كليـــــة الـطـب
و الصيدلة - مراكش
FACULTÉ DE MÉDECINE
ET DE PHARMACIE - MARRAKECH
MARRAKECH
جامعة القاضي عياض
UNIVERSITÉ CADI AYYAD

Year 2024 Thesis N° 271

Preoperative measurement of abdominal circumference as a predictor of difficult spinal anesthesia and maternal hypotension during cesarean section.

THESIS

PRESENTED AND PUBLICLY DEFENDED ON 31/05/2024

BY

Mr. Moses WILSON

Born On August 11th 1994 in Monrovia

TO OBTAIN A DEGREE OF DOCTORATE IN MEDICINE

KEYWORDS

Patient Safety – Cesarean Section – Spinal Anesthesia
Obesity – Maternal hypotension

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Hippocratic Oath

AT THE TIME OF BEING ADMITTED AS A MEMBER OF THE MEDICAL PROFESSION:

I SOLEMNLY PLEDGE to consecrate my life to the service of humanity;

I WILL GIVE to my teachers the respect and gratitude that is their due;

I WILL PRACTISE my profession with conscience and dignity;

THE HEALTH OF MY PATIENT will be my first consideration;

I WILL RESPECT the secrets that are confided in me, even after the patient has died;

I WILL MAINTAIN by all the means in my power, the honour and the noble traditions of the medical profession;

MY COLLEAGUES will be my sisters and brothers;

I WILL NOT PERMIT considerations of age, disease or disability, creed, ethnic origin, gender, nationality, political affiliation, race, sexual orientation, social standing, or any other factor to intervene between my duty and my patient;

I WILL MAINTAIN the utmost respect for human life;

I WILL NOT USE my medical knowledge to violate human rights and civil liberties, even under threat;

I MAKE THESE PROMISES solemnly, freely, and upon my honor.

Geneva Declaration, 1948

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326	TITOU Hicham	Pr Ass	Dermatologie
327	EL GHOUL Naoufal	Pr Ass	Traumato-orthopédie
328	BAHI Mohammed	Pr Ass	Anesthésie-réanimation
329	RAITEB Mohammed	Pr Ass	Maladies infectieuses
330	DREF Maria	Pr Ass	Anatomie pathologique
331	ENNACIRI Zainab	Pr Ass	Psychiatrie
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333	JENDOUZI Omar	Pr Ass	Urologie
334	MANSOURI Maria	Pr Ass	Génétique
335	ERRIFAIY Hayate	Pr Ass	Anesthésie-réanimation
336	BOUKOUB Naila	Pr Ass	Anesthésie-réanimation
337	OUACHAOU Jamal	Pr Ass	Anesthésie-réanimation
338	EL FARGANI Rania	Pr Ass	Maladies infectieuses
339	IJIM Mohamed	Pr Ass	Pneumo-phtisiologie
340	AKANOUR Adil	Pr Ass	Psychiatrie
341	ELHANAFI Fatima Ezzohra	Pr Ass	Pédiatrie
342	MERBOUH Manal	Pr Ass	Anesthésie-réanimation
343	BOUROUMANE Mohamed Rida	Pr Ass	Anatomie
344	IJDDA Sara	Pr Ass	Endocrinologie et maladies métaboliques

LISTE ARRETEE LE 09/01/2024

DEDICATIONS

First and foremost, the Almighty who inspired me; and guided me on the right path.

To you, I owe what I have become.

Praise and thanks for your clemency and Mercy

To the memory of my grandmother

There's no greater love than that of a grandmom.

I dedicate this work to you as a testimony of my greatest love and deep affection.

Rest in peace, Grandma.

To my Dearest Mother

Thank you. Words cannot express the depth of my gratitude for everything you have done for me.

Your unwavering love, endless sacrifices, and boundless support have shaped me into the person I am today.

None of this would be possible today without your prayers and unconditional support.

I am forever grateful and I pray God grants you good health and a long life to enjoy the fruits of your labor.

To my Father

I acknowledge and appreciate everything you have done, big and small, to make my life better. I dedicate this work to you to express my love and gratitude.

To Auntie Sarah

I wish to express my deepest gratitude for all that you have done for us. Your kindness knows no bounds, and your generosity is unmatched.

You've been more than just an aunt to me; you've been a mother and a friend. For all the love, guidance, and encouragement you've bestowed upon me, I am profoundly grateful.

To Uncle Lawrence

Thank you for your encouragement and support throughout these years. I dedicate this work to you in recognition of the great affection you show me and to express all the gratitude and respect I have for you.

To Uncle Mathias

Thank you for the prayers and words of encouragement every time we talk. You have inspired me to achieve what I am today. For that, I am very grateful.

To Eyoung

Thank you for being a brother, and my closest friend.

From our shared adventures to the quiet moments of understanding, you have been a constant source of strength and inspiration. Your unwavering support during both the highs and lows of life has meant more to me than words can express.

To Cousin Michael

Thank you for all the support and words of encouragement all along. You were always there to the rescue when things got tough. I am truly grateful for all your help over these years.

To Peter Wilson

I want to acknowledge the incredible influence you've had on my life. Your presence, support, and unique perspective have shaped me in countless ways, molding me into the person I am today. Thank you for being a father figure and a great role model.

To my cousins: Mankalea, Grace, Ernest, Eddie, Andrew, Aaron, Kaweah, Becky

Thank you all for the support throughout this journey. You all hold a special place in my heart and I am grateful for the connection we share as a family.

To my uncles and Aunties and all the family members who supported me

Please find in this work my sincere gratitude and deepest respect.

To the guys: Jeremy, Parker, Stanley, Terry Toby, Josiah, Kotee

Growing up with you guys was fun, and I am continually amazed by the bond we share. Thank you for the countless laughs, the shared experiences, and the unwavering love.

To Dr. Keita, Dr. Cisse, Sidiki, Kingston, Lia, Isaac, Sokie

Please find in this work my sincere gratitude and appreciation.

To my colleagues at FMPM group 12: Aliaâ, Keba, Youness, Zineb, Chaimaa, Oumaima, Walid, Zainab

Thank you for the experience and for making this journey fun and bearable.

I am grateful for the opportunity to have known you guys and to be part of the team.

To professor and assistant supervisor MERYEM ESSASFTI

Department of Anesthesiology and Intensive Care

Mother-Child Hospital - Mohammed VI University Hospital Marrakech

I wish to express my sincere gratitude for your invaluable guidance, support, and encouragement throughout this project. Your expertise, patience, and constructive feedback have been instrumental in shaping this work and making it a reality.

My gratitude to you goes beyond mere ritual politeness.

To Me

Thank you for the perseverance

To all those who I might have forgotten to mention and all those who contributed to this work

I dedicate this to you

ACKNOWLEDGEMENTS

To the president of the jury SAID YOUNOUS

Head of Pediatric Anesthesia and Intensive Care Department

Mother-Child Hospital - Mohammed VI University Hospital Marrakech

We express our profound gratitude for having you preside over our thesis. It is with great admiration that we acknowledge your unwavering demonstration of exceptional professional and human qualities. Your dedication to creating the best possible learning environment for your students is truly remarkable.

Please accept, through this work heartfelt expression of our gratitude and deepest respect.

To Professor and supervisor A. R. EL ADIB

Head of Department at the University Hospital Mohammed VI and Professor of Anesthesiology and Intensive Care

I wish to express my sincere appreciation for your willingness to oversee this project.

Your unwavering dedication to excellence and commitment to innovation serve as a true inspiration. Your insightful feedback and expertise have played a pivotal role in this research work, and I am truly grateful for your mentorship and support every step of the way.

Please accept my sincere regards and admiration.

To professor and jury member ABOULFALAH ABDERRAHIM

Department of Obstetrics and Gynecology

Mother-Child Hospital - Mohammed VI University Hospital Marrakech

We wish to extend our sincere gratitude to you for the privilege of serving on our thesis jury.

We hold great respect for your exemplary professional and personal qualities, which have earned you the admiration of many.

It is with utmost honor that we convey our deep appreciation and profound respect to you.

To professor and jury member MOHAMMED KHALLOUKI

Department of INTENSIVE CARE UNIT

IBN TOFAIL UNIVERSITY HOSPITAL

We are deeply honored by your acceptance to serve on our thesis jury, and we wish to express our sincere gratitude for your scientific rigor and professional dynamism.

This work serves as an opportunity for us to demonstrate our appreciation for your esteemed presence.

FIGURES & TABLES

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PLANL

INTRODUCTION

Spinal anesthesia is the most secure and widely anesthetic technique used for patients undergoing cesarean section. This is due to the safety and effectiveness of the procedure. [1, 2]

Over the years, many studies have outlined its benefits in reducing maternal mortality, intraoperative time, urinary retention, intraoperative blood loss, and postoperative cognitive dysfunction (POCD). [3, 5]

Nonetheless, spinal anesthetic-induced hypotension remains a clinical concern. It is a frequent complication with patients undergoing cesarean section and poses problems for both the mother and the fetus. [3]

Previous studies have shown that the degree and duration of post-spinal anesthesia hypotension have adverse effects on the fetus, such as low Apgar score and umbilical acidosis, whereas maternal complications lead to events like cardiac arrest. [4, 5]

Although the procedure is simple, inexperienced practitioners and the patient's anatomy or body proportion have been shown to post difficulties with first-time success and non-traumatic occurrences. [6]

Numerous attempts to realize the procedure may cause distress and dissatisfaction for the patient, leading to complications like post-punctual headache, neurological impairment, and epidural hematoma. [7]

As difficult procedures bear importance for the patient's discomfort and satisfaction, and the frequent occurrence of hypotension, accurate prediction of these events could enhance clinical decision-making, alter therapeutic management, and prove crucial for providing quality perioperative care.

Therefore, we hypothesized that factors such as maternal obesity which is especially reflected by a higher abdominal circumference participate in maternal hypotension and contribute to the difficulty of spinal anesthesia during cesarean section.

Hence, this study was designed to determine the reliability of the maternal abdominal circumference as an easily available clinical evaluation tool during cesarean section to predict difficult spinal anesthesia and the occurrence of maternal perioperative hypotension.

MATERIAL AND METHOD

I. Type of study:

A prospective observational study, conducted over six months, from May 2023 to October 2023, following approval from the Ethics Committee of the Faculty of Medicine and Pharmacy Marrakech.

The study involved parturients who underwent cesarean section under spinal anesthesia in the gyno-obstetrical operating room at the Mother and Child Hospital of the Mohammed VI University Hospital Marrakech.

II. Population:

1. Inclusion criteria:

Parturients scheduled for elective cesarean section or admitted for emergency cesarean section, with American Society of Anesthesiology physical status (ASA) class II.

2. Exclusion criteria:

Excluded from the study were participants with the following impediments or complications:

- Acute fetal destress
- Umbilical cord prolapse
- Scoliosis
- Contraindication to spinal anesthesia
- Medical history of spinal surgery
- Preeclampsia

III. Data collection:

Data was collected from a Worksheet in the operation room after obtaining oral consent. (Appendix 1).

IV. Study variables:

1. Qualitative variables:

- Indication for surgery
- Patient medical history
- Anesthetic protocol
- Adverse events
- Visible spinous processes
- Palpation of spinous processes

2. Quantitative variables:

- Age
- Gestational age
- Weight at delivery
- Height
- Calculated Body mass index during delivery
- Sitting abdominal circumference
- Lying abdominal circumference
- Trunk length

- Number of skin punctures
- Number of reorientations of the spinal needle
- Skin to the medullary canal distance
- Motor block classification
- Sensory block level
- Time of motor block onset
- Duration of motor block
- Number of vasopressors used
- Time of onset of adverse events.

V. Pre-operative classification of parturients:

Patients were evaluated and then classified according to the physical status classification of the American Society of Anesthesiologists (ASA). [78]

Table I : ASA Physical Status Classification.

ASA PS Classification	Definition	Obstetric Example
ASA I	A normal healthy patient.	
ASA II	A patient with mild systemic disease.	Normal pregnancy, well controlled gestational HTN, controlled preeclampsia without severe features, diet-controlled gestational DM.
ASA III	A patient with severe systemic disease, not incapacitating.	Preeclampsia with severe features, gestational DM with complications or high insulin requirements, a thrombophilic disease requiring anticoagulation.
ASA IV	A patient with severe systemic disease that is a constant threat to life.	Preeclampsia with severe features complicated by HELLP or other adverse event; peripartum cardiomyopathy with EF <40; heart disease, acquired or congenital.
ASA V	A moribund patient who is not expected to survive without the operation.	Uterine rupture
ASA VI	A patient who has already been declared brain-dead and whose organs are being removed for transplant.	

DM : Diabetes mellitus

HTN: Hypertension

PS: Physical Status

ASA: American Society of Anesthesiologist

EF: Ejection fraction

VI. Peri-operative evaluation:

1. Hemodynamic monitoring:

Systolic blood pressure, diastolic blood pressure, and mean blood pressure were measured every 1 minute after performing spinal anesthesia. Scope/EKG and heart rate were continuously monitored.

2. Respiratory monitoring:

Consisted of continuous respiratory rate and pulse oximetry.

3. Neurological monitoring:

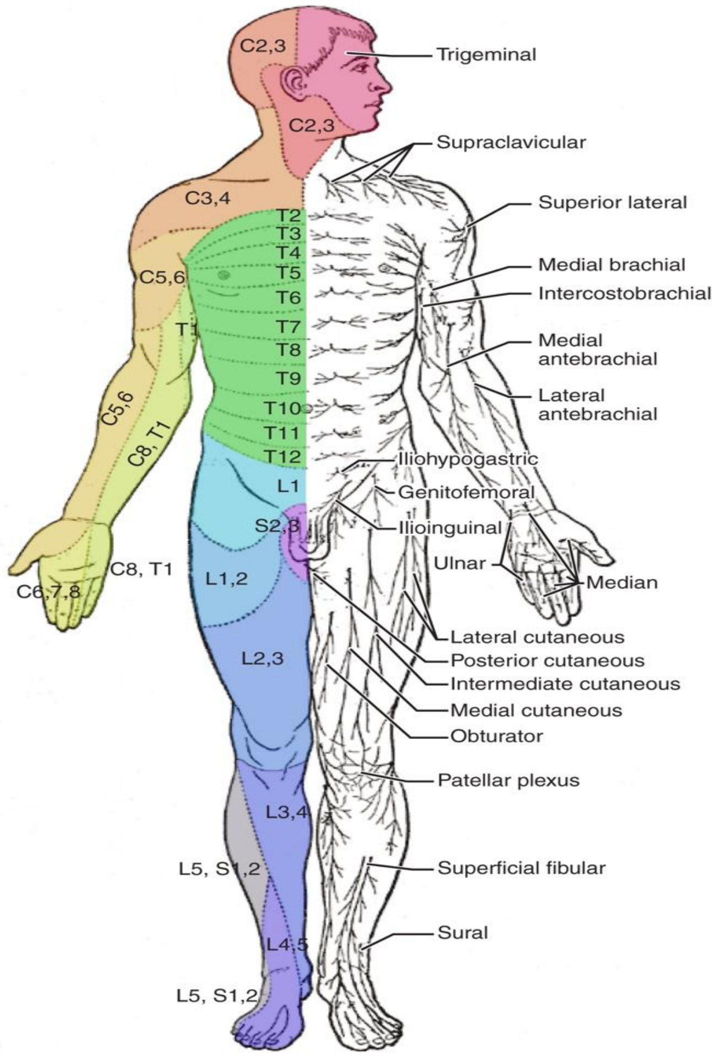
Neurological monitoring consists of assessing the state of consciousness by maintaining verbal contact with the patient.

4. Monitoring the quality of spinal anesthesia:

- The level of sensory block was sought by the ice method using a humidified cold compress every 5 minutes. (Figure 1)
- Bromage scale was used to assess the quality of motor blockades. (Table II) [8]

Table II : Bromage Scale

Grade	Criteria	Degree of block
I	Free movement of legs and feet	None
II	Just able to flex knees with free movement of feet	Partial 33%
III	Unable to flex knee, but with free movement of feet	Partial 66%
IV	Unable to move legs or feet	Complete paralysis



Sensory block level

Fingers: C8

Nipple: T4

Umbilical: T10

Thighs: L1

Figure 1 : Dermatomes of the sensory block level.

Image source: "Drawing Dermatomes and Cutaneous Nerves in an Anterior View - English labels" at AnatomyTOOL.org by Henry Vandyke Carter and Mikael Häggström is in the Public Domain.

VII. Definition of perioperative adverse events:

- Hypotension was defined by a drop over 20% of the base value or a systolic blood pressure below 90mmHg.
- Bradycardia was defined by a heart rate below 50 beats per minute (bpm).
- Traumatic spinal puncture was defined by a hematic flow of cerebrospinal fluid.
- Secondary cranial extension of spinal anesthesia above T4 level.
- Complete spinal block following spinal anesthesia implies an anesthetic block involving the cervical spine and above (such as brain stem and cranial nerves). It was defined by a high sensory level block above T4 with cranial nerve involvement and a motor block with upper limbs dysesthesia or paralysis, resulting in a respiratory compromise, apnea, loss of consciousness, severe hypotension, and bradycardia leading to cardiac arrest.

VIII. Definition of difficult spinal anesthesia:

Difficult spinal anesthesia was described as the need for more than one needle tip reorientation or more than one skin puncture.

Impossible spinal anesthesia was defined as failing to puncture the dural space and the absence of CSF (cerebral spinal fluid) flow after multiple attempts thus requiring conventional general anesthesia.

Failed spinal anesthesia was defined by the use of complementary sedation in patients with incomplete sensory or motor block during the procedure.

- Very easy: success after one first attempt without needle reorientation.
- Easy: success after One needle reorientation at first skin puncture.
- Mild: success after more than two needle reorientations at first skin puncture.

- Intermediate: a 2nd skin puncture is needed with 2 or less needle reorientations.
- Very difficult: more than 2 needle reorientations at the 2nd skin puncture or a 3rd skin puncture is needed, a change to a paramedian approach, or a call for another pair of hands.
- Impossible: incapacity to reach the dural space after multiple attempts thus converting to general anesthesia.

IX. Items:

1. Technical material:

- Necessary for hygiene and asepsis:
    - Sterile gauze
    - Sterile drapes
    - Sterile gloves
    - Antiseptic solution.
- Spinal needle
    - 25-gauge atraumatic pencil point spinal needle 90 mm (see Figure2). The same type and size were used for all patients.
    - Insertion guide (figure 3)
- Drugs for cardiorespiratory support
    - Saline 0.9%
    - Adrenaline 1mg/ml
    - Atropine 1mg/ml
    - Ephedrine (30mg in 10ml of Saline 0.9% or 3mg/ml)

    - Phenylephrine 50µg/ml
    - Noradrenaline 4µg/ml (2mg in a 500ml bag of Dextrose 5%)
- Local anesthetic solution
    - Isobaric bupivacaine 10mg
    - Fentanyl 25µg
    - Morphine 100µg
- Equipment and drugs for conversion to general anesthesia in the event of complications.

2. Method:

It was ensured that parturients were informed about the study and obtained oral consent upon arrival in the operating room. Parturients' demographics (age, height, weight, and BMI) were recorded. Abdominal circumference was measured in both sitting and lying positions at the level of the umbilicus starting at the anterior superior iliac spine (ASIS) (Figures 4 and 5). Trunk length was measured from the horizontal line passing from the pubic bone to the acromion with patient in a supine position (Figure6).

Standard monitors were installed, including an automated non-invasive blood pressure device, a pulse oximetry monitor, and an electrocardiography monitor. Intravenous access was established by placing a peripheral venous line, and 500ml Saline 0.9% was preloaded before anesthesia.

Baseline blood pressure and heart rate were recorded every minute before and after anesthesia. Before spinal anesthesia was administered, parturients were placed in a sitting position with the back curved. Tuffier's line (TL) was determined by palpating the upper iliac crest and assessing the corresponding level using ultrasound imaging (Figures7 and 8). Spinous processes were evaluated in terms of visibility and palpation (figure 9).

During the procedure, a 25-gauge Whitacre pencil point spinal needle was inserted through the midline at the tuffier's line (Figure10). A standardized dose of 10mg of isobaric bupivacaine associated with 25μg of fentanyl and 100μg of morphine was injected intrathecally after cerebrospinal fluid flow. [9, 10] The total volume of the injected solution was 3ml at a rate of 0.2ml/second.

