ADDIS ABABA UNIVERSITY COLLEGE OF HEALTH SCIENCES

DEPARTMENT OF ANESTHESIA

Incidence and Associated Factors of Failed Spinal Anesthesia on Adults Undergoing Elective Surgery in Selected Public Hospitals at Addis Ababa, Ethiopia : A Cross Sectional Study

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The Research Paper is submitted to The Department of Anesthesia, College of Health Sciences, at Addis Ababa University in Partial Fulfillment of The Requirements for The Degree of Masters of Anesthesia.

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I. Declaration

I, Ribka Tsegaye, declare that this research entitled "Incidence and associated factors of failed spinal anesthesia on adults undergoing elective surgery in selected public hospitals. A cross sectional study Addis Ababa, Ethiopia.2020/21 is the outcome of my own effort and study and that all sources of materials used for the study have been duly acknowledged.

I have produced it independently except for the guidance and suggestion of my research Advisor. This study has not been submitted for any degree in this University or any other University. It is offered for the partial fulfillment of the degree of Master of Anesthesia [MSc].

Name: Ribka Tsegaye **Signature**_____

Date_____

Approval of the Board of Examiners

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II. Acknowledgement

First and foremost, praises and thanks to the God, the Almighty, without whose grace, all these could not be possible.

I would like to express my sincere gratitude to my research advisors, Mr. Adugna Aregawi (Assistant Professor) and Mr. Zewetir Ashebir (BSc, MSc Anesthesia) for providing invaluable guidance and directing the methodology to carry out the research paper as comprehensive as possible.

Contents

III. Abbreviation and Acronyms

AOR……..Adjusted odds ratio

ASA ..... American Society of Anesthesiologists

BMI ..... body mass index

BSc……Bachelor degree in anesthesia

CI ..... confidence interval

COR ..... Crude odds ratio

CS..... Caesarean section

CSF ..... Cerebrospinal fluid

E.C. ..... Ethiopian Calendar

FSA ..... Failed spinal anesthesia

GA..... General Anesthesia

LA ..... Local anesthetic

MSc……. Master degree in anesthesia

OR..... Operation room

SA ..... Spinal Anesthesia

Sp……..Spinous process

SPSS..... Statistical Package for Social Science

TASH..... Tikur Anbessa Specialized Hospital

IV. List of Tables

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VI. Abstract

Background: Spinal anesthesia is the preferred anesthesia technique employed in a variety of surgical procedures. Even though it is safe and reliable technique, the occurrence of failed spinal anesthesia (FSA) may not possibly avoided. Sometimes the failure may have a serious consequence. Study reports on incidence of failed spinal anesthesia vary among countries .Some practitioners assert that an incidence rate of less than one present is attainable. In Ethiopia, although spinal anesthesia is widely used in a variety of surgical procedure, and failure is observed in a day to day practice, the incidence and associated factors of failed spinal anesthesia is not yet known. In order to minimize the risk of failure, the incidence and the associated factors have to be identified.

Objective: To investigate the incidence and associated factors of failed spinal anesthesia in adults who underwent elective surgery in public hospitals at Addis Ababa, Ethiopia.

Methods: An institutional based cross sectional survey was conducted on 266 eligible adult elective surgical patients from January 31st to April 30th, 2021 at selected public hospitals, Addis Ababa, Ethiopia. Systematic random sampling method was employed for selecting samples. Data was entered and analyzed with SPSS version 24. Binary and multivariable logistic regression analysis was done to access significance of factors associated with failed spinal anesthesia. At 95% confidence interval a p-value of less than 0.05 was considered as statistically significant. Both crude and adjusted odds ratio were calculated to show strength of association.

Results

The incidence of FSA among the adult who underwent elective surgery under SA was 21.01% (54/257). In multivariable analysis experience of anesthesia provider of service years less than two (AOR=3.556; 95% CI=1.832-6.905), Bloody CSF (AOR=2.738; 95% CI=1.365-5.491) and number of spinal attempt greater than two, (AOR=2.919, 95% CI =1.458 –5.846) were significantly associated with failed spinal anesthesia.

