value in the AROC was fair (0.645), it reinforces the idea that the

Table 3. Correlation coefficients for anthropometric measurements and hypotension

Hypotension	Coefficient	P > t	95% CI
Body mass index	-0.003	0.640	-0.015 to 0.097
Constant	0.26	0.154	-0.101 to 0.639
Waist circumference	-0.0008	0.822	-0.0083 to 0.0066
Hip circumference	-0.0041	0.212	-0.1072 to 0.0023
Constant	0.7210	0.015	0.1428 to 1.2993

CI=confidence interval. Source: Authors.

Table 4. Binomial model for hypotension

Hypotension	Relative risk	P	95% CI
Black race	2.32	0.000	1.52-3.54
Hip circumference >113cm	0.26	0.016	0.08-0.78
Newborn birth weight >R 3900g	2.12	0.021	1.12-4.01
Constant	0.0612	0.000	0.023-0.16

CI=confidence interval. Source: Authors.

estimated weight of the newborn is the variable with the highest weight as predictor of hypotension, and could help guide preventive interventions in the population with estimated fetal weights above this value. In any case, a higher fetal weight is expected to be associated with a higher WHR, but this relationship was not demonstrated on the basis of our results.

The weight of the newborn was identified as a risk factor for developing hypotension (RR 2.12, 95% CI 1.52–3.54, $P=0.021$) when it is higher than 3900 g. This finding correlates with hypotension due to aorto-caval compression supported by multiple studies.^{6,8,9} Black race was also associated with a higher relative risk (RR 2.32, 95% CI 1.52–3.54, $P=0.000$). However, this is not supported in the literature, and further studies as required to propose it as a possible predictive factor.

A potential explanation for the findings may be that hypertensive disorders in pregnancy are more frequent in overweight and obese women.^{10–12} They develop endothelial alterations and dysfunction as a result of elevated plasma levels of leptin, insulin, and systemic mediators such as C-reactive protein, interleukin 6, and tubular necrosis factor alpha.¹³ All these factors predispose to hypertension and counteract the typical after-load reduction resulting from lower systemic vascular resistance during pregnancy.^{13,14} Moreover, studies conducted in the general population point to arterial hypertension and obesity as risk factors for hypotension associated with regional spinal anesthesia^{15,16}; and although this is not comparable with the obstetric population, one could assume that they would behave similarly under the effects of anesthesia. This is yet another argument that reinforces the hypothesis of alternative pathophysiological mechanisms that prevent the development of hypotension in pregnant women under anesthesia.

Our study is not free from potential bias, and the unavailability of baseline data for the patients at the start of pregnancy (WHR and BMI) left us with weight gain and variations in WHR and BMI as variables that might play an important role. The ability to use these values in a cohort study might lead us to think that the differences could probably not be associated with the content of the abdominal cavity, but rather with the variations of these 2 variables, added to the weight of the newborn, despite the fact that some observations have not found a relationship between abdominal circumference and the risk of hypotension.¹⁷

Findings related to sensory level, anesthetic dose, and other variables, which, despite showing absolute risk of hypotension and being reported in multiple studies,^{6,8,9,18} were not included in the final model. This could be explained by the low doses of anesthetics used, under 10 mg of bupivacaine, supported in the literature as a means to reduce the incidence of hypotension and as a way to improve intraoperative comfort and postoperative pain

when combined with an opioid, as compared with high-dose bupivacaine with no opioid.¹⁹

Conclusions

Waist-to-hip ratio and BMI do not correlate with the risk of developing hypotension under regional subarachnoid block during cesarean section. On the contrary, fetal birth weight higher than 3900 g was shown to be a risk factor for the development of episodes of hypotension. Further studies are required to confirm this finding.

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Ethical disclosures

Protection of human and animal subjects. The authors declare that the procedures followed were in accordance with the regulations of the relevant clinical research ethics committee and with those of the Code of Ethics of the World Medical Association (Declaration of Helsinki).

Confidentiality of data. The authors declare that they have followed the protocols of their work center on the publication of patient data.

Right to privacy and informed consent. The authors have obtained the written informed consent of the patients or subjects mentioned in the article. The corresponding author is in possession of this document.

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Conflicts of interest

The authors declare having no conflict of interest.

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