Parturients were then placed in a supine position immediately after the procedure with a left lateral tilt of the table at 15°. Attempts of spinal anesthesia, orientation of the spinal needle, and skin puncture were recorded.

Blood pressure was measured at 1-minute intervals for 10 minutes after the spinal injection and then after every 2 minutes. Hypotension was defined by a drop over 20% of the base value or a systolic blood pressure below 90mmhg. Vasopressor choice was left to the discretion of the anesthetist; when hypotension was associated with bradycardia, Ephedrine was preferred with an intravenous bolus of 6mg repeated if needed; otherwise, diluted Noradrenalin 4μg/ml was administered until resolution along with fluid resuscitation.

Approximately 20-25 procedures each are necessary before residents in training demonstrate improvement in spinal and epidural anesthesia techniques. If a 90% success rate is desired, 45 and 60 attempts at spinal and epidural anesthesia, respectively, may be necessary [80]

Spinal anesthesia procedures and patient management were performed by the same experienced anesthesiologist, a 4th year resident with over 100 spinal anesthesia procedures performed, Data was collected by an independent physician not involved in patient management.

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Figure 2 : 25-Gauge atraumatic pencil point Whitacre spinal needle.

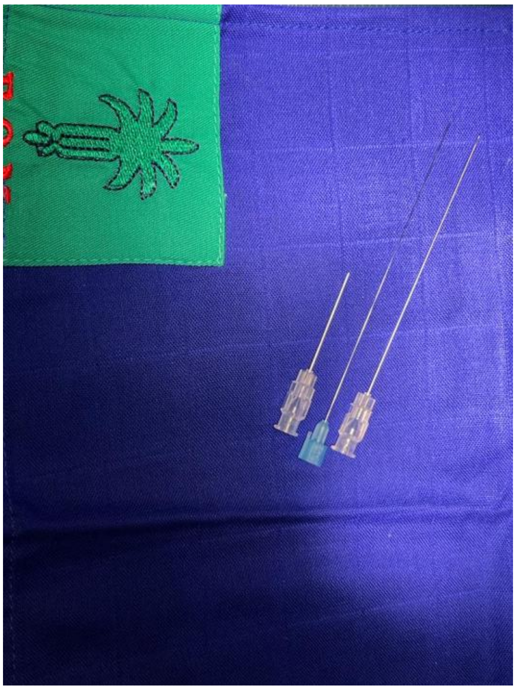


Figure 3 : Insertion guides (left) with a spinal needle at the right

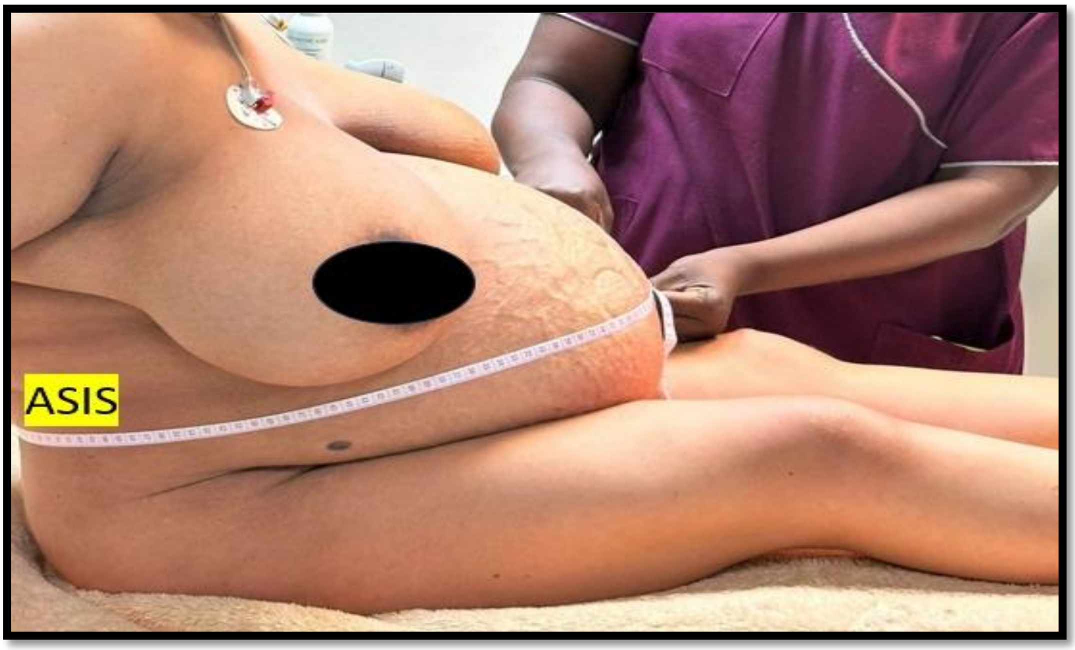


Figure 4 : Measurement of the abdominal circumference of a parturient in a sitting position starting at the Anterior Superior Iliac Spine (ASIS).

Figure 5 : Measurement of the abdominal circumference of a parturient starting at the Anterior Superior Iliac Spine (ASIS) in a supine position

Figure 6 : Measurement of parturient trunk length starting from the pubic bone to the acromion in a supine position.

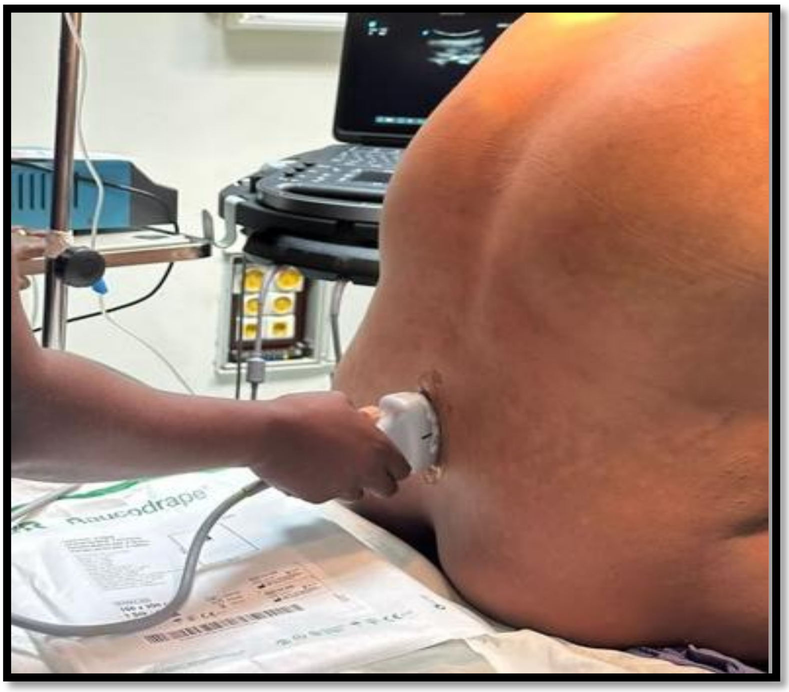


Figure 7 : Probe positioning in a longitudinal view.

a b c

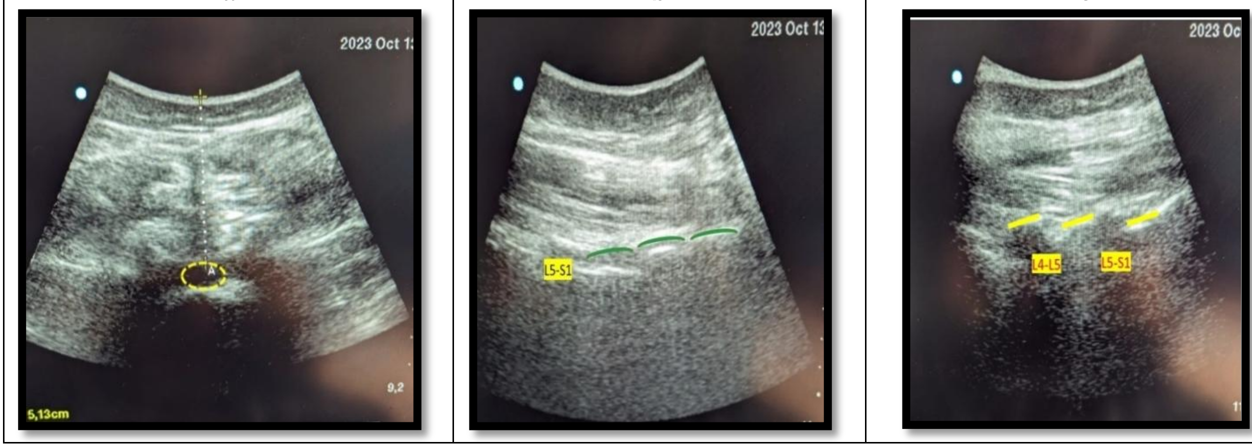


Figure 8 : Ultrasound images of anatomical landmark

a. Distance from skin to the posterior spinal canal in the transverse view.

b. Longitudinal view of the sacrum and the intervertebral space L5-S1.

c. Longitudinal view of intervertebral spaces

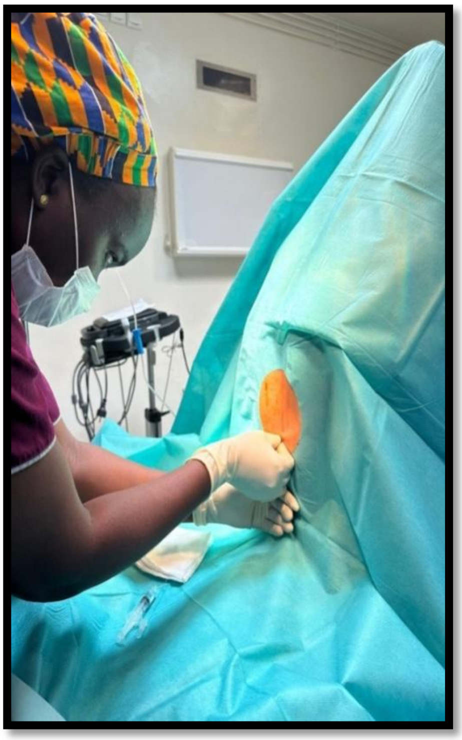


Figure 9 : Skin palpation of spinous processes.

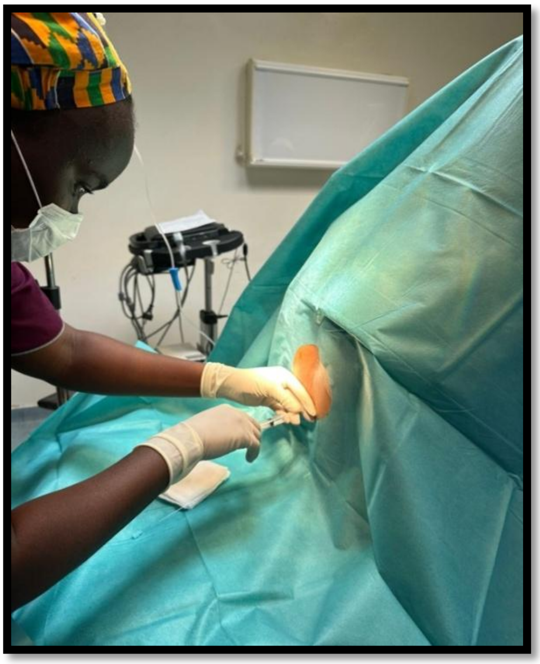


Figure 10 : Administration of spinal anesthesia with parturient in a sitting position and back curved.

X. Data analysis:

Data entry and statistical analysis were done using SPSS (Statistical Package for the Social Science) software Version 26 and Medcalc.

Numeric variables were expressed as mean (±SD) and discrete outcomes as absolute and relative (%) frequencies. We created 2 groups according to the values of difficult spinal anesthesia (easy and difficult).

Group comparability was assessed by comparing baseline demographic data and follow-up duration between groups.

Normality and heteroskedasticity of continuous data were assessed with Shapiro-Wilk and Levene's test respectively.

Continuous outcomes were compared with unpaired Student t-test, Welch t-test, or Mann-Whitney U test according to data distribution.

Discrete outcomes were compared with chi-squared or Fisher's exact test accordingly. The alpha risk was set to 5% and two-tailed tests were used.

A p-value < 0.05 was considered statistically significant. Patients with missing data were excluded from the analysis.

A Receiver Operating Characteristic (ROC) curve and its AUC (area under the curve) were generated to evaluate the reliability of abdominal circumference to discriminate the likelihood of difficult spinal anesthesia, whether measured in the lying or sitting position and the occurrence of maternal hypotension.

XI. Ethics approval and consent:

This prospective observational study was approved by the ethics committee of the University Hospital of Marrakech with reference No. 59/2023. Oral informed consent was obtained from all participants. (APPENDIX 2)

RESULTS

A total of 119 participants were enrolled in the study. 2 presented with fetal bradycardia, 2 had contraindications to spinal anesthesia (thrombocytopenia), 6 with preeclampsia, and 1 patient with cord prolapse. Hence excluded from the final analysis.

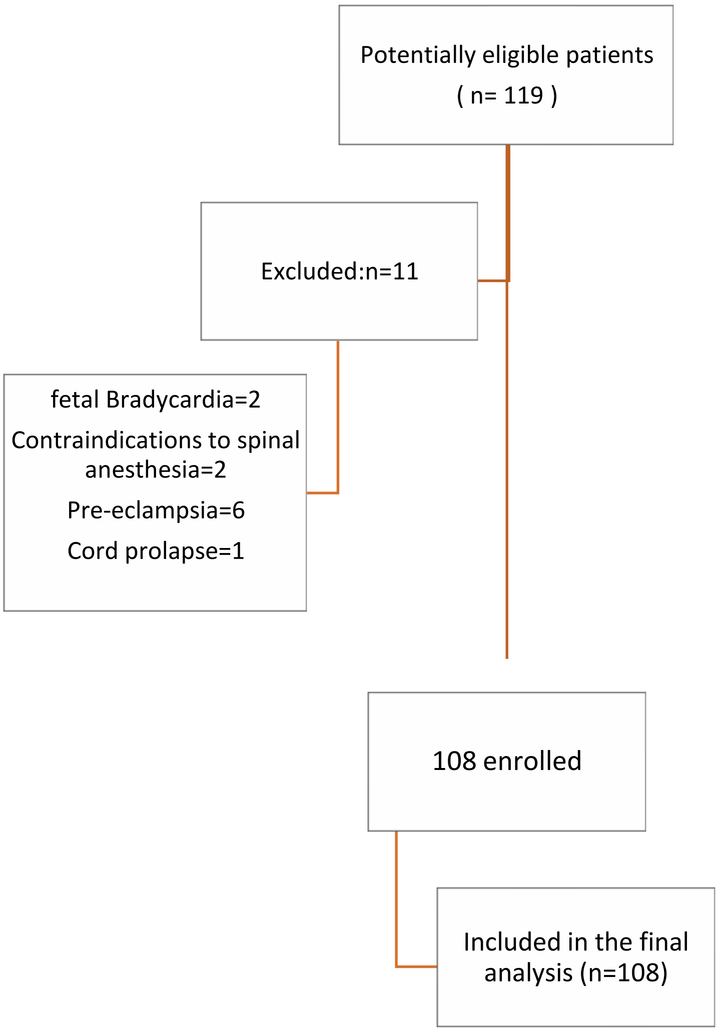


Figure 11 : Flow chat

During the study period from May 2023 to October 2023, a total of 1385 Cesarean sections were performed in the obstetrics operating theater of Mohammed VI University Hospital of Marrakesh. Recruitment was 7.7%.

I. Demographic description:

1. Age:

The mean age of this case series was 29.9 years, with a minimum age of 18 years and a maximum age of 45 years with a standard deviation SD of 6.75 (Figure 12).

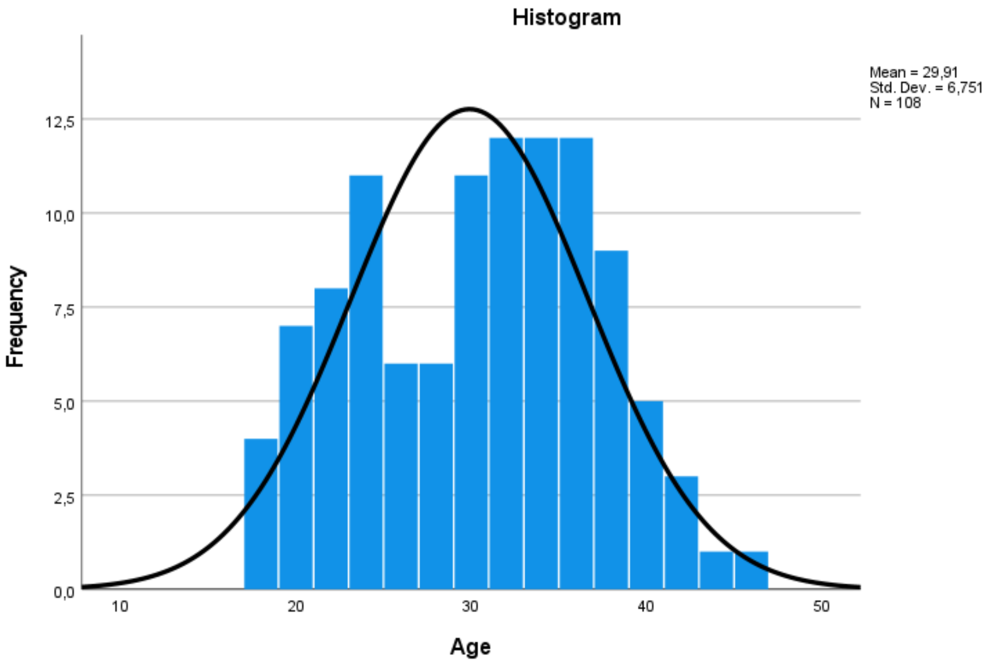


Figure 12 : Histogram of patients' age distribution.

2. Gestational age:

The mean age of pregnancy was 38.6 weeks of gestation, with a minimum of 31 and a maximum of 41.

12% of pregnancies were delivered prematurely before 37 weeks of gestation, whereas 10.2% were considered over-term pregnancies after 42 weeks of gestation (Figure 13).

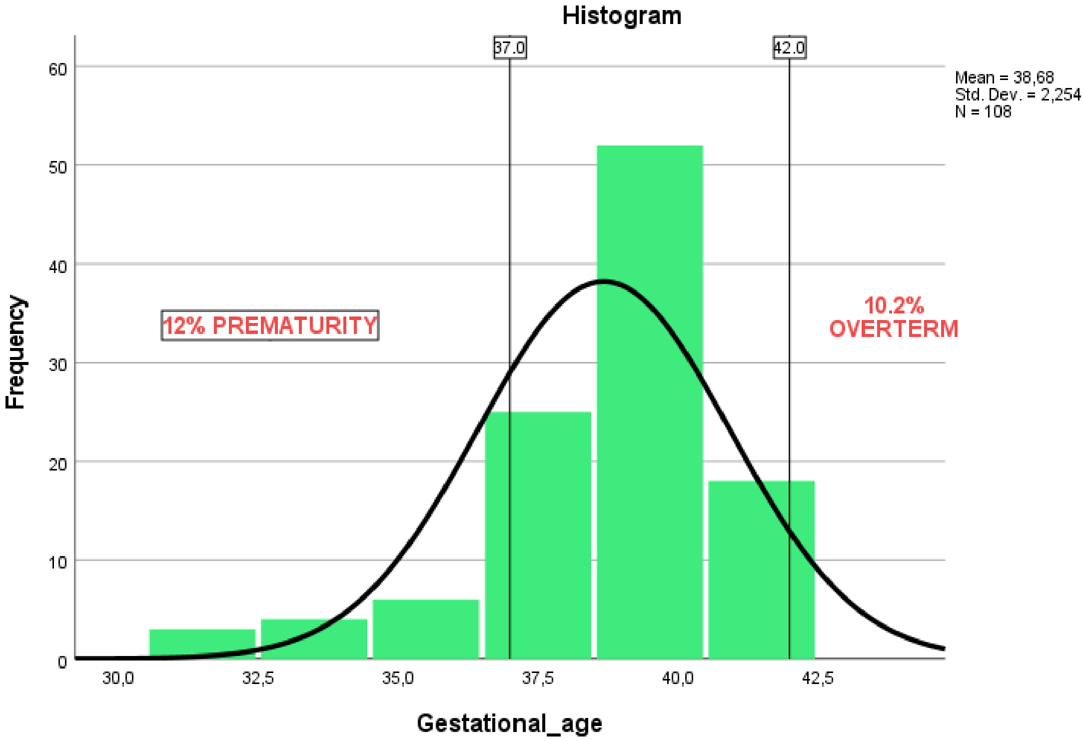


Figure 13 : Distribution of gestational age.