Conclusion and Recommendation: The results of this study reveal that the incidence of failed spinal anesthesia at Addis Ababa public hospitals, Ethiopia, is high compared to the results of studies done in other countries. Associated factors identified as significant predictors for failed spinal anesthesia in this study were more of avoidable factors. Hence, first, the anesthesia providers needs to be aware of the high incidence and then they should make the best possible effort to minimize failure by giving due attention to detail at each steps of the technique during procedures. Furthermore, the findings of this study and developments, if any, need to be reviewed with subsequent similar studies.

Key words: - Failed spinal anesthesia, neuraxial block, Spinal anesthesia, subarachnoid block, intrathecal block

CHAPTER - ONE

1. INTRODUCTION

1.1. BACKGROUND

Spinal anesthesia (subarachnoid or intrathecal block) is a commonly used anesthesia technique involving the lower abdomen, pelvic, perineal and lower extremity. Surgical procedures such as orthopedic, urologic, gynecologic, general surgery and caesarian section (CS) are widely performed using this technique (1).

Its simplicity, minimum drug use, reduced intraoperative blood loss, maintenance of cardiac and pulmonary function, prevention of pulmonary aspiration, avoiding airway complications are some of the reasons that make it a priority choice (2)(3)(4).

Despite the above mentioned advantages, failure does occur. Failed spinal anesthesia refers to a condition where one attempts spinal anesthetic but no block resulted (complete failure) or inadequate block for the intended surgery due to problems with the extent, quality, or duration of the local anesthetic action (incomplete block) (5).

In some patients measures taken to overcome block failure, may have a devastating effect. Repeating the block, for instance, may causes high or total spinal anesthesia, which may leads to loss of consciousness and/or respiratory compromise that results in a life threatening condition. For some patients with difficult airway and severe comorbidities, converting a spinal anesthesia to general anesthesia, may increase the risk of morbidity and mortality. Besides, failed spinal anesthesia might be a source of pain, anxiety, and psychological trauma to the patient and a concern and even a sequelae for medicolegal to anesthesia providers (5)(6)(7).

Furthermore, in this era of Covid-19 pandemic, general anesthesia, which involves both intubation and extubation, leads to aerosol generation that increases the risk of contamination in operating rooms. Because of this, experts advise avoiding general anesthesia as much as possible to reduce the risk (24).

The incidence rate of FSA reported in other countries is between 1-17 %. The figures vary among studies/countries. Most experienced practitioners assert that the incidence is less than 1%. The findings of available studies also reveal that the predictors for failed spinal anesthesia also vary from study to study.

In Ethiopia, comprehensive studies on incidence and risk factors encompassing all surgical procedures have not yet been conducted. Hence, this research aim to find out incidence and associated factors of FSA in adult patients undergoing elective surgery with spinal anesthesia and to contribute some input by suggesting a means based on the result.

1.2. STATEMENT OF THE PROBLEM

Spinal anesthesia is one of the most extensively utilized anesthetic techniques throughout the world. Its application is significantly growing. Nonetheless, failure is a quite common phenomenon in the operation theater.

The incidence of failed spinal anesthesia has been studied in a number of countries. However, the results were varied among the studies. The difference might be due to variation in clinical settings or specific objective of the researches. In this regard, drawing conclusions based on findings from other countries' research may not be reliable.

Furthermore, the limited research conducted on failed spinal anesthesia in Ethiopia, were primarily on obstetric, making generalizations concerning other surgical populations difficult.

In Ethiopia, irrespective of the wide use of spinal anesthesia procedure and observed failure in everyday practice, the problem seems not well noted. And information about incidence of failed spinal anesthesia on the various surgical procedures is based on, either on text books or from reports of some studies done in other countries that might be done on different clinical settings.

Therefore, the aim of this study is, to find out the incidence of failed spinal anesthesia in adults who undergo spinal anesthesia for elective surgeries, to explore factors associated with it, to provide an insight and suggest a means to resolving the problem.