3. Past medical history of patients:

The most common medical history in the study was gestational diabetes with 23.1% and only 3.7% of twin pregnancies. (Table III)

Table III : Past medical history of patients.

Past Medical History	Number of Patients (Percentage)
Actual Twin pregnancy	4 (3.7%)
Gestational Diabetes	25 (23.1%)
Others	0 (0%)

4. ASA classification:

All enrolled patients were categorized as ASA II status (100%), either with a normal pregnancy or with controlled diabetes.

5. Indications:

Scarred uterus was the most common indication for cesarean section with 32.4%.

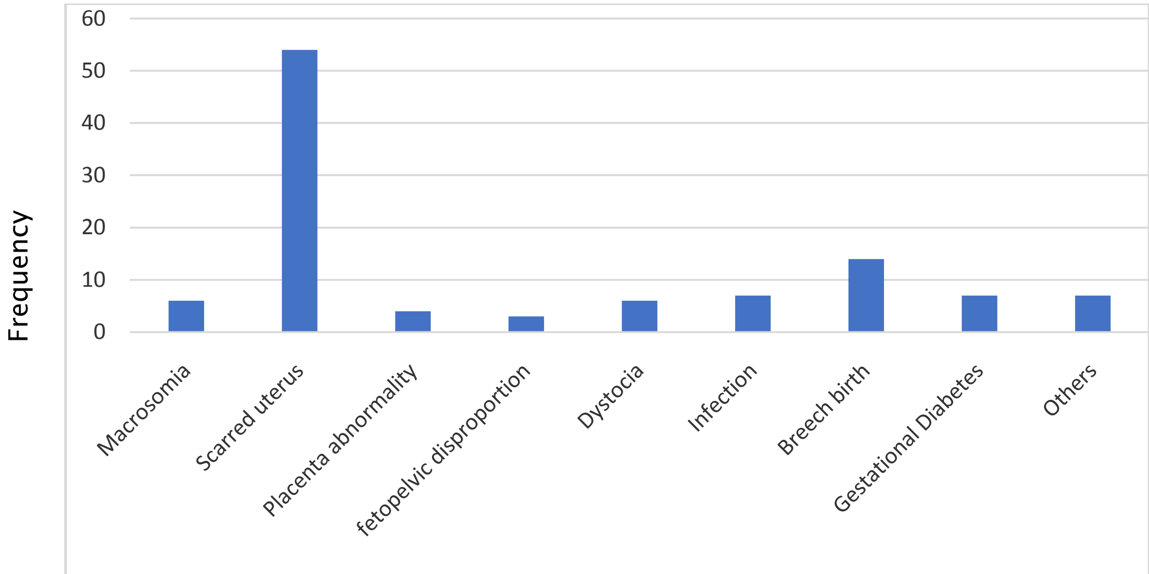


Figure 14 : Distribution of Indication for Cesarean

6. Elective vs Emergency Cesarean:

Most cesarean sections occurred in an emergency setting and only 27.8% of cases were scheduled.

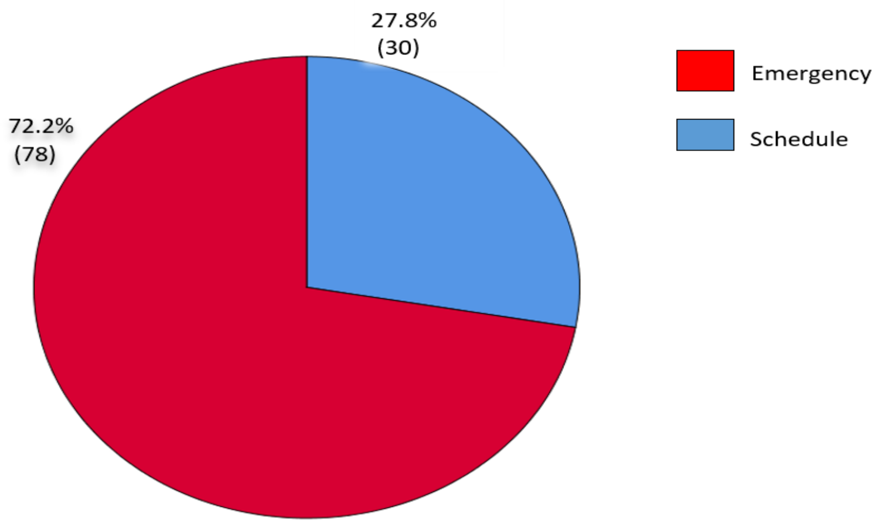


Figure 15 : Pie chart indicating emergency and elective cesarean section.

II. Clinical description:

1. Weight:

The mean body weight was 79.71 Kg with a minimum of 60 kg and a maximum of 140kg (SD of 12.78).

The Weight gain during pregnancy was not assessed due to a lack of monitoring and unreliable self-reported weight before pregnancy.

2. Height:

The average height was 164.31 cm with a minimum of 133cm and a maximum of 180cms (SD of 6.08)

3. Body Mass Index at delivery:

The mean BMI was 29.54 Kg/m² with a minimum of 21 Kg/m² and a maximum of 54 Kg/m². Patients were categorized according to their BMI at delivery into different categories (Figure 16).

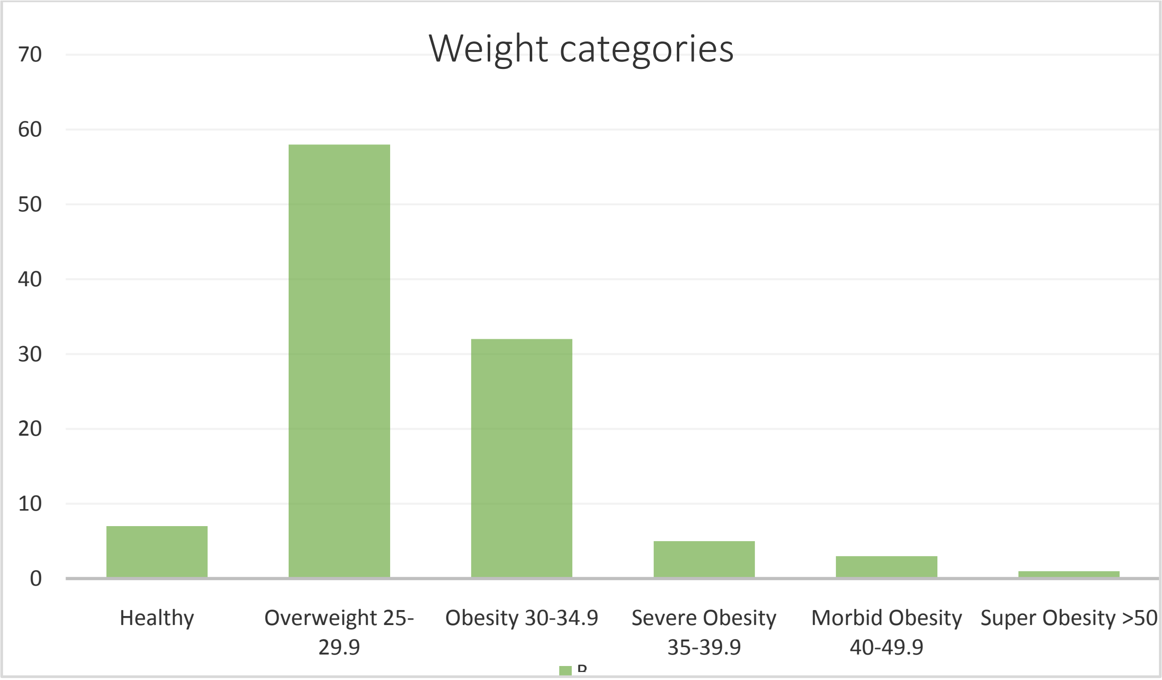


Figure 16 : Bar chart showing the distribution of Body Mass Index.

4. Trunk length:

The mean trunk length in a sitting position was 43cm ± 6.54 with a minimum of 32 cm and a maximum of 78cm.

5. Abdominal circumference in a sitting position:

The mean abdominal circumference measured in a sitting position was 110.56 ±12.39 with a minimum of 89cm and a maximum of 148cm.

6. Abdominal circumference in a lying position:

The mean abdominal circumference measured in a supine position was 104.50 ±12.65 with a minimum of 80cm and a maximum of 160cm.

The difference between the sitting and lying positions in terms of abdominal circumference varied between -7cm to +25cm with an average of 6.98cm±3.98.

7. Spinous processes:

Only 25.0% of the patients in the study presented visible spinous processes, while 65.7% were palpable.

There were more cases of not visible and not palpable spinous processes in parturients with difficult spinal anesthesia.

Pearson's chi-square and Fischer's exact test were statistically significant $p < 0,001$ and $p<0,001$ for the differences.

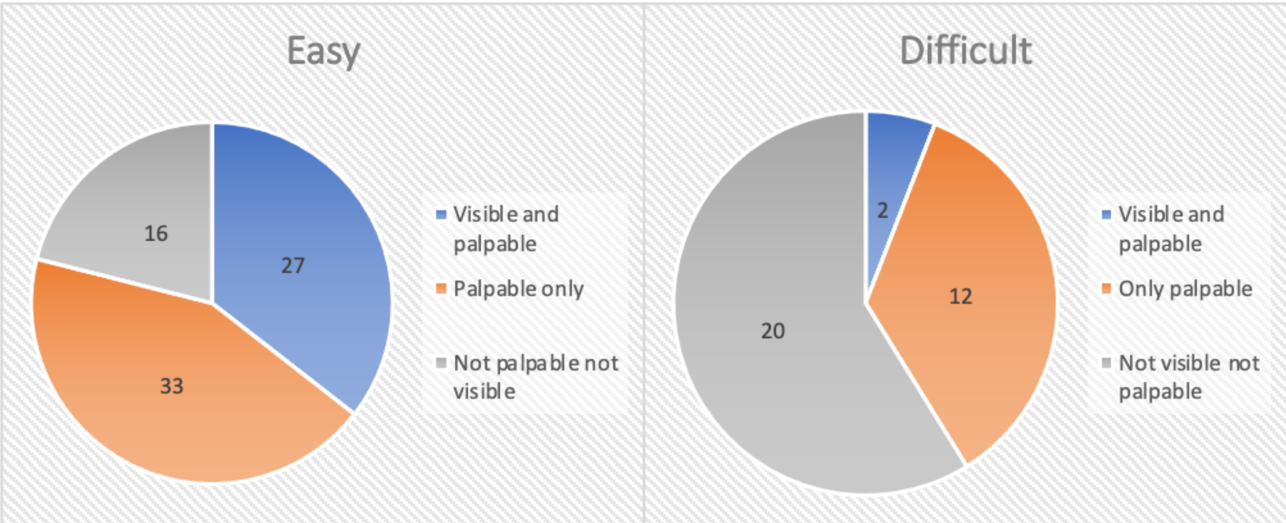


Figure 17 : Comparison between easy and difficult spinal anesthesia with spinal processes.

8. Ultrasound guidance:

8.1. Tuffier's line:

Palpation of anatomical Tuffier's line corresponding to the virtual line connecting the two iliac crests corresponded to L3-L4 in 57.4% of cases and to L4-L5 in 40.7%. Only one case of lower Tuffier's line matched with the L5-S1 space and one case of a more cephalic location corresponded to L2-L3.

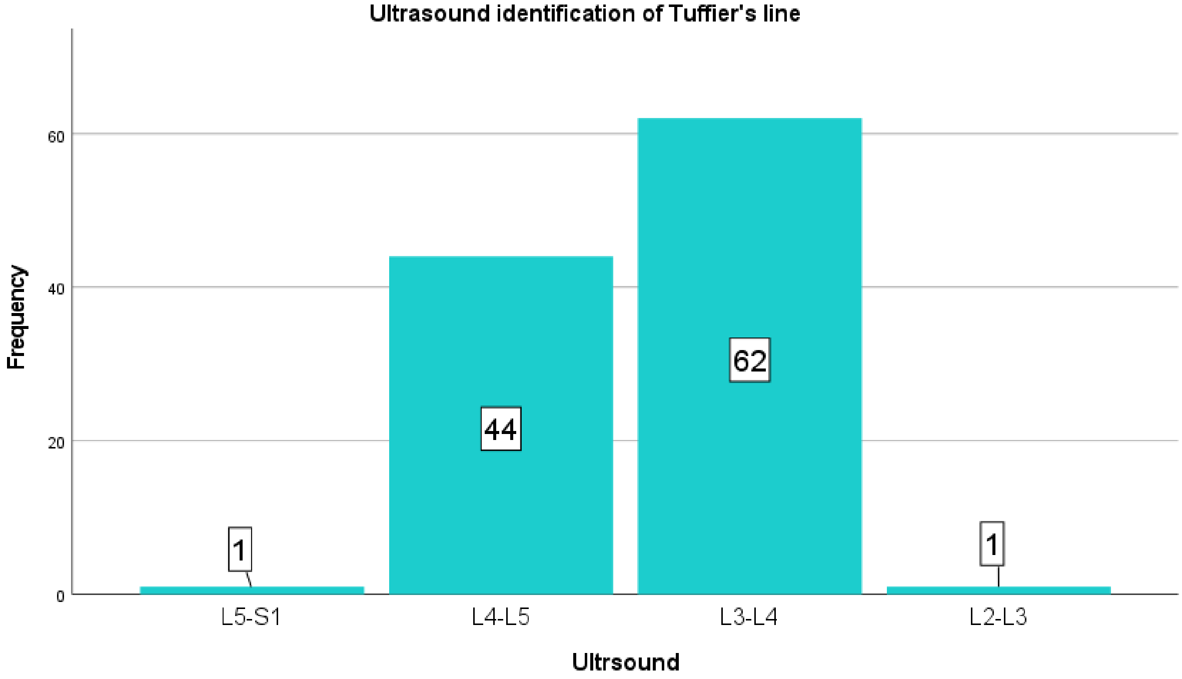


Figure 18 : Ultrasound identification of Tuffier's line.

9. Skin to the medullary canal distance:

The average distance of the skin-to-medullary canal was 4.79cm (SD=0.36) with a minimum of 3.23cm and a maximum of 5.50cm.

A significant correlation was observed between distance of skin-to-medullary canal and abdominal circumference (Pearson correlation = 0.464; 95% CI: [0.313; 0.592], p < 0.001) as well as BMI (Pearson correlation = 0.466; CI 95%: [0.313; 0.596]

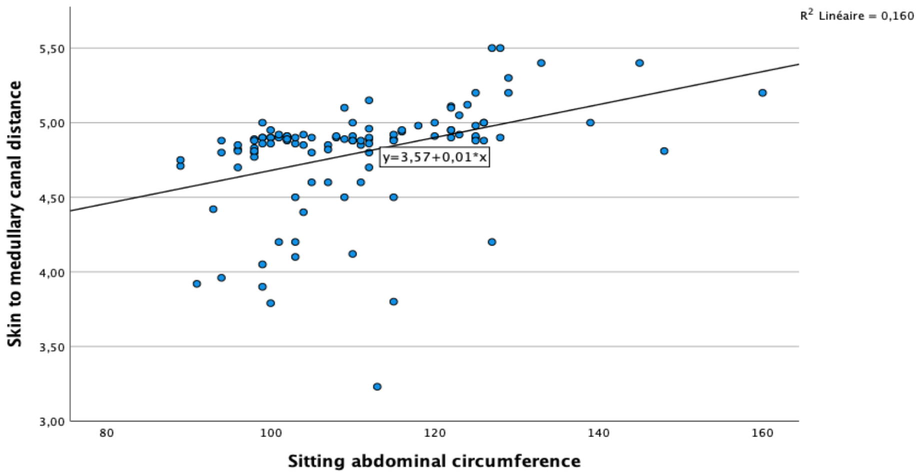


Figure 19 : Scatter Plot of Skin to medullary canal Distance by Sitting Abdominal Circumference

Figure 20 : Scatterplot of Skin to medullary canal distance by Body Mass Index

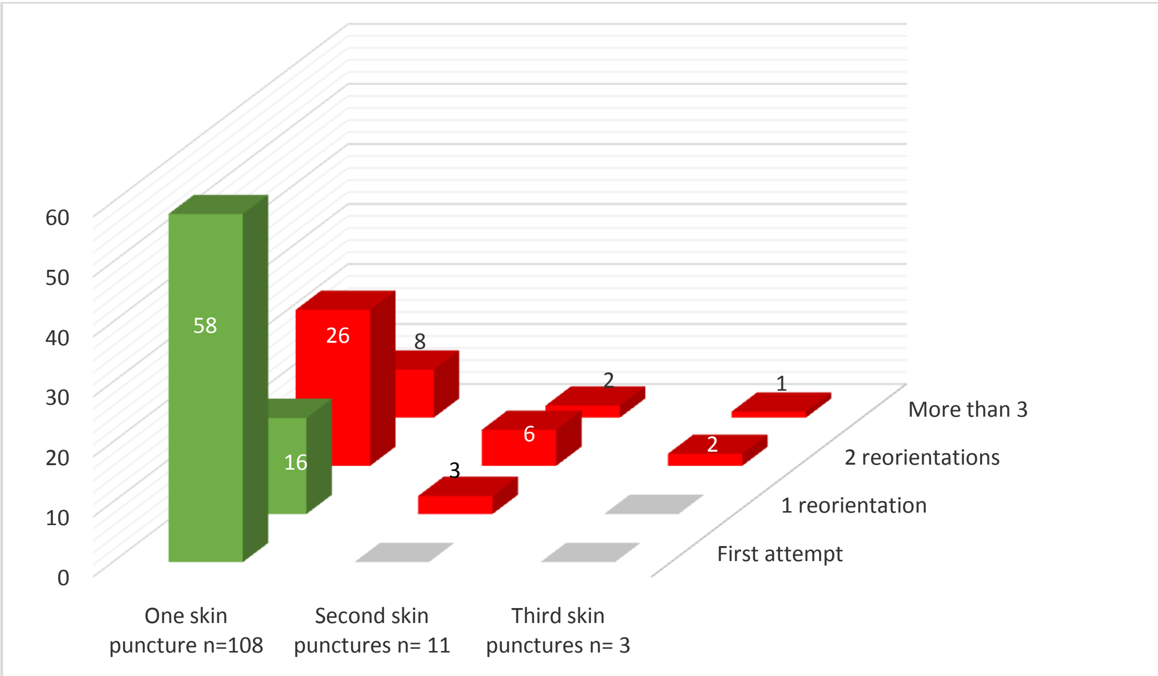
III. Spinal anesthesia technique:

1. Number of skin punctures:

The total sum of patients with successful spinal anesthesia at first attempt was 58 patients and 16 patients required one needle reorientation to reach the dural space.

11 patients needed a second skin puncture and 3 patients a third skin puncture of which one case was doomed impossible after more than 3 needle reorientations and was converted to general anesthesia (figure 21).

The overall proportion of difficult spinal anesthesia was 31.4%



Easy spinal anesthesia

Difficult spinal anesthesia

Figure 21 : Distribution of the number of skin punctures.

2. Difficulty scale:

- Very easy: success after one first attempt without needle reorientation.
- Easy: success after one needle reorientation at first skin puncture.
- Mild: success after more than two needle reorientations at first skin puncture.
- Intermediate: a 2nd skin puncture is needed with 2 or less needle reorientations.
- Very difficult: more than 2 needle reorientations at the 2nd skin puncture or a 3rd skin puncture is needed, a change to a paramedian approach, or a call for another pair of hands.
- Impossible: incapacity to reach the dural space after multiple attempts thus converting to general anesthesia.