1.3. JUSTIFICATION OF THE STUDY

Despite the fact that spinal anesthesia has a number of benefits, including a shorter hospital stay, reduced post-operative delirium, cost effectiveness, minimum drug use, especially opioids, and less post-operative nausea and vomiting (PONV), these benefits may be compromised if spinal anesthesia fails.(8).

With advance in technology and medical care, life expectancy and the number of geriatric patients are increasing. These patient groups have concomitant medical problems and limited physiologic adaptation. Even though, spinal anesthesia is an ideal anesthetic technique for these patient groups, the advantage is hampered and sometimes things may get complicated with failure of spinal anesthesia (10) (10) (12).

Similarly, when spinal anesthesia fails, the commonly stated advantages spinal of anesthesia for ambulatory patients' in particular improved patient engagement, reduced post-operative analgesic demand, improving operating theater efficiency and reduced cost may be lost which is a major concern for resource limited countries like Ethiopia. (9) (13) (14) .

Furthermore, the added benefits of spinal anesthesia in reducing the risk of infectious respiratory diseases such as COVID-19 spread to healthcare providers particular by avoiding the aerosol-generating procedures during general anesthesia may be jeopardized by spinal anesthesia failure.

The rates of failure of spinal anesthesia, according to studies conducted in a number of countries, range from 1 to 17 percent. It has been presumed that a failure rate of less than 1% is attainable (5).

Failed spinal anesthesia may be managed by conversion of anesthesia technique, but for some patients, the consequence might be a life threatening and even catastrophic.

According to some studies, measures taken to manage inadequate block include repeating the injection, use of systemic sedation or analgesic drugs, and changing to general anesthesia, which might results in complications (5).

Minimizing the incidence of failure is a necessity to gain the benefits of spinal anesthesia. Therefore, to address some of avoidable causes and to improve the efficiency of the anesthesia practice, understanding the rate of failure and identifying the factors that significantly contribute to failure, is of a paramount significance.

CHAPTER TWO

2. LITERATURE REVIEW

In spite of the widely use of spinal anesthesia technique and it is a major issues for the anesthesia providers, the numbers of literatures on failed spinal anesthesia that considers the range of surgical procedures are proportionately few (15).

Failed spinal anesthesia is broadly defined as "occurrence of failure of block when the spinal anesthetic was attempted but no block resulted or a block is present but inadequate for the proposed surgery" (5).

Definition of failed spinal anesthesia differs from study to study based on the objective and scope of the study. A multi-center study by Fuzier et al (2011) defines FSA as failure of the block after injection of local anesthetics in to CSF. In this study technical failure such as failure to identify interspace is excluded (15).

According to Colish et al., (2020) on their eight years prospective study, failure of SA define as failure to block after documentation of CSF return through the spinal needle, repeating anesthetic within two hours of spinal anesthesia is also considered as failure. Based on this definition dry tap is excluded (16).

A one year retrospective study by Yüksek A.et al (2020) made a range of definition for their study aimed to compare most frequent SA failure by type of surgery and cause of failure. According to the study three or more SA attempts, failed dural puncture, or unsuccessful injection, and anesthesia applications that did not provide sufficient sensory block for surgery despite successful drug treatment were defined as failure (17).

According to Rukewe et al., (2015) definition of failure covered complete (preoperative) failure to achieve a pain-free operative condition and pain during surgery (intraoperative failure) (18).

On the other hand, Parikh KS (2008), defined failed spinal anesthesia as pain or discomfort necessitating the need to undertake additional measures to continue surgery or failure to provide satisfactory surgical conditions and/or patient satisfaction during the surgical procedure with or without conversion to general anesthesia. In this study, failed spinal

anesthesia refers to either inadequacy of the administered spinal anesthesia to commence the intended surgery or repeating the block after the failure (19).

For Alabi et al., (2017) failed spinal anesthesia refers to the condition that pain or discomfort during surgery necessitating the need to undertake additional measures to continue surgery is regarded as failed spinal anesthesia (20). A five year prospective auditee by Kinsella (2008) defines failed spinal anesthesia as conversion to general anesthesia, inadequate block that require analgesia and pain during surgery (21).

From the above reviews, definitions of FSA vary according to the objective and scope of the study, and hence no standard definition can be used as guideline for all.

In this study, failed spinal anesthesia refers to either inadequacy of the administered spinal anesthesia to commence the intended surgery due to partial and incomplete failure or repeating the block after the failure.

Most experienced practitioners would consider the incidence of failure with spinal anesthesia to be very low, possibly less than 1%. However, a figure as high as 17%, has been quoted from an American teaching hospital (22)(5). Other researchers considered this rate as high and 'unacceptable', and come up with a much lower, but still significant, rate of 4%. Miss judgement is assumed to be the major factor.

Regarding the incidence of failed spinal anesthesia, a study by Fuzier R et el (2011) on a multicenter prospective analysis which is done on different 21 centers, incidence of failed spinal anesthesia is 3.2% (15). A prospective audit of regional anesthesia on failure in caesarean sections by Kinsella SM (2008) UK, the incidence of failed spinal anesthesia was 6% for electives and 4.9% for emergency caesarean sections (21).

According to Colish, Jane, et al (2020) on an 8-year retrospective analysis of patients undergoing elective hip and knee joint arthroplasty reported their finding somehow near the above, with an incidence of failed spinal to be about 3.8% (16).

According to Yüksek, Ahmet, et al. (2020), of all anesthesia procedures, failure rate of spinal anesthesia is 16.6%. In this study, obstetric anesthesia was the most common surgery with failed SA (28.7%) (17). The study conducted by Alabi et al., (2017) reported that the incidence of failed spinal anesthesia was 11.7%, (20).

A retrospective survey by Rukewe et el (2015), the failure rate in obstetric anesthesia was 9.1%. It indicates that the rate of failed spinal anesthesia of the study was high. The researchers suggest developing clear guidelines to standardize obstetric spinal anesthetic practice as well as the management of failures (18).

The result of studies conducted in our country on obstetrics that may have similar clinical settings revealed that the overall incidence according to Ashagrie et al., (2020) on the incidence and factors associated with failed spinal anesthesia among parturient underwent cesarean section, at Gonder University teaching hospital, Ethiopia, (2019) the overall incidence of failed spinal was 19.5% (22).

Results of the above studies reveal that, the incidence was significant. And the magnitude is different across countries. It also showed that, in everyday practice, a failure rate of <1% is attainable. It should also be noted that, most of these studies are done on a single surgical procedure such as obstetrics and orthopedics (5).

In order to gaining the full benefits of spinal anesthesia, minimizing the incidence of failure is obviously a pre-requisite. For the anesthesia provider professional to give meticulous attention, they need regular updates and reviews on incidence and associated factors. For the incidence to be managed, first and utmost, it should be measured. Accordingly, to fill the gap of absence for concrete fact on failure of spinal anesthesia on range of procedures and to have a regular updates, estimating the failure rates and identifying the associated factors needs to be an agenda.

With respect to associated factors, results of different studies come up with different predicting factors. Colish, Jane, et al (2020) reported that spinal anesthetic failure was associated with younger age, lower body mass index (BMI), needle insertion site, needle size and baricity (16). On the other hand, Rukewe et el (2015), reported that the predictors for failed spinal anesthesia were more due to multiple attempts, use of the L4/L5 interspace, and the level of experience of the anesthesia provider (18). Alabi AA et (2017) suggests that the risk factors for failure of spinal anesthesia were; obesity, prior anesthesia, bloody CSF, dry tap and multiple puncture attempts (20).

A study by Fuzier R et al (2011) reported that the number of puncture attempts at 3 or more and the absence of adjuvant medication associated with local anesthetic were independent factors associated with the increased risk of failure. On top of this their finding showed that, failure of spinal anesthesia was rare in patients older than 70 years (15).