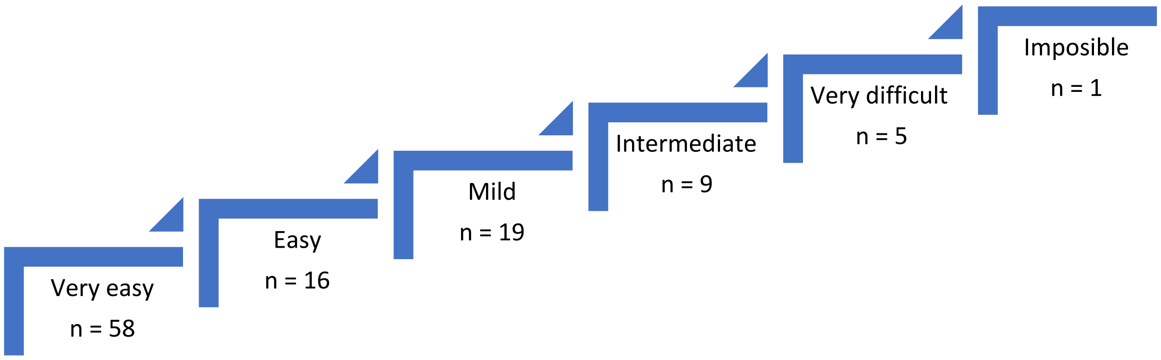


Figure 22 : Difficulty scale

3. Motor block installation delay:

Motor block installation delay was attained at 3 minutes, with the maximum at 5 minutes and the minimum at 1 minute (SD = 0.846).

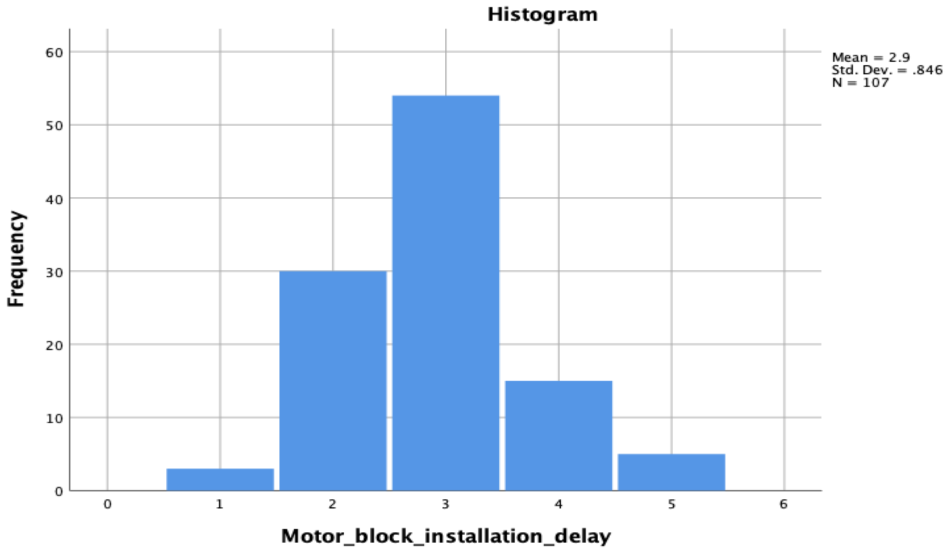


Figure 23 : Distribution of motor block installation delay.

4. Motor block degree:

75.5% of parturients reached a Bromage score estimated at IV. No parturient had a Bromage score of 1 after spinal anesthesia.

Table IV : Motor blocks degree.

Degree	Number of cases
II	1 (0.9%)
III	25 (23.4%)
IV	81 (75.5%)

5. Motor block duration:

The main motor block duration was 102.68 minutes (SD=17.32) with a minimum of 40 minutes and a maximum of 119 minutes.

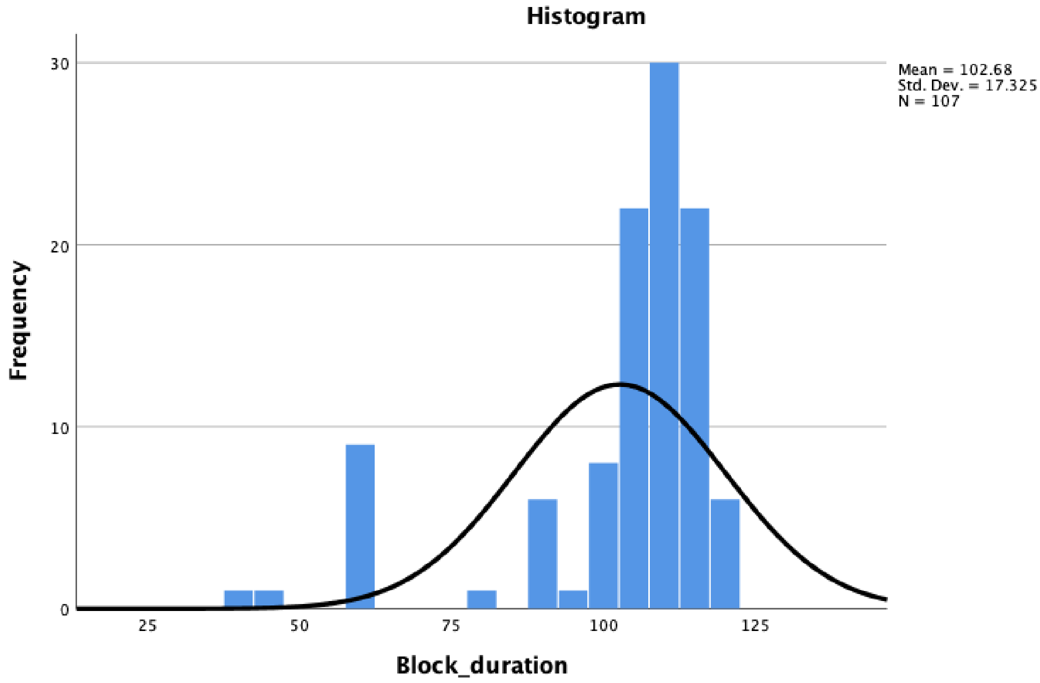


Figure 24 : Distribution of motor block duration.

Table V : Mean motor block for easy and difficult spinal anesthesia.

variable	Easy	Difficult	P – value
Mean motor block duration (minutes)	103±16.58	99,76±18.82	P = 0.451

6. Sensory blocks level:

T4 was the maximum sensory block level attained in the study.

Table VI : Sensory blocks level.

Sensory block level	Number of cases (%)
T10	7 (6.5%)
T11	1 (0.9%)
T4	91 (84.3%)
T6	4 (3.7%)
T7	1 (0.9%)
T8	2 (1.9%)
T9	1 (0.9%)

IV. Adverse events:

1. Maternal hypotension:

Maternal hypotension was defined as low systolic blood pressure below 90mmHg or a drop of >20% of the base value before spinal anesthesia.

Hypotension occurred in eight patients within 8.5 min on average after spinal anesthesia, with a minimum of 2 min and extending until 30 min later.

The mean ephedrine dose administered was 10.7mg ranging from 6mg to 30mg in only one severe case of hypotension prolonged after fetal extraction. Low doses of norepinephrine were needed in two cases (2 and 4 µg respectively) (Table VII).

Table VII : Description of maternal hypotension parameters in terms of delay of onset, doses of vasopressors, and lowest measured arterial pressures.

Parameters	N	Minimum	Maximum	Mean	Std. Deviation	Variance
Low pressure (PAS)	8	61	84	74,63	7,347	53,982
Low pressure (PAM)	8	48	76	54,50	9,008	81,143
Low pressure (PAD)	8	32	51	40,37	6,927	47,982
Delay of hypotension installation	8	2	30	8,50	9,725	94,571
Dose of ephedrine	7	6	30	10,71	8,807	77,571
Dose of baby Norepinephrine	2	2	4	3,00	1,414	2,000

PAD: Diastolic Arterial pressure
PAM: Mean Arterial Pressure
PAS: Systolic Arterial Pressure

Table VIII : Comparison of different parameters for maternal hypotension

	Hypotension n= (8)	No hypotension (n = 99)	P value
Sitting abdominal circumference	111 ± 13.76 95% CI: [100.12 ; 123.13]	110± 12.26 95% CI : [107.85 ; 112.74]	0.753
Lying abdominal circumference	110 ± 22.68 95% CI: [91.29 ; 129.21]	103± 11.4 95% CI: [101.06 ; 105.62]	0.590
Trunklength	46.25 ± 9.3 95% CI: [38.42 ; 54.08]	42.64± 6.19 95% CI: [41.40 ; 43.87]	0.103
BMI at delivery	30.74 ± 7.21 95% CI: [24.28 ; 37.19]	29.34 ± 4.33 95% CI: [28.58 ;30.21]	0.648

2. Others:

- One patient required complimentary sedation with no adverse events
- There was no episode of bradycardia.
- Three cases of traumatic spinal anesthesia with hematic cerebral fluid without further neurological impairment at follow-up.
- No cases of cephalic extension of motor block above T4 or total spinal anesthesia were recorded.
- Only one patient experienced hypoxemia, the same patient whose spinal anesthesia was impossible and required general anesthesia in rapid sequence induction.
- Eight cases presented with maternal hypotension.

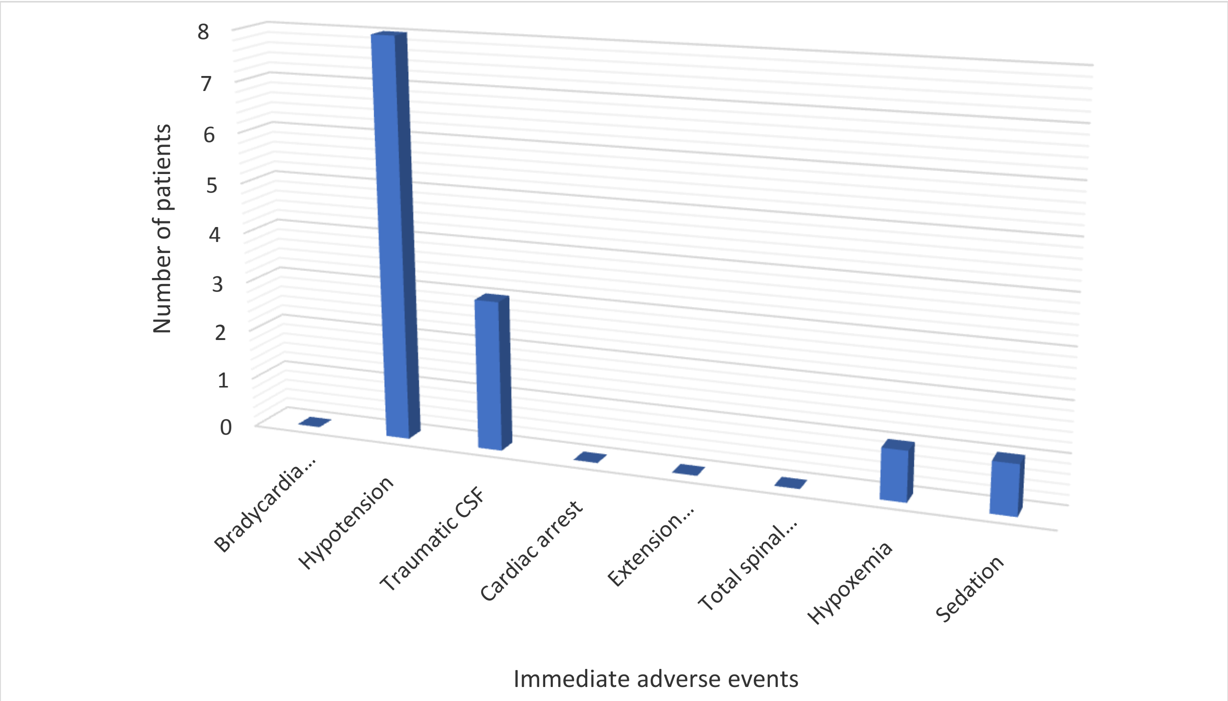


Figure 25 : Distribution of immediate adverse events.

Table IX : Distribution of adverse events among difficult and easy spinal anesthesia

		Easy n=74	Difficult n=34	P value
Adverse events	n=total	3	8	0,077
	Hypotension	2 (2.78%)	6 (17.04%)	0,01
	Traumatic CSF	1 (1.35%)	2 (5.88%)	NA
	Hypoxemia	0	1	NA
	Sedation	1	0	NA
	Maternal bradycardia	0	0	NA
	Extension over T4	0	0	NA
	Cardiac arrest	0	0	NA

There were more cases of hypotension in the case of difficult spinal anesthesia. ($p = 0.01$)

V. Data analysis:

1. Univariate analysis:

Out of the 108 participants in the study, 34 (34.1%) met the criteria for difficult spinal anesthesia, as various parameters were compared for easy and difficult spinal anesthesia procedures (Table X).

Table X : Comparison of different parameters for difficult and Easy spinal anesthesia.

Variables	Easy (74)	Difficult (34)	P value
Weight in Kilogram	77.01 ±10 .1	85.59±15.79	<0.001
Height in centimeters	163.51 ±4.91	166.06±7.84	0.043
Body Mass Index	28.79 ±3.51	31.18±6.38	0.014
Sitting abdominal circumference	107.2 ±10,28	117.88 ±13.54	0.001
Lying abdominal circumference	100.74 ± 9.79	111.24 ± 15.16	0.001
Trunk length	41.76 ±4.35	45.74 ±9.27	0.003
Age	30.09 ± 7.03	29.5 ± 6.16	0.521
Gestational age	36.68 ± 2.53	38.68 ± 1.49	0.011
Skin canal distance	4.79±0.26	4.80 ± 0.51	<0.001

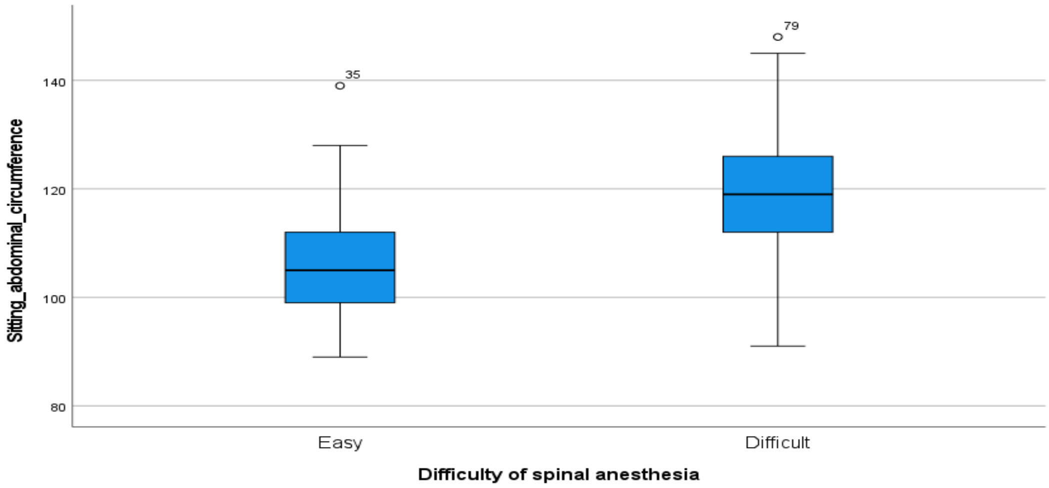


Figure 26 : Difference in comparison of difficult and easy spinal anesthesia in a sitting position.

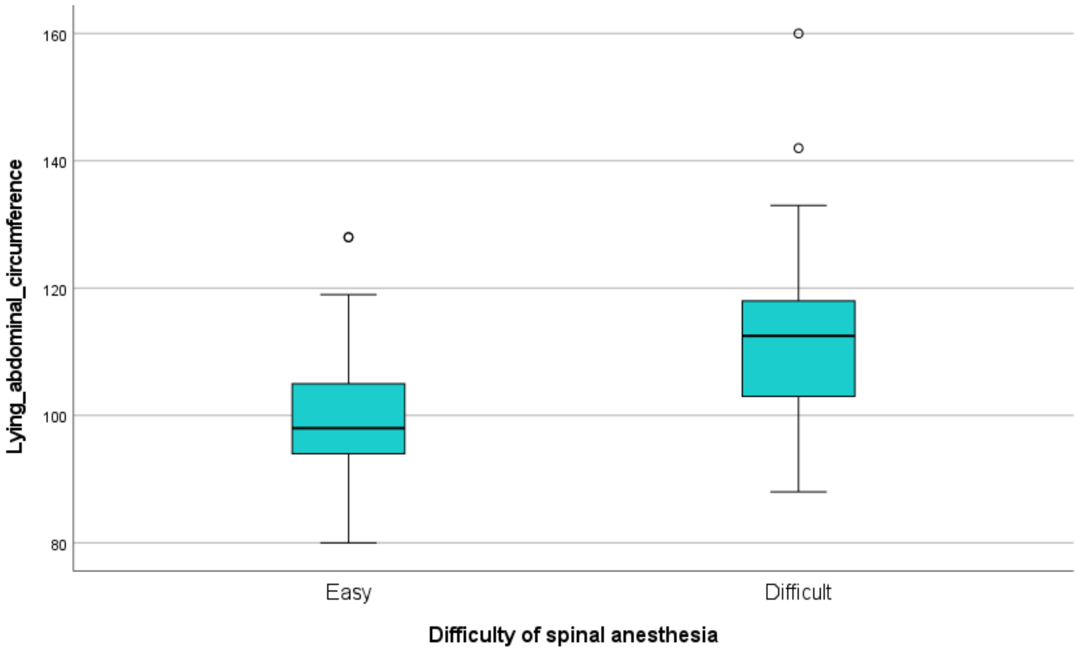


Figure 27 : Difference in comparison of difficult and easy spinal anesthesia in a lying position.

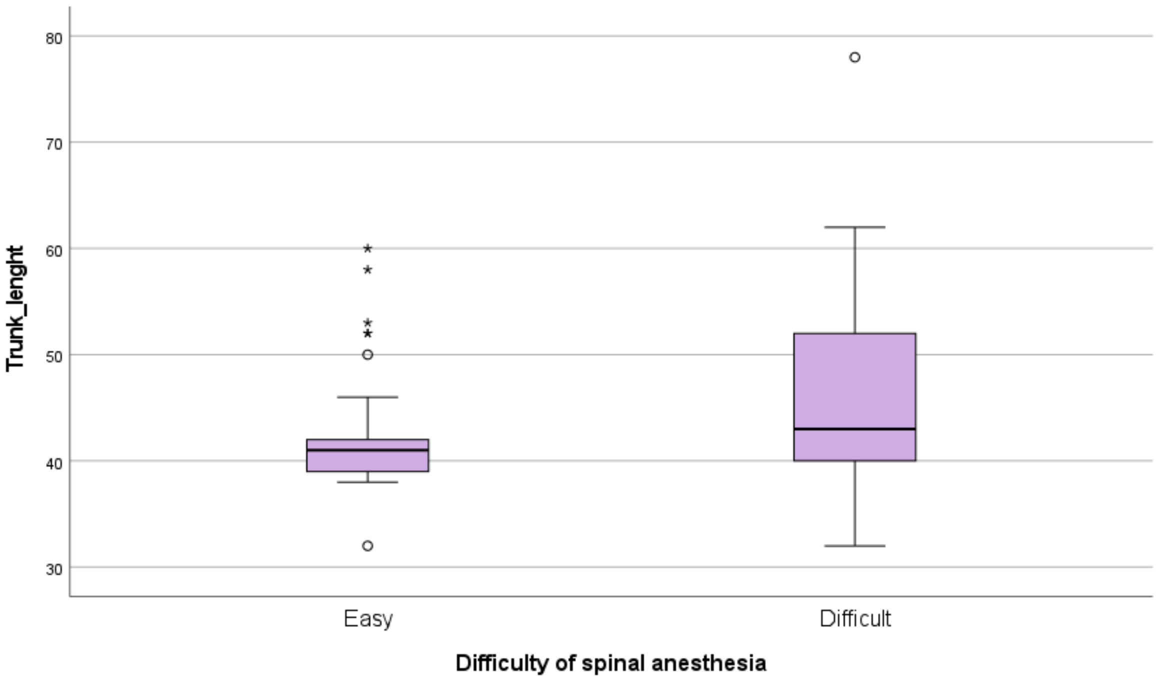


Figure 28 : Difference in comparison of difficult and easy spinal anesthesia in trunk length.

1.1. Receiver Operating Characteristic(ROC) curve

A receiver operating characteristic (ROC) curve was generated to evaluate the abdominal circumference as a predictor for difficult spinal anesthesia and maternal hypotension in a lying and sitting position.