A prospective observational study conducted by Ashagrie HE et al (2019) reported that the predictors for Failed spinal anesthesia are co-morbidity, needle size, anesthetist's experience, surgeon's experience, bloody CSF flow, and volume of local anesthetics (22).

CHAPTER THREE

3. OBJECTIVE

3.1. GENERAL OBJECTIVE

To assess the incidence of failed spinal anesthesia and associated factors on adults undergoing elective surgery under spinal anesthesia in public hospitals at Addis Ababa, Ethiopia.

3.2. SPECIFIC OBJECTIVE

- To assess the incidence of failed spinal anesthesia.
- To identify significant predictors of failed spinal anesthesia.
- Based on the findings, to suggest means to minimize risks associated with failed spinal anesthesia

CHAPTER - FOUR

4. METHODOLOGY

4.1. Study Area

The study area is Addis Ababa, the capital city of Ethiopia and the head quarter of African Union. The population of Addis Ababa is 4,794,000, with an area of 527 km².

Addis Ababa has 39 hospitals among these 11 are public while the 28 are NGO and private.(Melese et al. 2020). For this study, four public hospitals were randomly selected, namely, Ras Desta Damtew Memorial Hospital, St. Paul's Hospital Millennium medical college, Minilik Memorial Hospital and Tikur Anbesa Specialized hospital.

Ras Desta Damtew Memorial Hospital is located in Arada Sub city, Woreda 04. The hospital was built in 1924 E.C. It provides a comprehensive medical service with 550 clinical and non-clinical staff. The hospital has 168 beds in five inpatient wards

(37 beds for gynecological and obstetric, 39 beds for surgical, 33 beds for medical, 19 beds for pediatric and 40 beds for adult and neonatal intensive care unit).

St. Paul's Hospital was built in 1969 by Emperor Haile Selassie in collaboration with the German Evangelical Church, to provide medical care for low income populations. Currently the hospital has 392 beds with an annual average of 200,000. Approximately 75% of the patients receive medical services free of charge. There is over 1,300 clinical and non-clinical staff. It is the second largest hospital in Ethiopia.

Minilik II Referral Hospital is a located at Yeka sub city. It is the first modern hospital built by Emperor Minilik II in 1906. The hospital has 635 clinical and non-clinical staff. It provides medical care to approximately 150,000 people each year. The Hospital receives referrals from around the country.

Tikur Anbessa specialized hospital is the largest multi-specialist tertiary care referral and teaching hospital in Ethiopia, opened in 1972. TASH is now the main teaching hospital for clinical and preclinical trainings of most disciplines. It is also an institution where specialized clinical services that are not available in other public or private institutions are rendered to the whole nation. It has 694 clinical and 950 non-clinical staffs. It has 800 beds, 12 operation theatres, 6,000-8,000 operation done annually.

These four hospitals serve a significant portion of patients in the capital city Addis Ababa and a majority of the referral patients in the country.

4.2. Study design and study period

An institutional based cross sectional study design was employed from January 31st to April 30th, 2021.

4.3. Population

4.3.1. Source Population

All patients who were scheduled for elective surgery and planned for spinal anesthesia.

4.3.2. Study population

Patients, who had been planned for spinal anesthesia and underwent elective surgery during the study period.

4.4. Eligibility criteria

4.4.1. Inclusion Criteria

- All patients of ASA classification I, II and III
- Patients of aged 18 years and older, and
- Patients that underwent elective surgery and had been planned for spinal anesthesia.

4.4.2. Exclusion Criteria

- Patients with contraindications to spinal anesthesia such as
    - coagulopathy
    - septicemia
    - known previous spinal pathology
    - allergy to local anesthetic agents
    - patient refusal

4.5. Sample size determination and sampling procedure

4.5.1. Sample size determination.

The sample size was determined using the standard sample size formula (Cochran's formula) (23)

$$n = \frac{Z^2 P(1-P)}{d^2}$$

Where:- n is the sample size,

Z is the statistic corresponding to level of confidence,

P is expected percentage of occurrence, and

d is precision (corresponding to effect size).