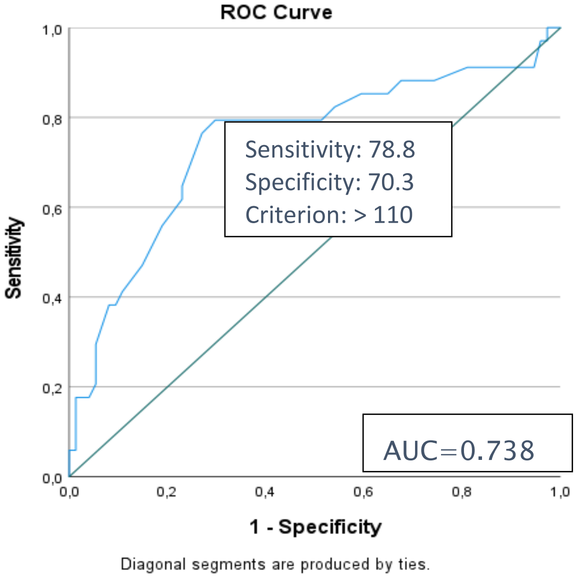


Figure 29 : ROC curve for abdominal circumference in a sitting position

AUC= Area under the curve

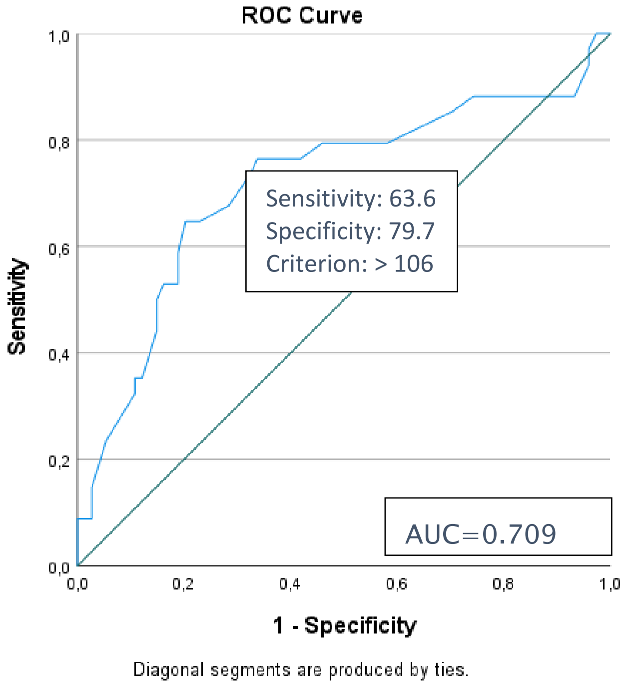


Figure 30 : ROC curve for abdominal circumference in a lying position

AUC= Area Under the curve

Table XI : Cutoff points

Coordinates of the Curve					
Parameters	Positive if Greater Than or Equal To[a]	Sensitivity	1 – Specificity	AUC	P value
Lying abdominal circumference	> 106	63.6	79.7	0.709	P = < 0.001
Sitting abdominal circumference	> 110	78.8	70.3	0.738	P = < 0.001

DISCUSSION

I. Anatomical Review:

1. The vertebrae column: [11-13]

1.1. Description:

The vertebral column or spine, commonly known as the backbone, forms the central axis of the human skeletal system, extending from the skull to the coccyx. Within its internal canal is the spinal cord. The vertebral column fulfills several crucial functions, which include safeguarding the spinal cord from external trauma, supporting the thorax and abdomen, maintaining proper body posture, and facilitating flexibility and movement.

It is a chain of bony structures superimposed on each other, consisting of 33 bones in total divided into five regions (Figure 31, 32):

- 7 Cervical vertebrae denoted C1 - C7.
- 12 Thoracic vertebrae denoted T1 - T12
- 5 Lumbar vertebrae denoted as L1 - L5
- 5 Fused vertebrae of the sacrum, denoted S1 - S5
- 4 Fused coccygeal vertebrae

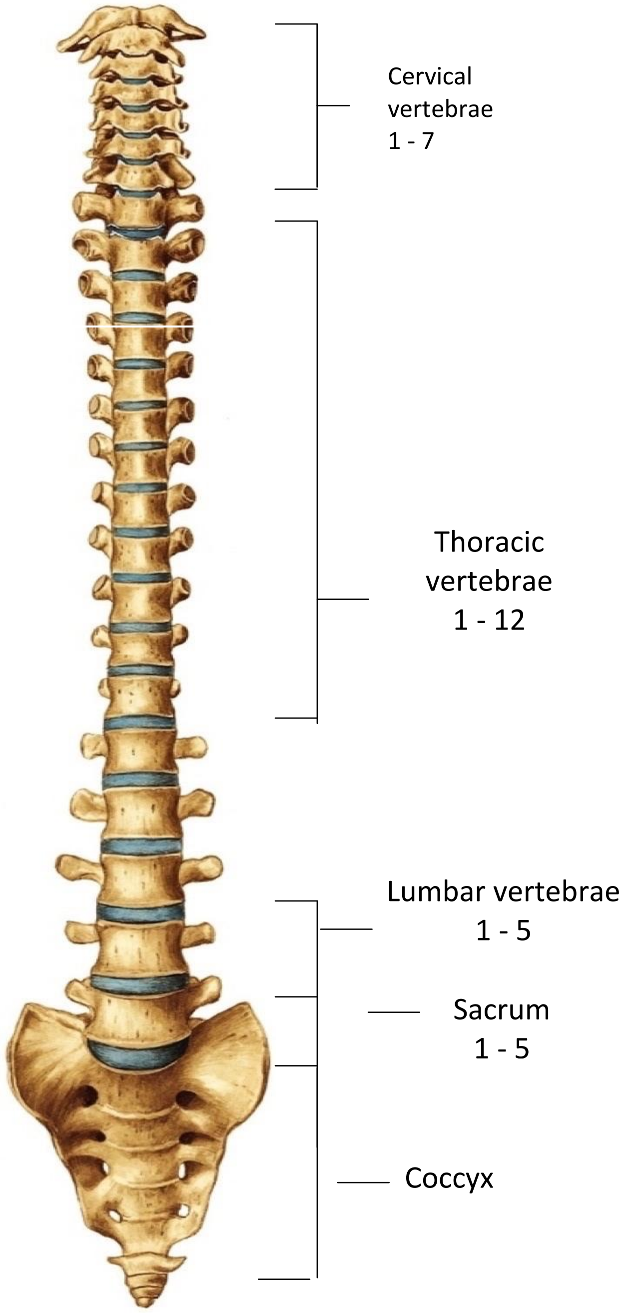


Figure 31 : Vertebral column anterior view.

Image reference: Mahadevan V, Anatomy of the vertebral column, Surgery (2018), https://doi.org/10.1016/j.mpsur.2018.05.006

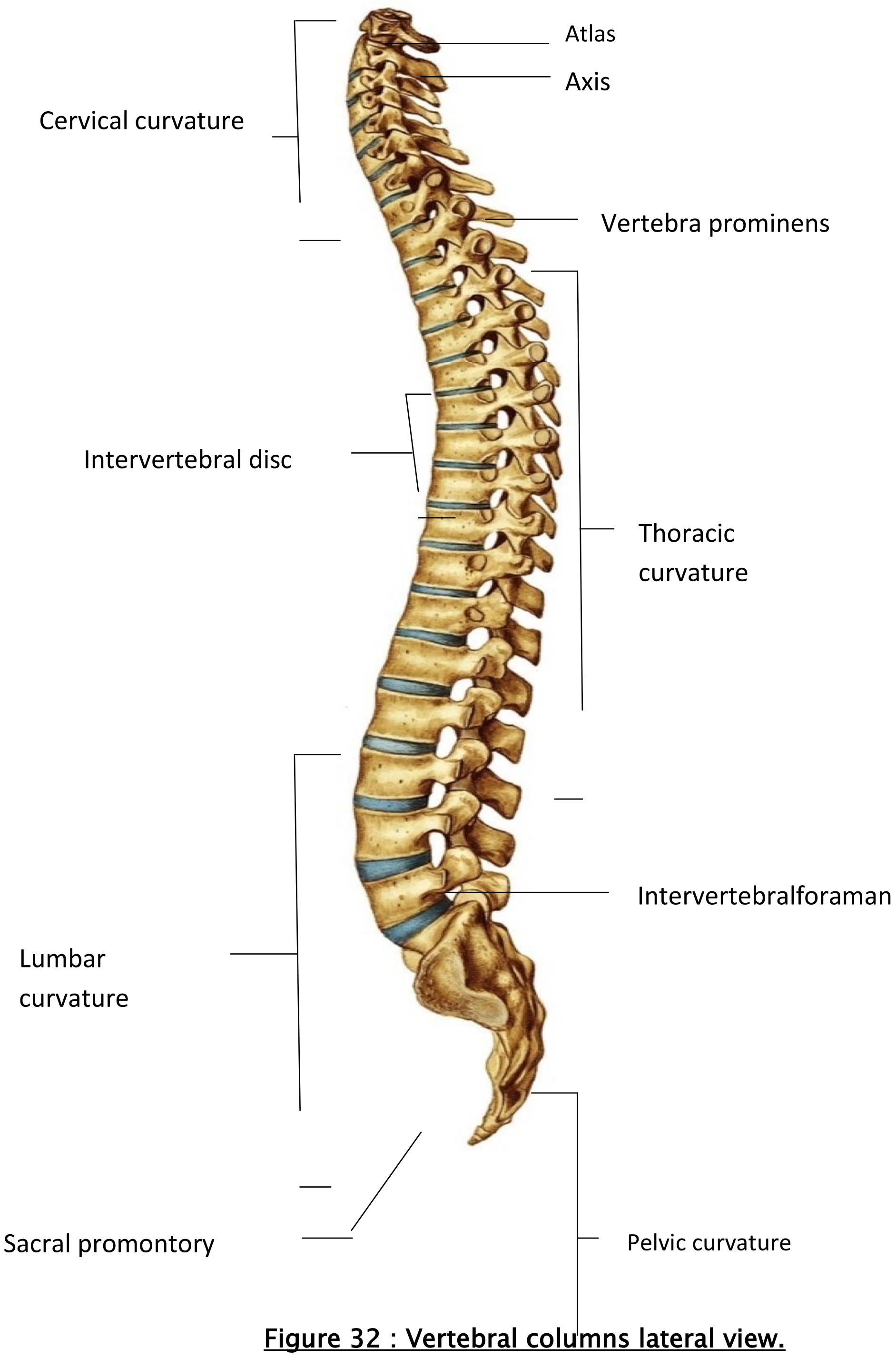


Figure 32 : Vertebral columns lateral view.

Image reference: Mahadevan V, Anatomy of the vertebral column, Surgery (2018),

https://doi.org/10.1016/j.mpsur.2018.05.006

1.2. Morphology:

A typical vertebra has a cylindroid anterior structure called the vertebral body, which extends posteriorly to the back with a bony arch, the vertebral arch, and several processes (figure 33). A spinous process, centered posteriorly at the point of the vertebral arch, two transverse processes projecting laterally, pedicles connecting both the vertebral body, and the transverse process, two articular processes located at the intersection of the lamina and the pedicles with their inferior counterpart.

Spinous process can be visible in skinny individuals and palpable in most. This anatomy is the basis of ultrasound guidance for spinal puncture.

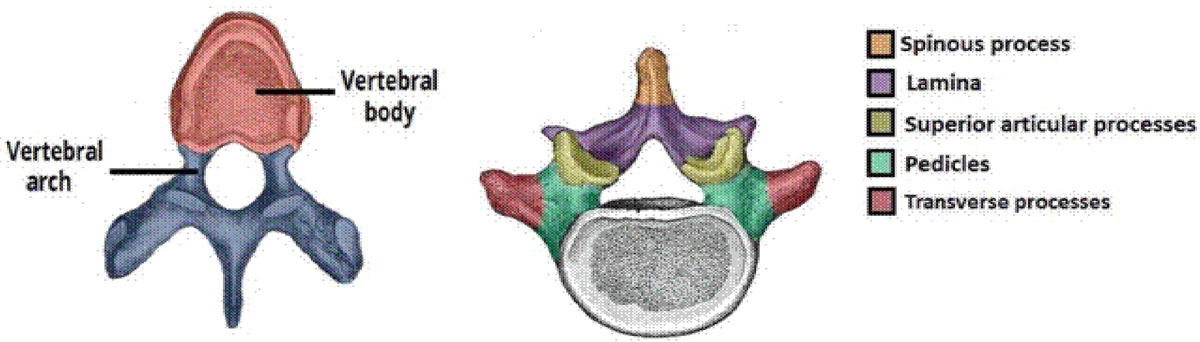


Figure 33 : General body of a vertebrae.

Image source: Oliver Jones, The Vertebral Column, https://teachmeanatomy.info/contact-us/

1.3. Vertebral arch ligaments:

These ligaments provide stability to the vertebral column. Two ligaments strengthen the vertebral body: the anterior and posterior longitudinal ligaments. They run along the vertebral body (Figure 34). The thick anterior longitudinal ligament prevents hyperextension, while the posterior longitudinal ligament, much thinner, prevents hyperflexion. Schematically, from the back to the front, are the following ligaments:

- Supraspinous ligament: a dense band of fibrous.

- Interspinous ligament: a sheet of fibrous
- Ligamentum flavum
- Intertransverse ligaments

These structures are transpassed with the spinal needle and are visible on ultrasound.

1.4. Lumbar vertebra:

They are five in number, denoted L1-L5. It follows the dorsal spine and precedes the sacral spine. The lumbar spine forms an anterior curvature called lordosis. L5 has the largest body of all vertebrae in the vertebral column. The lumbar vertebra presents the following characteristics:

- Presence of a large vertebral body, kidney shape that has a transversal form
- Short and thick spinous process that is horizontal, which allows the passage of lumbar puncture.
- Presence of a mammillary process on the poster aspect of the superior articular process.
- Process a thicker intervertebral disc from the rest of the vertebrae.
- A voluminous and triangular vertebral foramen.

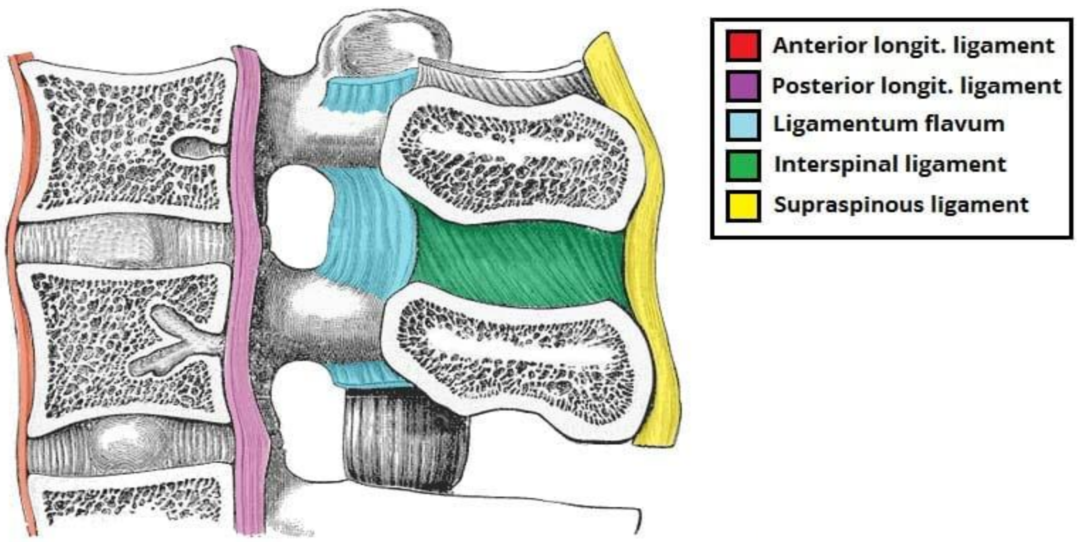


Figure 34 : Vertebral arc ligaments.

Image source: Oliver Jones, The Vertebral Column, https://teachmeanatomy.info/contact-us/

2. The spinal cord: [14-16]

2.1. Introduction:

The spinal cord is an extended part of the central nervous system that runs through the internal canal of the vertebral column. It acts as a conduit that conveys information between the brain and the peripheral nervous system.

a. Description:

Starting at the brainstem, extending through the foramen magnum, and ending at the second lumbar vertebra, the average length of the spinal cord measures approximately 45cm in an adult human and stops at the level of L1 - L2.

It is covered by three protective layers, from superficial to profound (dura, arachnoid, and pia mater), called the spinal meninges.

The spinal dura mater is separated from the wall of the vertebral canal by the epidural space. This space is usually used for analgesic purposes and contains various anatomical structures such as adipose tissue, connective tissue, nerves, etc.

The spinal arachnoid mater lies between the dura and the pia mater, separated from the dura mater by the subarachnoid space, which contains cerebrospinal fluid. Distal to the conus medullaris, the subarachnoid expands, forming the lumbar cistern and serves as a site for lumbar puncture and spinal anesthesia.

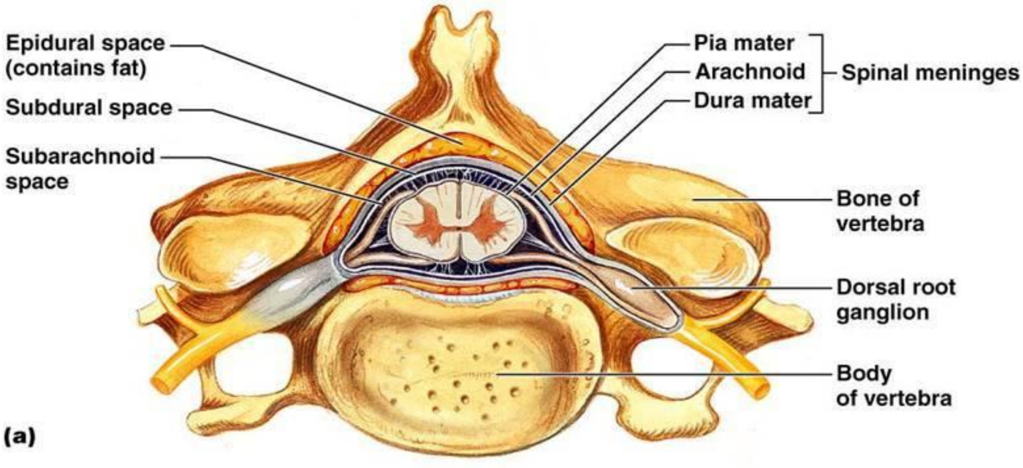


Figure 35 : Cross-section of the spinal cord.

Image source: Biology pictures,http://biology-pictures.blogspot.com/2011/11/spinal-cord-crossection.html

3. The autonomic nervous system: [17]

3.1. Introduction:

The autonomic nervous system is a part of the peripheral nervous system that regulates involuntary physiologic processes such as heart rate, blood pressure, respiration, digestion, etc. It contains three anatomically distinct divisions: sympathetic, parasympathetic, and enteric.

3.2. Sympathetic system:

The sympathetic nervous system stimulates the body's fight and flight response. It consists of two neurons that serve in the transmission of signals: preganglionic and postganglionic neurons.

A preganglionic neuron with a cell body in the intermedio-lateral columns, or lateral horns, of the spinal cord at the thoraco-lumbar region and a postganglionic neuron with its cell body in the periphery that innervates target tissues. Its stimulation causes hemodynamic changes (increased heart rate, hypertension, and increased cardiac output).

3.3. The parasympathetic system:

The parasympathetic system regulates the "rest-and-digest" activities of the body. Parasympathetic nerve pathways consist of two sets of cholinergic neurons.

A set of cholinergic neurons whose cell bodies are located in the spinal cord of the cranial nerves III, VII, IX, X, and sacral nerve roots of S2 to S4, and a second neuron whose cell bodyis located in the peripheral parasympathetic ganglia that innervate target tissues. Its stimulation leads to low heart rate, hypotension, and decreased cardiac output.

3.4. Enteric system:

The enteric nervous system (ENS) is a network of nerves that function independently and play a crucial role in regulating digestive processes.

4. Spinal anesthesia: [18-21]

4.1. Introduction:

Anesthesia is a method used to alleviate pain. Three broad categories of anesthesia include general, regional, and local anesthesia.

General anesthesia results in unconsciousness and lack of total sensation, while regional and local anesthesia involves blocking transmissions of nerve impulses from a specific body part, resulting in numbness as the patient stays awake.

Spinal anesthesia is a regional anesthetic technique that involves the injection of small doses of local anesthetic solution in the subarachnoid space for a fast surgical block. It is widely used for cesarean deliveries due to its simplicity in terms of performance and safety as compared to general anesthesia.

4.2. Brief history:

The first spinal anesthetic was administered accidentally in 1885 by J. Leonard Corning while experimenting with the effect of cocaine on spinal nerves in a dog. The experiment led to paralysis of the hindquarters of the animal when he accidentally breached the dura between two lumbar vertebrae, hence inadvertently performing the first spinal anesthetic.

A major development in spinal anesthesia was the work of Augustus Karl Gustav Bier when he performed the first spinal anesthesia for a surgical procedure in 1898 in Kiel, Germany.

Since then, it has been the gold standard of care for cesarean section.

4.3. Technique:

Understanding the neuraxial anatomy and patient positioning is paramount in administering spinal anesthesia. Spinal anesthesia is performed in the lumbar area of the spine to avoid injury to the spinal cord and the interaction of anesthetic with the upper thoracic and cervical region.

Once patients have gone through appropriate selection, the optimal patient position for the procedure is established. This ensures a straight path for needle insertion between the spinal vertebrae, as patient comfort is consequential.

The procedure is usually carried out with the patient in a sitting or a lateral decubitus position. The former remains widely used in obstetrical and urological interventions.

For the sitting position, patients sit on the edge of the table, with their feet resting on a support, knees in flexion, arms crossed over a cushion placed on the thigh, head and shoulders bent forward, usually with the help of an assistant to help maintain the patient's spine in a flexed position.

In the lateral decubitus position, the patient is placed on their side, back paralleled to the edge of the table, hips and knees flexed, neck and shoulder flexed toward the knees.

After the patient is placed in a proper position, the access site is identified by palpation which is usually difficult with obese patients due to subcutaneous fat between the skin and the spinous process. Ultrasound guidance can be helpful.

Achieving a strict aseptic technique is vital; this is done by observing the following steps:

- Adequate hand washing.
- Wearing a face mask, a hair cap, and surgical gloves.

- Disinfection of the skin surface using an antiseptic solution (from the center to the periphery starting from the access site in a circular motion).
- Isolation of access area with a drape.
- Local anesthetic (usually 1 ml of 1% lidocaine) for skin infiltration.

a. *Spinal approach (Midline and Paramedian):*

In the midline approach, to access the intrathecal space, the spinal needle is inserted midline with a straight line shot following numbness of the site with lidocaine. The spinal needle goes through the skin and then through the subcutaneous fat. Pierces the supraspinous and interspinous ligaments, where it is met with resistance; the ligamentum flavum. A release of pressure is felt when punctured, hence the epidural space. Insertion of the needle continues until it reaches the dura-subarachnoid membranes, indicated by free-flowing CSF. At this point, spinal anesthetic is administered.

For the paramedian approach, local anesthetic is injected about 2 cm from the midline. The spinal needle advanced towards the midline at an angle, avoiding the supraspinous and interspinous ligaments. Thus, creating minimal resistance.

b. *Anesthetic agents:*

Choosing a specific type of local anesthetic is influenced by several factors. The intended block type, whether a motor block or an exclusive sensory block, as well as the anticipated duration of the surgical procedure, is taken into account to ensure the optimal choice of an anesthetic agent for a better surgical outcome and enhanced patient comfort.

Drugs used:

Amines:

- Lidocaine (5%): The onset of action occurs in 3 to 5 minutes with a duration of anesthesia that lasts for 1 to 1.5 hours

- Bupivacaine (0.5%): One of the most widely used local anesthetics; onset of action is within 5 to 8 minutes, with a duration of anesthesia that lasts from 90 to 150 minutes
- Mepivacaine 2%
- Ropivacaine 0.75%
- Levobupivacaine 0.5%

Ester:

- Chloroprocaine 3%
- Tetracaine 0.5%
- Procaine

Protocol for spinal anesthesia during cesarean section has been adapted to the physiological changes in the parturient and the risk of hypotension. Hence: Bupivacaine 10mg maximum; Fentanyl 25µg and Morphine for postoperative analgesia not exceeding 100µg.

c. ***Complications of spinal anesthesia:***

Complications associated with spinal anesthesia are rare, making it a safer method for surgery. However, the procedure is associated with numerous physiological effects that are of clinical relevance:

- Cardiovascular side effects are common following spinal anesthesia, with hypotension occurring in 10-40% of cases. Hypotension is associated with a reduction in systemic arterial and venous tone due to the extent of sympathetic blockade. As a result, cardiac output drops due to a decrease in venous return. Severe hypotension is treated with appropriate administration of intravenous fluids and the use of vasoactive drugs like ephedrine or phenylephrine and norepinephrine. In rare cases, healthy patients experience sudden cardiac arrest during the administration of a spinal anesthetic, often preceded by severe bradycardia in an otherwise stable patient.

- Postdural puncture headache (PDPH) is a frequent complication of spinal anesthesia, which occurs when cerebrospinal fluid (CSF) leaks through the puncture site in the dura, resulting in increased pressure on the nerves and blood vessels in the meninges, causing severe headaches. It is often seen in young adults, including obstetric patients, with an incidence rate of 14% compared to 7% in individuals older than 70 years.

Over the years, the use of smaller pencil-point tip needles has significantly reduced the incidence of post-dural puncture headaches. Treatment includes bed rest, intravenous hydration, nonsteroid anti-inflammatory agents, and blood patch.

- Fetal complication

When spinal anesthesia results in severe hypotension, blood flow to the uterus and placenta is reduced if not corrected. Such reduction in blood flow causes fetal acid-base imbalances and leads to late decelerations in fetuses that are severely compromised.

- Other complication:
    - Infection
    - Nausea and vomiting (linked to arterial hypotension).
    - Acute retention of urine (linked to blockage of lumbosacral roots).

Figure 36 : Spinal anesthesia in a sitting position.

Image source:MEDINDIA NET https://www.medindia.net/health/treatment/spinal-anesthesia.htm

5. Cesarean section: [22,23]

5.1. Introduction:

Cesarean section is a fetal delivery through an open abdominal incision (laparotomy) and an incision in the uterus (hysterotomy). The word ''cesarean'' derives from the Latin word ''caesare'', which means ''to cut''. It is the most effective means to ensure the survival of both the mother and infant when performed for medically indicated reasons.

With over a million deliveries by cesarean annually, the cesarean delivery rate rose from 5% in 1970 to 31.9% in 2016 in the United States. It is the most common surgery performed in the United States and worldwide.

5.2. Brief History:

Cesarean section dates far back to ancient times, as evidenced by ancient texts. The procedure was mentioned in the Cuneiform tablet of the reign of King Hammurabi of Babylon (1795-1750 BC), the "Lex Regia" (the Law of the Kings) of King Numa Pompilius of Rome (716-673 BC), etc.

"Lex Regia" which was later renamed the "Lex Cesarea" during the Roman Empire, was a law established by King NumaPompilius that allowed for the delivery of a child through an incision in the abdomen after the mother had died.

Julius Caesar being linked to cesarean delivery is a misinterpretation of the writings of Pliny (a Roman historian), which mentioned the birth of a "Caesar" by cesarean delivery.

The first documented cesarean section on a living woman who survived the operation was performed by Jacob Nufer, a Swiss sow-gelder, on his wife in 1500.

Lebas first mentioned the use of sutures to close uterine incisions after cesarean delivery in 1769. However, it was not until 1882 that Max Sanger brought the importance of uterine sutures to the attention of the obstetric community.

Adolf Kehrer, in1882, suggested incision be done in the lower segment of the uterus during cesarean delivery.It only became popular after Monro Kerr reintroduced the ideain 1926.

5.3. Indication:

There are various reasons for cesarean section as listed below and can be classified into:

- Extremely urgent (maternal or fetal immediate life-threatening conditions)
- Urgent (maternal or fetal compromise without immediate life-threatening situation)
- Emergency (no maternal or fetal compromise but requires early delivery).
- Elective

Maternal Indications for Cesarean:

- Prior cesarean delivery
- Maternal request
- Pelvic deformity or cephalopelvic disproportion
- Previous perineal trauma
- Prior pelvic or anal/rectal reconstructive surgery
- Herpes simplex or HIV infection
- Cardiac or pulmonary disease
- Cerebral aneurysm or arteriovenous malformation
- Pathology requiring concurrent intraabdominal surgery
- Perimortem cesarean

Uterine/Anatomic Indications for Cesarean:

- Abnormal placentation (such as placenta previa, placenta accreta)

- Placental abruption
- Prior classical hysterotomy
- Prior full-thickness myomectomy
- History of uterine incision dehiscence
- Invasive cervical cancer
- Prior trachelectomy
- Genital tract obstructive mass
- Permanent cerclage

Fetal Indications for Cesarean:

- Nonreassuring fetal status (such as abnormal umbilical cord Doppler study) or abnormal fetal heart tracing
- Umbilical cord prolapse
- Failed operative vaginal delivery
- Malpresentation
- Macrosomia
- Congenital anomaly
- Thrombocytopenia
- Prior neonatal birth trauma

II. Result of our study:

1. Age:

Age as a predictor of difficult spinal anesthesia has shown a positive correlation. [24]

Gvalani SK et al. indicated that age increases the difficulty of spinal block as the prevalence of osteoporosis, degenerative, and other pathological processes of the spine increase with age. [25]

In 2022, Chaudhuri et al. conducted a study involving 100 patients undergoing cesarean section under spinal anesthesia, indicating that increasing age is a determinant of difficult spinal anesthesia. [79] A finding consistent with previous studies. [1, 26]

Data from our study indicates otherwise, as there was no significant difference between age and difficult spinal anesthesia (p = 0.521).

Table XII : Distribution of age among different studies

Study series	Country	Study duration	Sample size	Mean age (SD)	Age range
Gvalani SK et al (2016)	India	M	498	M	20 – 60
Atashkoei et al (2019)	Iran	M	110	40.3(17.6)	18 –40
Del Buono et al (2021)	Italy	5 months	427	M	M
Chaudhuri et al (2022)	India	3 months	100	28.3 (7.6)	25 –35
Current study (2023)	Morocco	6 months	108	29.9(6.75)	18 –40

M = missing; SD = standard deviation

2. Gestational age:

When it comes to gestational age and difficult spinal anesthesia, previous studies investigated the correlation between gestational age and failed spinal anesthesia during cesarean section rather than the difficulty associated with spinal needle placement. [27, 28]

A study conducted in the USA by Adesope et al. on 5,015 patients found that the failure rate of spinal anesthesia was higher in preterm parturients than in those at term. Preterm parturients with a gestational age of less than 28 weeks had the highest failure rate. Ashagrie et al also found gestation age < 37week to be associated with failed spinal anesthesia. [27, 28]

Contrary to previous studies, only one failed spinal anesthesia was observed in the current study. However, we found a positive correlation between difficult spinal anesthesia and gestation age(p =0.011).

Table XIII : Distribution of gestational age among different studies

Study series	Country	Sample size	Mean (± SD) gestation age (weeks)
Adesope et al (2016)	USA	5015	G1 (< 28)
			G2 (28 to < 32)
			G3 (32 to < 37)
			G4 (> 37)
Ashagrie et al (2022)	Ethiopia	275	39.16 ± 1.85
Current study (2023)	Morocco	108	38.6 ± 2.25

G = group

SD = standard deviation

3. Medical history:

Studies have shown that a previous history of difficult spinal anesthesia was associated with an increased probability of difficult spinal anesthesia. [29]

Patients who have experienced difficulties with neuraxial blocks are likely to have the same anatomical conformation that caused the previous difficulty. However, previous history of difficult spinal anesthesia was not found to be a significant predictor of difficult spinal anesthesia by Del Buono et al. [26, 29]

In the present study, no previous history of difficult spinal anesthesia was recorded due to a lack of such medical records on parturients.

4. Indication:

Scarred uterus was the most common indication for cesarean section in the current study.

The rate of cesarean sections has increased in recent years. Yet, not justified by a reduction in maternal-fetal risk or perinatal outcomes. It is important to consider this procedure's risks and benefits and avoid unnecessary surgeries. [30]

Previous Caesarean scar, malpresentation and malposition, antepartum hemorrhage, obstructed labor, cephalopelvic disproportion, non-reassuring fetal heart rate pattern, and multiple pregnancies are all common indications of Caesarean section. [31]

In a systemic review and Meta-analysis of the prevalence and indication of cesarean section on a study population of 36, 705, Cephalopelvic disproportion was the most common indication of cesarean section followed by non-reassuring fetal heart rate pattern. [31] In a similar study done in India, the most common indication was fetal distress followed by previous cesarean sections, which is consistent with the present study. [32]

5. Weight, height and body mass index and trunk length:

The Mean BMI (body mass index) in this study was 29kg/m^2, similar to that of Ataskhoei et al which was 32.25kg/m^2 but significantly higher than the population of the study of Khoshrnge et al with 25kg/m^2. This may be due to the ethnic and cultural particularities of each country. [1, 33]

It was observed in the current study that performing spinal anesthesia presented difficulties among participants with higher BMI at delivery (p=0.014) and weight at delivery (p= <0.001), as subarachnoid space depth is affected by these variables.

Previous studies suggest that weight gain during pregnancy may be associated with difficult spinal anesthesia. [1, 34]

However, this variable was not recorded because parturients could not recall their weight at the start of the pregnancy, and it was not documented in their medical records.

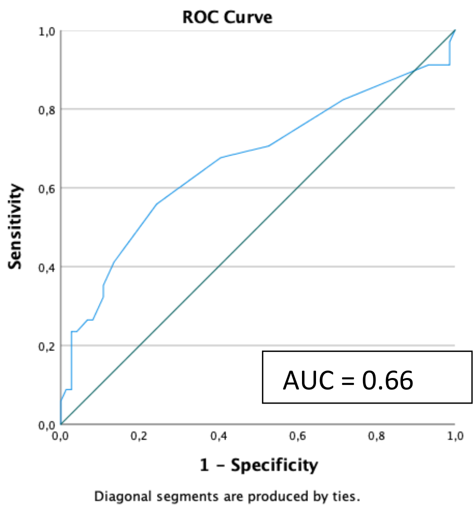
In the current study, we found a positive correlation between weight at delivery and difficult spinal anesthesia but not weight gain.

A conventional spinal needle may fall short of length in obese patients to reach the subarachnoid space and may prove too long for a lean patient, consequently resulting in multiple punctures, and unsuccessful attempts, hence leading to patient discomfort. [35]

A study done by Ataskhoei et al. of 109 parturients undergoing elective cesarean section suggested a positive correlation between weight, BMI, and difficult spinal anesthesia, a finding similar to Khoshrange et al. [1, 33]

Height didn’t correlate with difficult spinal anesthesia and was not an effective factor for predicting difficult spinal anesthesia reported Ataskhoei et al., this is true for the current study.

Trunk length was found to be associated with difficult spinal anesthesia in this present study. Unlike the current study, previous studies on trunk length were only based on the relation between trunk length and the spread of spinal block in parturient. [36, 37]



ROC curve for trunk length

AUC = Area Under the curve

Wei et al., with a sample of 128 parturients, indicated that vertebral column length (trunk length) correlated with a greater cephalad spread of spinal block, similar to Lee et al. [36, 37]

6. Spinous processes:

The quality of anatomical landmarks of the lumbar spine has long been recognized as an important factor in predicting the level of technical difficulty involved in gaining neuraxial access during spinal anesthesia. [38, 39]

Navigating between the spinous process and the lamina facilitates the percutaneous approach to accessing the interlaminar space. The bony confines of the spinous process and the lamina serve as landmarks to guide the procedure during spinal anesthesia. [40]

Nonetheless, the non-visibility or palpation of the spinal process and physiological changes during pregnancy may pose a technical difficulty.

The anatomical landmarks have subjectively been graded by different studies as follows:

"**none**" (for none-palpable spinous processes), "**poor**" (for hardly palpable spinal processes), and "**good**" (for easily palpable spinous processes) or as "**Grade 1**" (for visible spinous processes), "**Grade 2**" (not visible but palpable spinous processes), "**Grade 3**" (not visible and hardly palpable spinous processes) and "**Grade 4**" (for neither visible nor palpable spinous processes). [38,39]

In the present study, the anatomical landmark of the lumbar spine was evaluated based on palpation (palpable) and visualization (visibility). It was a significant predictor of technical difficulty during spinal anesthesia as there were more cases of not visible and not palpable spinous processes in parturients with difficult spinal anesthesia.

In a study by Del Buono et al. performed on 427 patients on a scoring system for the prediction of difficult lumbar spinal anesthesia, spinous processes not visible or not palpable had a positive correlation as predictors of difficult spinal anesthesia, which is consistent with our study. [26]

In another study, Atashkhoei et al indicated that non-palpable spinal processes were correlated with difficult spinal anesthesia in parturients. [1]

7. Ultrasound guidance:

Tuffier's line is a known reference point that intersects the spine either at the L4 spinous process or at the L4-L5 intervertebral space. It is a transverse virtual line connecting the top of the two iliac crests used as an anatomical landmark in spinal anesthesia for needle insection to avoid damage to the spinal cord. However, during pregnancy, the physical changes that occur in full-term parturient women make it difficult to accurately determine the vertebral level using Tuffier's line through palpation. [41]

Identifying this anatomical landmark with ultrasound guidance has been indicated to reduce the number of attempts and repositioning of spinal needles during spinal anesthesia. [26]

Margarido et al. measured with ultrasound the vertebral levels with Tuffier's line in full-term parturient women while they were in the sitting position and reported that the median of the vertebral levels was the L2-3 intervertebral space which was more cephalad compared to non-parturient women. [42]

Kim et al did a similar study with 80 parturient women in a lateral position, and their results demonstrated a vertebral level at L3 and L3-4, for parturient women 37 (93%), and a vertebral level at L4 and L4-5 for the non-pregnant-group-35 (88%) all patients showed a vertebral level lower than L2-3. [41]

In the present study, Palpation of the anatomical Tuffier's line corresponded mostly to L3-L4 in 57.4% of cases and L4-L5 in 40.7%, similar to previous studies. Only one case of lower Tuffier's line matched with the L5-S1 space and one case of a more cephalic location corresponded to L2-L3.

Ultrasound guidance can also help determine the midline, the puncture level, the distance to the medullary canal and guide the angle to the best interspace, studies have shown. [43, 44]

Li et al indicated that Pre-procedure ultrasound assessment can facilitatethe administration of spinal anesthesia in obese parturients (with a BMI between 35 kg/m2 and 43 kg/m2) positioned laterally. This approach enhances the initial success rate, reduces the number of needle passes and puncture attempts, reduces the overall procedure duration, and contributes to improved patient satisfaction. [45]

In another study, Jain et al also found that the use of ultrasound improves the success rate of combined spinal and epidural anesthesia at 1st attempt from 74.3% in their control group ("A") to 85.7% in their Ultrasound group ("B") (P = 0.038). There were fewer needle insertion attempts, passes, and the need for another anesthesiologist in their ultrasound group. [43]

It is therefore recommended in parturients with predictive factors of difficult spinal block.

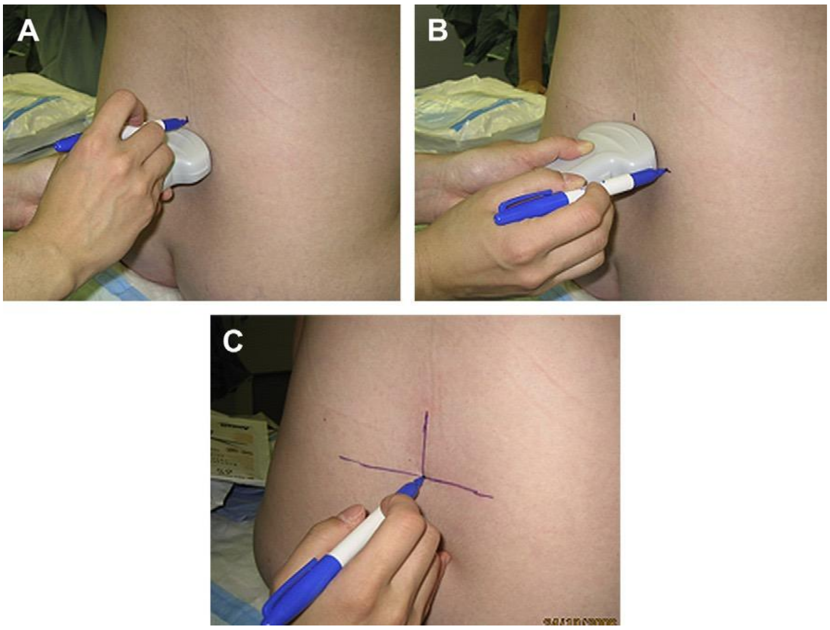


Figure 37 : Pre-procedure ultrasound assessment of parturient

Identification of spinal needle insertion point; determined by the intersection of the extensions of the two marks on the skin in the vertical and horizontal planes. (a,b,c)

Image source: Ultrasound-Facilitated Epidurals and Spinals in Obstetrics, Carvalho,2008. [46]

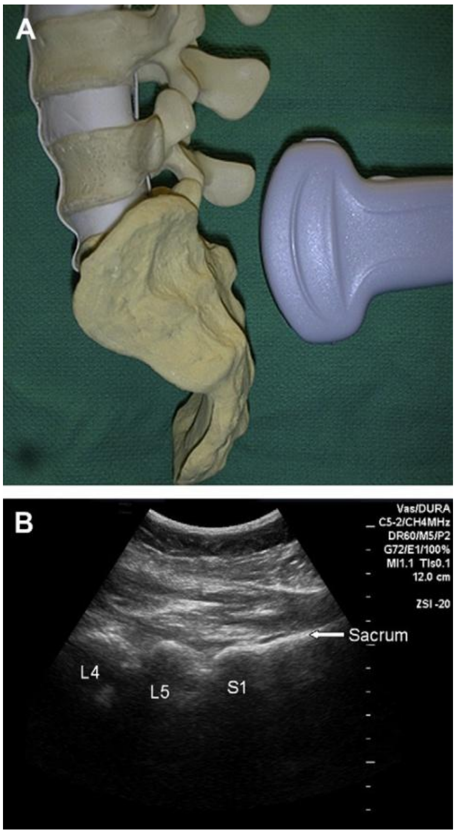


Figure 38 : Identification of intervertebral space with ultrasound

Orientation of the ultrasound probe to identify the sacrum and the lumbar interspaces. (A)

Hyperechoic image of the sacrum and of the saw sign, which represents the articular processes of the lumbar vertebrae and the interspaces. (B)

Image source:Ultrasound-Facilitated Epidurals and Spinals in Obstetrics, Carvalho,2008. [46]

8. Skin to the medullary canal distance:

Prior knowledge of how far the spinal needle needs to be inserted from skin to the subarachnoid space distance (SSD) is paramount in guiding spinal needle placement and reducing complications relating to lumbar puncture during spinal anesthesia. [35]

The mean ± SD (standard deviation) distance from the skin to the medullary canal of parturients differed among ethnicities, ranging from 6.3 ± 1.6 cm in African Americans, 5.5 ± 1.2 cm in Caucasians, 5.4 ± 1.1cm in Hispanic to 4.8 ± 0.9 cm in Asians. [47]

Several studies have found a significant positive association between SSD and pregnancy and reported longer skin to SSD in parturient females compared to males and non-pregnant females. [48- 50]

This could be explained by fat collection in the subcutaneous tissue and the effects of pregnancy hormones such as weight gain, and softening of tissues, and ligaments in pregnant patients. [38]

In the current study, the mean distance from skin to subarachnoid space was 4.79±0.36 cm with a minimum of 3.23cm and a maximum of 5.50cm, similar to Parkash et al with 4.73±0.73 cm but shorter than Fati et al with a mean SSD 5.53 ±0.63 cm in the parturient group.

In a study by Razavizadeh et al on the relationship between patients' anthropometric characteristics and the depth of spinal needle insertion, they found a significant correlation between waist circumference and the depth of spinal insertion. [7]

Table XIV : Distribution of skin to subarachnoid space among different studies

Study series	Country	Mean SSD in cm (± SD)
Parkash et al	India	4.73 ± 0.73
Fati et al	Ethiopia	5.53 ± 0.63
Current study	Morocco	4.79 ±0.36

SSD = skin to subarachnoid distance

SD = standard deviation

III. Spinal block assessment:

The Bromage scale is the standard tool for assessing motor block by evaluating patients' ability to move their lower extremities. [8] (See Table II)

It was used to determine the failure or success of the spinal block in the current study.

In this study, the motor block installation delay was attained at 3 minutes; the maximum motor block was at IV and the mean motor block duration was 102.68 ± 17.32 minutes. Which is slightly different from Gunusen et al. [51]

Sensory block level T4/T5 is widely used to indicate an adequate level block for spinal anesthesia during cesarean section. [52, 53]

In this study, T4 was the maximum sensory block level attained after spinal anesthesia.

There were no cases of extended cephalic sensory or motor block levels.

Studies suggest that Parturients with greater abdominal circumference values have a higher level of sensory blockade. [54]

However, our study did not find a significant change in sensory block level, regardless of abdominal circumference or BMI (body mass index).

Table XV : Spinal block assessment

Variables	Günüsen et al	Current study
Maximum motor block score	III (1 – 3)	IV (1 – 4)
Motor block installation delay (minutes)	5.9 ± 3.92 minutes	3 minutes
Motor block duration (minutes)	151.22 ± 46.23	102.68 ± 17.32
Maximum sensory block level	T4	T4

IV. Definition of difficult spinal anesthesia:

There was no standard definition for difficult spinal anesthesia in the literature as different authors defined difficult spinal anesthesia differently. In reference to the studies mentioned below, the degree of difficulty of spinal anesthesia in this study was categorized on a scale from very easy to impossible. [1, 6, 24]

Table XVI : Definition of difficult spinal anesthesia among different studies

Study series	Definition /Grade/Criteria of difficult spinal anesthesia
Subramanian et al (2023)	• Easy – free flow of CSF obtained in first attempt. • Moderate – free flow of CSF obtained after trying for more than one attempt in one spinal level or shifting to next spinal level (2 – 4 attempts) • Difficult – free flow of CSF obtained after trying 5 or more attempts or shifting to third spinal level (5 – 7 attempts)
Karim et al (2023)	• The following events were considered as difficult spinal anesthesia: • more than three punctures required, • three punctures but more than six passes, • performer handing over the procedure to another performer and considering it as difficult after the second puncture.

Atashkhoel et al (2019)	• Difficulty score: • Score 0: The first effort without needle movement. • Score 1: The first attempt with one or two needle redirections. • Score 2: The first attempt with more than two needle redirections. • Score 3: New attempt in the same or another level of intervertebral space. • Score 4: New attempt with paramedian approach. • Score 5: New attempt with another needle in the same size or larger. • Score 6: Failure in performing the technique. Ultimately, the ease or difficulty of performing SA was graded as follows: • Score 0-1: easy. • Score 2-3: moderate. • Score 4-5: difficult, and • Score 6: impossible or failure.

CSF = cerebral spinal fluid

1. Number of skin punctures:

The variable used to determine the degree of difficulty of spinal anesthesia in the present study was the number of attempts at needle placement, defined as the number of skin punctures and needle reorientation.

Using these variables, the difficulty encountered in performing the procedure was graded into very easy, easy, mild, intermediate, very difficult, impossible and graded as follows:

- Very easy –success after first attempt without needle reorientation.
- Easy – success after one needle reorientation at first skin puncture.
- Mild – success after more than two needle reorientations at first skin puncture.
- Intermediate – a 2nd skin puncture is needed with 2 or less needle reorientations.

- Very difficult - more than 2 needle reorientations at the 2nd skin puncture or a 3rd skin puncture is needed, a change to a paramedian approach, or a call for another pair of hands.
- Impossible - incapacity to reach the dural space after multiple attempts thus converting to general anesthesia.

In a study involving 253 patients, Kim et al reported a first puncture success rate of 44.7%. [55]

Prakash et al in their study designed to assess the association between first puncture success and the number of attempts made, as a predicting factor of difficult neuraxial block also found a first puncture success rate of 52.9%, which is similar to our study with a 53.7% first-puncture success rate. [56]

Table XVII : Rate of first puncture success among different studies

Study series	Sample size	Rate of first puncture success
Kim et al	253	44.7%.
Prakash et al	1647	52.9%,
Current study	108	53.7%

V. Abdominal circumference:

Despite the benefits of spinal anesthesia, it becomes even more challenging for obese parturients. [57]

Gunkaya et al reported that body mass index and waist circumference can be used and interpreted as independent parameters reflecting the increasing incidence of obesity while studying the effects of waist circumference and body mass index on spinal anesthesia levels. [58]

Many studies have also investigated the relationship between abdominal circumference and the success or difficulty of performing spinal anesthesia in a non-obstetrical setting. [24, 59, 60]

Subramanian, et al in a study involving 200 patients, found that patients with abdominal greater than 100cm were associated with difficult lumbar puncture (LP) while performing spinal anesthesia. [24]

Zhou et al also demonstrated a strong correlation between abdominal circumference and the dosage of intrathecal plain bupivacaine for the loss of pinprick discrimination at T12 and T10 for patients under spinal anesthesia for lower limb surgery. [61]

They suggested that as greater abdominal circumference was associated with a more notable increase in the intra-abdominal pressure, it could accurately predict the dosage of intrathecal plain bupivacaine for T12 and T10 block level along with trunk length.

Abdominal circumferences have also been investigated to predict the height of spinal block in geriatric patients undergoing transurethral resection of the prostate.

Yahya et al found that geriatric patients with shorter trunk lengths and larger abdominal circumferences would tend to have greater block height after spinal anesthesia. [60]

The mechanism is the increased intraabdominal pressure when in a supine position which is proportional to the abdominal circumference.

However, this parameter hasn't yet been evaluated for difficult spinal anesthesia in an obstetrical setting, making this a pilot study.

In the current study abdominal circumference of parturients was used as an independent variable to reflect obesity in parturients and as a parameter to predict difficult spinal anesthesia.

The mean abdominal circumference of parturients in this study was 110.56 ±12.39 and 104.50 ±12.65 in both sitting and lying positions respectively, which is slightly higher than Kuok et al with 98.4 ± 6.8 and Parthasarathy et al with 96.39 ±2.48. [54, 62]

Abdominal circumference has long been used to describe abdominal obesity in the context of metabolic syndrome and cardiovascular risk assessment; while the measurement is done in a standing position. [63,64]

However, this parameter is not consensual in the pre-operative evaluation of parturients and differs widely between the lying position and the sitting position, as evidenced by the results of the current study with a mean difference of (6.98 ±3.98)

In this context, we decided to evaluate the parameter in both positions and determine which is the most sensitive for predicting difficult spinal anesthesia.

<u>Table XVIII : Distribution of abdominal circumference among different studies</u>

Study series	Country	Mean (± SD) abdominal circumference
Kuok et al	Taiwan	98.4 ± 6.8 (supine position)
Parthasarathy et al	India	96.39 ± 2.48 (supine position)
Current study	Morocco	104.50 ± 12.65 (lying position)
		110.56 ± 12.39 (sitting position)

VI. Score for predicting difficult spinal anesthesia:

The different variables discussed in this literature have been included in various clinical scores to predict difficult spinal anesthesia. [6, 26]

Below is a score developed by Karim on the difficulty of spinal-arachnoid puncture. [6]

This study was based on analyzing 300 dural punctures in non-obstetric and found that A value above 2 has a specificity of 98.15% and sensitivity of 56.5%

Nevertheless, this score did not take into account other variables that may be important such as patient's characteristics including BMI (body mass index).

Table XIX : Difficult Spinal-Arachnoid Puncture (DSP) Score

Study	variables	Description	Score assigned
Karim et al Difficult Spinal-Arachnoid Puncture (DSP) Score (2023)	Anatomical landmark of the spine	Recognition of spinous processes and intervertebral space by inspection	0
		Superficial palpation of spinous processes and intervertebral space	1
		Spinous processes and intervertebral space felt by deep palpation	2
		Non palpation of spinous processes and intervertebral space	3
	Anesthetist experience	Up to a year	0
		More than one year	3
	Difficulty of Positioning patient	No	0
		Yes	3

Del Buono et al also developed a similar score for neuraxial block assessment to predict the difficulty of spinal anesthesia. [26]

Table XX : Neuraxial Block Assessment (NBA) score

Study	Variables	Points
Del Buono et al Neuraxial Block Assessment (NBA) score (2021)	Previous history of difficult spinal anesthesia	4
	Spinous processes not visible	3
	Spinous processes not palpable	5
	Spinal deformities	5

The following scores were assigned to predict the difficult probability of spinal anesthesia: score 0 = no difficulty, score 3 to 5 = low, score 7 to 9 = intermediate, and above 10 = High.

The NBA score was calculated on the probability range of first puncture failure during spinal anesthesia.

- NBA Score 0: no predicted difficulty, with low probability of first puncture failure;
- NBAScore3-5:low difficulty, with ≤42.5% probability of first puncture failure;
- NBA Score 7-9: intermediate difficulty, with 57-70% probability of first puncture failure;
- NBA Score 10-17: >75% probability of first puncture failure

They suggested that the NBA score ≥7 is the cut-off value above which more than 50% of spinal were predicted to be difficult, requiring at least a second skin puncture.

VII. Maternal hypotension:

Hypotension remains a frequent complication of spinal anesthesia during cesarean section. This is due to the extent of the spinal anesthesia's sympathetic blockade and sensory block level. [65]

In the literature, definitions of hypotension varied between using an absolute blood pressure value, ranging from 80mmHg to 100mmHg, a decrease of 0 - 30% from a baseline, or a combination of an absolute value and a percentage decrease. [81] In our study, we used a drop of 20% from the baseline value to include more participants, and due to the hemodynamic and fetal consequences of a small drop in blood pressure.

In parturient, the gravid uterus compresses the inferior vena cava, leading to greater epidural venous plexus distension, causing a decrease in the subarachnoid space and the CSF volume, hence, causing greater sympathetic blockade and sensory block spread. [62]

When cephalad spread of spinal anesthesia is confined to lower or midthoracic regions, vasodilatation of the lower extremity is compensated by vasoconstriction of the upper extremity. However, such compensation is abolished with greater thoracic levels of spinal anesthesia and may lead to hemodynamic complications. [66]

The incidence of hypotension during spinal anesthesia for cesarean section varies, significantly, with a range of 7.4% to 74.1% across different studies. Skelbar et al Günüsen et al and Kuok et al reported similarly high rates of 52% and 62%, respectively. Unlike these studies, in the current study, we found a much lower incidence of hypotension 7.4%. [4, 51, 54]

Factors such as the height of sensory block (ideally T4/T5) required for the procedure, higher sensitivity to local anesthetics, the effects of anesthesia's sympathetic blockade, and the gravid uterus compression of the aortocaval during pregnancy could explain such adversity. [4,67]

Risk factors for spinal-induced hypotension have been investigated using multivariate analysis, indicating age, body mass index, high spinal block, etc. as major contributors.

An Indian study with a sample of 511 parturients found that age >35 years and BMI ≥30 kg/m^2 were associated with both moderate and severe hypotension and Weight gain of 11-20 kg during pregnancy was associated with the development of severe hypotension. [67, 68]

These findings are aligned with the study done by Brencket et al. In the same study, a greater sensory block level > T4 has also been indicated to be associated with spinal-induced hypotension during cesarean section. [69]

Abdominal obesity during pregnancy may be more crucial in its effects on the cephalad spread of spinal anesthesia due to raised intraabdominal pressure and aortocaval compression. Therefore, a more accurate predictor of sensory block level and maternal hypotension after spinal anesthesia. [51]

In 2016, Kuok et al investigated the relationship between abdominal circumference, spinal block level, and the incidence of hypotension following spinal anesthesia of parturients undergoing cesarean section and reported that parturients with greater abdominal circumference had a higher level of sensory blockade at 5 minutes after spinal anesthesia and suggested that hemodynamic instability due to spinal anesthesia would be severe in parturients with greater abdominal circumference but found no significant correlation between abdominal circumference and the incidence of hypotension. [54]

Unlike the previous study, Parthasarathy et al reported a positive correlation between abdominal girth and the incidence of hypotension during cesarean section. They observed a higher level of sensory blockade with increased abdominal circumference. Ghabach et al also found weight gain during pregnancy to be a valuable predictor of spinal anesthetic-induced hypotension. [54, 62, 70]

In the current study, there were only a few cases of maternal hypotension, as prevention strategies were undertaken for all parturients which involved fluid co-loading, and left lateral tilt. We statistical correlation between spinal-induced hypotension and other variables such as age, body weight, BMI, height, trunk length, and abdominal circumference. Abdominal circumference in supine and sitting positions had an undiscriminating low AUC of 0.557 and 0.533 respectively.

However, in a systematic review of 38 studies with a larger based population (n=3086 patients) to identify predictors of hypotension induced by spinal anesthesia during a cesarean section, Yul et al speculated that maternal demographics, such as BMI, weight, height, and body proportion, may not be a direct determinant of blood pressure and hence may have a limited predictive value. [3]

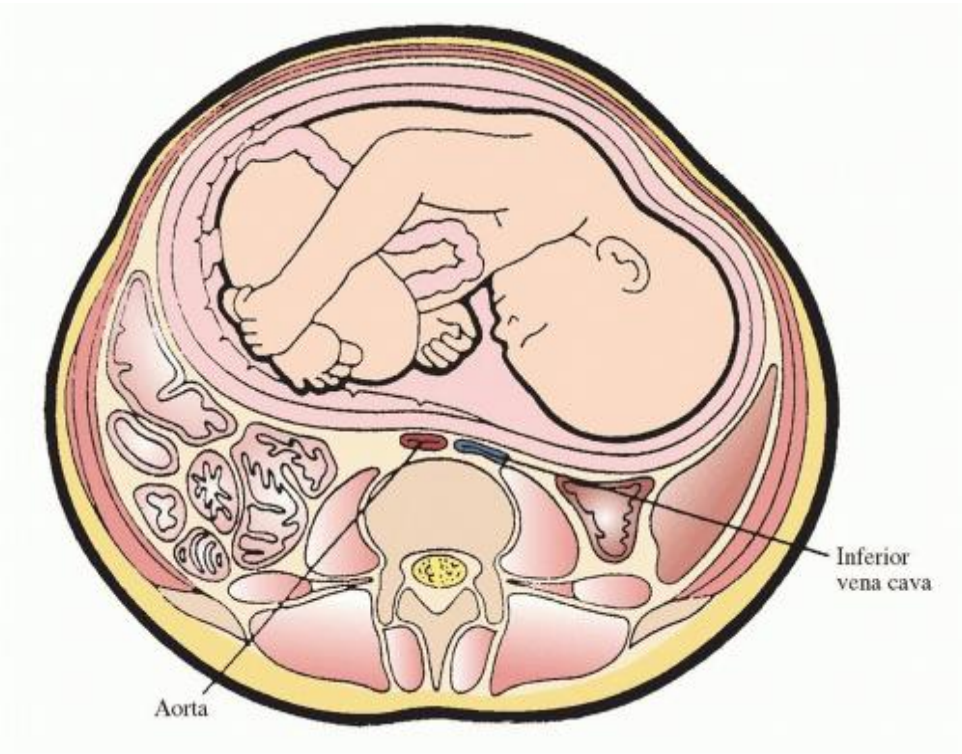


Figure 39 : Uterus compression of the Aorta and vena cava in a supine position.

Image source: GW. Regional anesthesia techniques in obstetrics. New York, NY: Breon

Laboratories; 1980.)

VIII. Prevention of maternal hypotension:

Due to the potentially severe consequences of spinal-induced hypotension for both mother and fetus, preventive measures and treatment of this incidence have been the subject of numerous scientific and clinical studies. [4]

Studies have investigated the effectiveness of crystalloid and colloid preloading or co-loading in preventing hypotension. It was found that administering a 500 to 1500mL crystalloid preload was ineffective due to its rapid redistribution in the body, hence a new approach "co-loading'' was adopted. This involves the rapid administration of crystalloids parallel with the induction of spinal anesthesia, which yields a better response. Colloids administered alone or in combination with crystalloids also prove effective in reducing the incidence or severity of spinal-induced hypotension. Still, an increased risk of colloid anaphylaxis was a concern. [4, 65]

In the present study co-loading with saline 0.9% 500ml and left lateral tilt of 15° right after spinal anesthesia was performed.

A low dose of spinal anesthesia reduces the incidence and severity of spinal-induced hypotension and its negative effects as various studies suggest. [71,72]

In a meta-analysis including 12 studies (693 parturients), Arzola et al demonstrated that a lower incidence and severity of hypotension was associated with administering a lower dose of bupivacaine (< 8mg) when compared to a higher dose (≥ 8mg). However, lower doses of bupivacaine are associated with inadequate spinal block. [73]

Dose of bupivacaine used in the current study was standardized at 10mg in all parturients regardless of their body weight or height.

It is a common clinical practice to apply left lateral tilt (15°), considering that aortocaval compression in the supine position is an important contributing factor to maternal hypotension during cesarean section. It has been recommended along with intravenous colloid pre-loading or crystalloid co-loading, in addition to vasopressors by the current international consensus statement in the management of maternal hypotension. [5, 65]

To prevent the reduction of preload, Physical methods such as leg wrapping with compression stockings or bandages, and the use of inflatable splints/boots, although only moderately effective, as well as using the Trendelenburg position up to 20 degrees, are all useful basic measures to prevent hypotension. [4, 74]

IX. Treatment of maternal hypotension :

Given that these preventive measures for the prevention of maternal hypotension do not yield a satisfactory level of efficiency, the use of vasopressors becomes essential. In this regard, vasoactive medications including ephedrine, phenylephrine and recently norepinephrine have been extensively investigated. [4, 65]

Evidence supports the use of phenylephrine as the vasopressor of choice to treat spinal anesthesia-induced hypotension. It is preferred over ephedrine due to its fast onset and short duration, which makes it easier to administer via boluses or infusion. It is also more effective, has a lower rate of placental transfer, and is less likely to depress fetal pH. [75]

It is recommended to be administered using a syringe pump starting at 25-50 µg/minute immediately after intrathecal local anesthetic injection and titrated depending on blood pressure and pulse rate according to the international consensus statement in the management of maternal hypotension. [5]

Ephedrine has been used for many years to prevent and treat maternal hypotension. It works by increasing both heart rate and systemic vascular resistance. However, studies have shown that phenylephrine is associated with a more favorable acid-base status of the neonate than ephedrine. [4,76]

Therefore Kinsella et al recommended that small doses of ephedrine(3-6 mg)are suitable for managing parturients with SAP (systolic arterial pressure) < 90% of baseline combined with a low heart rate. [5]

Norepinephrine has been studied as an alternative to phenylephrine due to its potential adrenergic effects resulting in increased heart rate and cardiac output. This is because phenylephrine has been associated with severe bradycardia. The ED_{90} of norepinephrine to prevent maternal hypotension is 5.8µg. [77]

Currently, the use of norepinephrine is still not widely used. However, results so far suggest it could be a good alternative to current vasopressors, especially when trying to avoid bradycardia. [4]

In the current study, low doses of norepinephrine (also called baby-noradrenaline) were the first choice of treatment with doses starting at 4µ repeated as needed, and ephedrine was used in case of bradycardia without surpassing 15mg before fetal extraction.

X. Adverse events:

Complications associated with spinal anesthesia are rare, nonetheless, the procedure may result in some technical, intra-operative, and post-operative adversities.

A study done by Prakash et al on the difficulty of spinal block with a sample of (1647 patients), reported 266 (16.1%) cases of traumatic tap, 82 (5%) cases of bradycardia, and 259 (15.7%) cases of hypotension. [56]

Gunusen et al with a sample size of (125 patients) reported four cases of bradycardia, 65 (52%) cases of hypotension, followed by 23 (35.4%) cases of nausea and vomiting. [51]

In the present study, three cases of traumatic spinal anesthesia with hematic cerebral fluid were recorded, with no further neurological impairment at follow-up.

One case of impossible spinal anesthesia that required general anesthesia, one case of hypoxemia, eight cases of maternal hypotension, and one case of complimentary sedation.

Further investigations on post punction headache, and acute urinary retention were not carried out. There was no incidence of bradycardia, nausea, or vomiting.

XI. Limitations and difficulties:

- It should be noted that the sample size was not determined.
- Sampling only took place during daytime cesarean sections, which could explain our small size sample.
- Very few cases of hypotension were recorded.
- Definition of difficult spinal anesthesia was not standardized which may influence the results.
- A need for a Database on previous anesthetics and outcomes on parturient.
- Trunk length measurement was not standardized.

CONCLUSION

Spinal anesthesia is the safest and most commonly used anesthetic technique for parturients undergoing a cesarean section compared to general anesthesia. Nonetheless, it can be challenging for obese patients undergoing a cesarean section.

The difficulty and success of the procedure may be influenced by the patient's demographic and anthropometric characteristics, anatomical landmarks, as well as body proportions.

This study highlighted the challenge of performing spinal anesthesia in parturients with larger abdominal circumferences and higher BMI at delivery, among other variables.

Hence, abdominal circumference in the sitting position is more reliable than the lying position in predicting difficult spinal anesthesia and remains an easy and available clinical tool for preoperative assessment in parturients and can help guide the anesthetic procedure technique, therefore the following recommendations were made:

- In parturients with abdominal circumference greater than 110cm, ultrasound may be useful, as well as in cases where spinous processes are neither visible nor palpable.
- SCORE as a RESEARCH QUESTION to validate; integrating the different significant variables into a clinical score (abdominal circumference, visibility and palpation of spinous processes, BMI, and weight gain during pregnancy) to be validated in a future study.
- A larger study with a large sample size to evaluate the relationship between maternal hypotension and patient’s anthropometric characteristics

SUMMARY

Abstract

Introduction:

Difficult spinal anesthesia procedures often require multiple needle punctures and reorientations, which may be very uncomfortable for the patient, leading to dissatisfaction and post-puncture complications. Accurate prediction of such events proves essential for providing high-quality patient care.

It was hypothesized that factors such as maternal obesity especially reflected by a higher abdominal circumference participate in maternal hypotension and may contribute to the difficulty of spinal anesthesia during cesarean section.

Aim:

Therefore, this research work was designed to determine the reliability of maternal abdominal circumference as a predictor of difficult spinal anesthesia and the occurrence of maternal hypotension during cesarean section.

Methods

Patient's demographic characteristics such as (age, sex, height, weight, body mass index (BMI), trunk length), anatomical landmarks, and gestational age were recorded. Abdominal circumference was measured in both sitting and lying positions before spinal anesthesia. Difficulty of spinal anesthesia was assessed regarding the number of attempts of spinal needle placement and reorientation. Protocol of spinal anesthesia was standardized for all patients.

Hypotension was defined as a drop in blood pressure over 20% or a Systolic pressure below 90mmHg.

A univariate analysis using the T-student test and Mann -Whitney U test was used to study the relationship between variables in the groups of difficult and easy spinal anesthesia.

A Receiver Operating Characteristic (ROC) curve and its AUC (area under the curve) were generated to evaluate the reliability of abdominal circumference to discriminate the likelihood of difficult spinal anesthesia and maternal hypotension.

Results

108 parturients with ASA II, age 18 - 45 undergoing elective or emergency cesarean section under spinal anesthesia in the gyno-obstetrical operating room at the Mother and Child Hospital of the Mohammed VI University Hospital Marrakech, from May 2023 to October 2023 were included in this prospective observational study.

First puncture success was obtained in 56 (53.7%) parturients. The proportion of difficult spinal anesthesia was 31.4%, and the incidence of hypotension was 7.4%.

Mean abdominal circumference in the sitting (110.56 ± 12.39) and the lying (104.50 ± 12.65 cm), were significantly higher in the group with difficult spinal anesthesia.

Greater BMI (p= 0.014), weight (p = <0.001), and trunk length (p= 0.003) were respectively associated with difficult spinal anesthesia.

The ROC curve indicated a fairly significant difference between abdominal circumference and difficult spinal anesthesia but found no significant correlation between abdominal circumference and maternal hypotension.

Conclusion

The findings from this study suggest that parturients with greater sitting and lying abdominal circumference may be associated with difficult spinal anesthesia but not a predictor of maternal hypotension.

Abdominal circumference can predict difficult spinal anesthesia, especially in the sitting position, with a Sensitivity of 78.8% and a Specificity of 70% when above 110cm.

Résumé

Introduction

Les procédures difficiles de rachianesthésie nécessitent souvent de multiples piqûres et réorientations d'aiguilles, ce qui peut être très inconfortable pour le patient, entraînant une insatisfaction et des complications post-ponction. Une prédiction précise de tels événements s'avère essentielle pour fournir des soins aux patients de haute qualité.

Il a été émis l'hypothèse que des facteurs tels que l'obésité maternelle, notamment reflétés par une circonférence abdominale plus élevée, participent à l'hypotension maternelle et peuvent contribuer à la difficulté de l'anesthésie rachidienne lors d'une césarienne.

But

Par conséquent, ce travail de recherche a été conçu pour déterminer la fiabilité de la circonférence abdominale maternelle en tant que prédicteur d'une anesthésie rachidienne difficile et de la survenue d'une hypotension maternelle lors d'une césarienne.

Méthodes

Les caractéristiques démographiques de la patiente telles que (âge, sexe, taille, poids, indice de masse corporelle (IMC), longueur du tronc), les repères anatomiques et l'âge gestationnel ont été enregistrées. La circonférence abdominale a été mesurée en position assise et couchée avant la rachianesthésie. La difficulté de l'anesthésie rachidienne a été évaluée en fonction du nombre de tentatives de placement et de réorientation de l'aiguille rachidienne. Le protocole de rachianesthésie a été standardisé pour tous les patients.

L'hypotension était définie comme une baisse de la pression artérielle supérieure à 20 % ou une pression systolique inférieure à 90 mmHg.

Une analyse univariée utilisant le test T-student et le test Mann-Whitney U a été utilisée pour étudier la relation entre les variables dans les groupes d'anesthésie rachidienne difficile et facile.

Une courbe des caractéristiques de fonctionnement du récepteur (ROC) et son AUC (aire sous la courbe) ont été générées pour évaluer la fiabilité de la circonférence abdominale afin de discriminer la probabilité d'une anesthésie rachidienne difficile et d'une hypotension maternelle.

Résultats

108 parturientes ASA II, âgées de 18 à 45 ans, subissant une césarienne élective ou d'urgence sous rachianesthésie au bloc opératoire gynéco-obstétrical de l'hôpital mère-enfant du CHU Mohammed VI de Marrakech, de mai 2023 à octobre 2023, ont été incluses dans cette étude. étude observationnelle prospective. Le premier succès de ponction a été obtenu chez 56 (53,7 %) parturientes. La proportion de rachianesthésies difficiles était de 31,4 % et l'incidence de l'hypotension était de 7,4 %.

La circonférence abdominale moyenne en position assise (110,56 ± 12,39) et en position couchée (104,50 ± 12,65 cm) était significativement plus élevée dans le groupe avec anesthésie rachidienne difficile.

Un IMC plus élevé (p = 0,014), un poids (p = <0,001) et une longueur du tronc (p = 0,003) étaient respectivement associés à une anesthésie rachidienne difficile.

La courbe ROC indiquait une différence assez significative entre la circonférence abdominale et une anesthésie rachidienne difficile mais ne retrouvait aucune corrélation significative entre la circonférence abdominale et l'hypotension maternelle.

Conclusion

Les résultats de cette étude suggèrent que les parturientes ayant une plus grande circonférence abdominale en position assise et couchée peuvent être associées à une anesthésie rachidienne difficile, mais ne constituent pas un prédicteur d'hypotension maternelle. La circonférence abdominale peut prédire une rachianesthésie difficile, notamment en position assise, avec une sensibilité de 78,8% et une spécificité de 70% lorsqu'elle est supérieure à 110 cm.

ملخص

مقدمة

تتطلب إجراءات التخدير النخاعي الصعبة غالبًا عدة محاولات لإدخال الإبرة وإعادة توجيهها، مما يمكن أن يكون غير مريح للغاية للمريض، مما يؤدي إلى عدم الرضا والمضاعفات بعد العملية. يعتبر التنبؤ الدقيق بمثل هذه الأحداث ضروريًا لتقديم رعاية عالية الجودة للمرضى.

لقد تم افتراض أن عوامل مثل السمنة الأمومية، التي تنعكس بشكل خاص في زيادة محيط البطن، تساهم في انخفاض ضغط الدم الأمومي وقد تسهم في صعوبة التخدير النخاعي أثناء الولادة القيصرية.

الهدف

لذلك، تم تصميم هذا البحث لتحديد مدى موثوقية محيط البطن الأمومي كمؤشر على صعوبة التخدير النخاعي وظهور انخفاض ضغط الدم الأمومي أثناء الولادة القيصرية.

الطرق

تم تسجيل الخصائص الديموغرافية للمريضة مثل (العمر، الجنس، الطول، الوزن، مؤشر كتلة الجسم(BMI) ، طول الجذع)، والمعالم التشريحية وعمر الحمل. تم قياس محيط البطن في وضعيتي الجلوس والاستلقاء قبل التخدير النخاعي. تم تقييم صعوبة التخدير النخاعي بناءً على عدد محاولات وضع الإبرة وإعادة توجيهها. تم توحيد بروتوكول التخدير النخاعي لجميع المرضى.

تم تعريف انخفاض ضغط الدم على أنه انخفاض في ضغط الدم بنسبة تزيد عن 20٪ أو ضغط انقباضي أقل من 90 مم زئبق.

تم استخدام تحليل أحادي المتغير باستخدام اختبار T-student واختبار Mann-Whitney U لدراسة العلاقة بين المتغيرات في مجموعتي التخدير النخاعي الصعب والسهلة.

تم إنشاء منحنى خصائص التشغيل للمستقبل (ROC) ومساحته تحت المنحنى (AUC) لتقييم مدى موثوقية محيط البطن في التنبؤ بصعوبة التخدير النخاعي وانخفاض ضغط الدم الأمومي.

النتائج

تم تضمين 108 من النساء الحوامل من الدرجة الثانية(ASA II) ، تتراوح أعمارهن بين 18 و 45 عامًا، واللواتي خضعن للولادة القيصرية الانتقائية أو الطارئة تحت التخدير النخاعي في غرفة العمليات النسائية والولادة بمستشفى الأم والطفل في المركز الاستشفائي الجامعي محمد السادس بمراكش، من مايو 2023 إلى أكتوبر 2023، في هذه الدراسة الملاحظة المستقبلية. تم تحقيق النجاح الأولي للوخز لدى 56 (53.7٪) من النساء الحوامل. كانت نسبة التخدير النخاعي الصعب 31.4٪ وبلغ معدل حدوث انخفاض ضغط الدم 7.4٪.

كان متوسط محيط البطن في وضعية الجلوس (110.56 ± 12.39) وفي وضعية الاستلقاء (104.50 ± 12.65 سم) أعلى بشكل ملحوظ في المجموعة التي واجهت صعوبة في التخدير النخاعي.

تم ربط مؤشر كتلة جسم أعلى(p = 0.014) ، وزن أعلى (p = <0.001) وطول الجذع (p = 0.003)على التوالي بصعوبة التخدير النخاعي.

أشار منحنى ROC إلى اختلاف كبير بين محيط البطن وصعوبة التخدير النخاعي ولكنه لم يجد أي ارتباط كبير بين محيط البطن وانخفاض ضغط الدم الأمومي.

الاستنتاج

تشير نتائج هذه الدراسة إلى أن النساء الحوامل اللواتي لديهن محيط بطن أكبر في وضعيتي الجلوس والاستلقاء قد يكن مرتبطات بصعوبة التخدير النخاعي، ولكنهن لا يشكلن مؤشرًا على انخفاض ضغط الدم الأمومي. يمكن لمحيط البطن التنبؤ بصعوبة التخدير النخاعي، خاصة في وضعية الجلوس، بحساسية تبلغ 78.8٪ وخصوصية تبلغ 70٪ عندما يكون أكبر من 110 سم

APPENDIX

Worksheet: Abdominal Circumference and Caesarean Section

<table>
<tr><td>IP:</td><td>Age:</td><td>Gestational age:</td><td>Emergency ? Programmed?</td></tr>
<tr><td colspan="3">Weight:......................kg
Height: ....
BMI: ....
Seated abdominal circumference.......................cm
Abdominal perimeter lying down.......................cm
Trunk length:...cm</td><td>Date:......../...../......

Indication for caesarean section:.....................

ASA:.........................</td></tr>
<tr><td colspan="4">MEDICAL HISTORY</td></tr>
<tr><td colspan="4">Twin pregnancy: Yes? No?
Gestational Diabetes: yes? No?
Pre-eclampsia: yes? No?
Medical history of difficult spinal anesthesia: Yes? No?</td></tr>
<tr><td colspan="4">Technique : <u>standardise doses (Bupi 10mg) + fentanyl 25u + Morphine 100u</u>
<u>Injection time 0.2ml/second</u></td></tr>
<tr><td colspan="2">Puncture level : ....
Difficult spinal anesthesia (>2 attempts): yes? No?
Traumatic (haematic CSF): Yes? No?
Associated sedation: Yes? No?
Conversion to GA : Yes? No?</td><td colspan="2">Visible spinous processes: Yes? No?
Palpation identification: Easy? Difficult?
Ultrasound:
• Tuffier line = level:...
• Skin to lumbar canal distance:.........cm</td></tr>
<tr><td colspan="4">Block Installation</td></tr>
<tr><td colspan="2">Time to install motor block:..............min
Motor block degree :.........................
Sensory block level:..............................
Block duration:.................................min</td><td colspan="2">Bradycardia (<50bpm) : yes? No?
Hypotension (<90 PAS or <20% baseline) ; yes ? No?
Low Pressure : PAS: PAM: PAD:
Hypotension onset time:...............min
Dose of ephedrine (without exceeding 15mg):..................mg
Dose of Baby Nad (1 cc=4µ):.......................cc</td></tr>
<tr><td colspan="4">Complications</td></tr>
<tr><td colspan="4">Post spinal headache: yes? No?
Sensation of acute retention of urine: yes? No?
Extension of the block above T4: yes? No?
Total spinal anesthesia: yes? No?
Heart failure: yes? No?
Others:...</td></tr>
</table>

Exclusion:

Acute fetal destress
Umbilical cord prolapse
Scoliosis
Contraindication to spinal anesthesia
Medical history of spinal surgery
Preeclampsia

كليـــــة الطب
والصيدلة - مراكش
FACULTÉ DE MÉDECINE
ET DE PHARMACIE - MARRAKECH

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S. ZAOUI

Comité d'Éthique
Hospitalo-universitaire de Marrakech

Objet : Décision du Comité sur le protocole soumis

Titre du travail : Preoperative measurement of abdominal circumference as a predictor of difficult spinal anesthesia and maternal hypotension during caesarian section.

N° 59/2023

Investigateur principal: M. Essafti

Le comité a reçu votre protocole en Octobre 2023.

Le Comité a étudié votre protocole le 13 Novembre 2023 et les membres ont émis la délibération suivante : **Avis favorable.**

Le comité demande à l'investigateur de rapporter tout incident éventuel survenant lors du déroulement de l'étude et de l'informer sur sa clôture et ses résultats.

Date : 27 /11/20223

Signature :

Professeur Said AIT BENALI
Chef de Service de Neurochirurgie
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قسم الطبيب

أقسم بالله العظيم

أن أراقب الله في مهنتي
وأن أصون حياة الإنسان في كافة أطوارها في كل الظروف والأحوال باذلا وسعي في إنقاذها من الهلاك، والمرض، والألم، والقلق.
و أن أحفظ للناس كرامتهم و أستر عورتهم و أكتم سرهم.
وأن أكون على الدوام من وسائل رحمة الله، مسخرا كل رعايتي الطبية للقريب و البعيد، للصالح و الطالح، و الصديق و العدو.
و أن أثابر على طلب العلم و أسخره لنفع الإنسان لا لأذاه.

وأن أوقر من علمني وأعلم من يصغرني وأن أكون أخا لكل زميل(ة) في المهنة الطبية متعاونين على البر و التقوى.

وأن تكون حياتي مصداق إيماني في سري وعلانيتي، نقية مما يشينها تجاه الله ورسوله والمؤمنين.

و الله على ما أقول شهيد.

كليـــــــة الـطـب
والصيدلة - مراكش
FACULTÉ DE MÉDECINE
ET DE PHARMACIE - MARRAKECH
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UNIVERSITÉ CADI AYYAD

سنة 2024 أطروحة رقم 271

قياس محيط البطن قبل العملية كمتنبئ بصعوبة التخدير الشوكي وانخفاض ضغط الدم لدى الأم أثناء العملية القيصرية.

الأطروحة

قدمت ونوقشت علانية يوم 2024/05/31

من طرف

السيد موسيس ويلسون

المزداد في 11 غشت 1994 بمونروفيا

لنيل شهادة الدكتوراه في الطب

الكلمات الأساسية:

سلامة المريض - عملية قيصرية - تخدير شوكي

سمنة - انخفاض ضغط الدم لدى الأم

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