The level of confidence aimed for this study is 95%. The corresponding Z score value for 95% confidence interval (CI) is 1.96. The assumed percentage (p) estimated from previous studies at Gonder University and 19.5% (22) and since it is large enough (more than 10%), a precision (d) of 5% was considered to be appropriate.

Using the above formula, the sample size required for the study was 241. With a provision of 10% for missing values / incomplete data the study sample size was 266.

4.5.2. Sampling Procedure

Prior to the study, in order to get information on the study population, a situational analysis was conducted based on three months log books of the hospitals. During these periods, in all the surgical procedures, a total of 1,158 patients were managed using spinal anesthesia in these hospitals. Sample size allocation for each hospital was determined based on proportion. Then, the study participants were selected using systematic random sampling technique from the daily schedule. The sampling interval; K was determined for each hospital using the formula: K=N/n. where, N = population (all spinal procedures over the 3 months - 1,158), n = total sample size (266). Therefore, the sampling interval (k) was four and the first study participant was selected using lottery method from

the daily schedule .However, due to COVID - 19 pandemic surgical cases were decrease by 50%. Accordingly, the k value is revised and every other patients for the study.

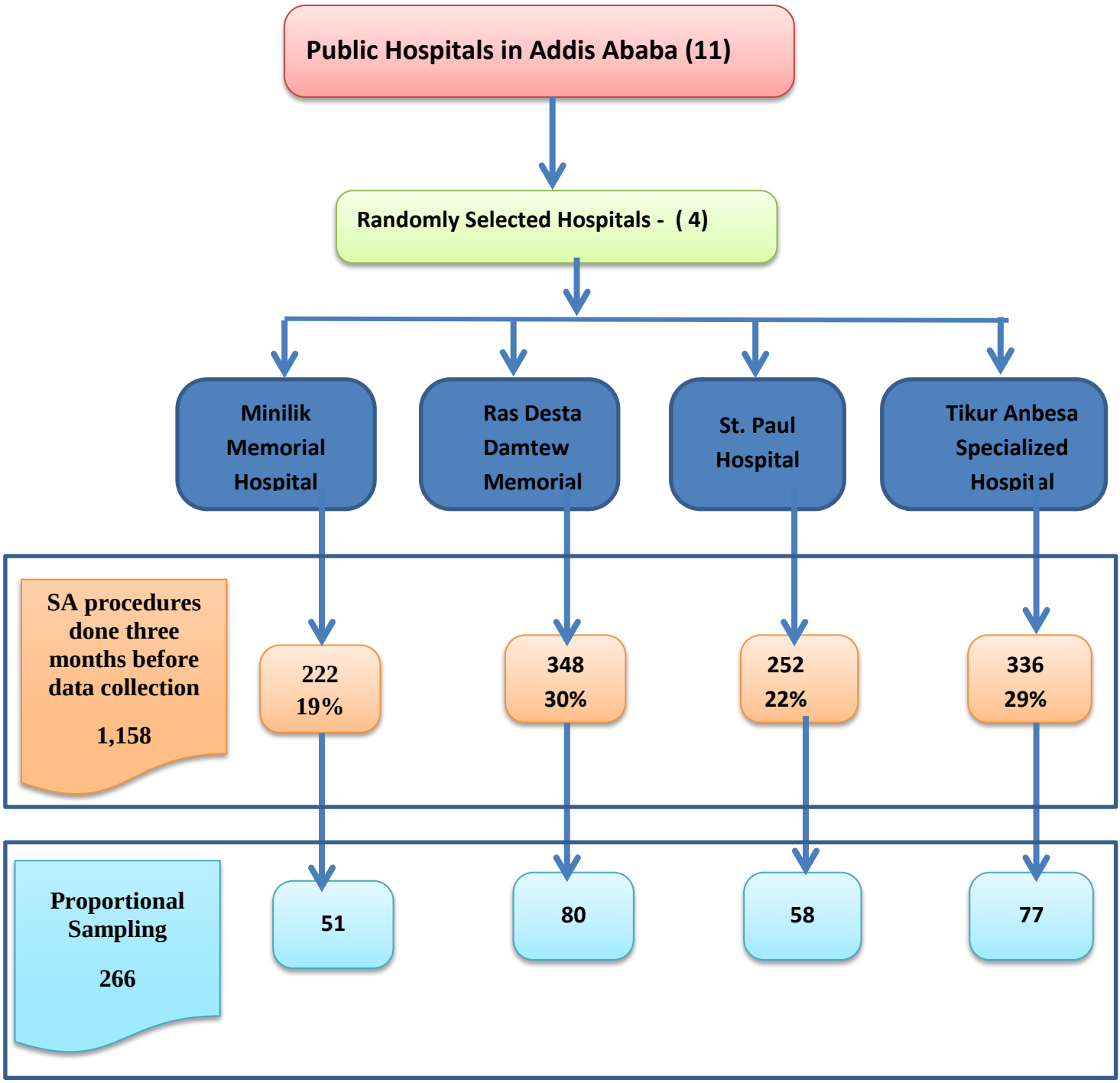

Figure 1 – Sample size allocation for selected hospitals

4.6. Study variables

4.6.1. Dependent Variables

- Failed spinal anesthesia

4.6.2. Independent variable

- Sex, Age
- Weight, height and BMI
- ASA status
- Surgery Type
- Number of attempt
- Position during procedure
- Palpability of spinous process
- Anatomical deformity of the spine
- Drug factor: LA Type, Dose, Baricity
- Level of education
- Experience of anesthesia providers
- CSF characteristics
- Needle size and type

4.7. Data collection tool and procedure

Data collection was done using structured and pretested questionnaire before actual data collection. The structured questionnaire was filled, by the data collector, using relevant information from the patient chart and direct observation of the procedure in the operation room. Data included in the questionnaire were demographic data (age, height, weight), BMI ,ASA Status, Spinal landmark (easily palpable spinous processes, poorly palpable spinous processes and unable to positively identify spinous processes), spinal anatomy (normal or deformed), needle gauge, status of the anesthetists (educational level and experience), number of attempts, patient position during the procedure and type of surgery (orthopedic surgery, urologic surgery, gynecologic surgery, general surgery, caesarian section)

4.8. Data Processing and Analysis

4.8.1. Data quality assurance

Before actual data collection, comprehensiveness, accuracy and clarity of questions were assessed by the investigator. Training and orientation about the objectives and relevance of the study, clarification on each items included in the study was given to data collectors. Completeness and consistency of data collected was checked on regular basis. Incomplete data were excluded.

4.8.2. Data entry and analysis

After the data has been collected, the questionnaire paper was checked manually for completeness and then it was coded, entered and analyzed using SPSS Version 24. Binary and multivariable logistic regression analysis was done to access significance of factors associated with failed spinal anesthesia. To check strength of association further those with p value less than 0.2 on univariate regression were fitted for multivariable analysis. At 95% confidence interval a p-value of less than 0.05 was considered as statistically significant. Hosmer –Lemeshow test was used to check fitness of the model. Both crude and adjusted odds ratio were calculated to show strength of association.

4.9. Operational Definitions

For better understanding of the study, the following terms ae defined in the context of this research.

- **Adequate block**. Condition where the planned surgery can be conducted after sensory and motor block checked with out pain and discomfort**.**
- **Bloody CSF** - where the color of the CSF is blood tinged.
- **Bromage scale** . an accepted tool to assess the intensity of motor block of lower extremity.
- **Clear CSF**– where the color of the CSF is colorless
- **Easily palpable sp** – where the spinous process can be touched, felt

- **Failed Spinal anesthesia**. Refers to either inadequacy of the administered spinal anesthesia to commence the intended surgery or repeating the block after the failure.

- **Adult. –**refers to age equal or greater than 18 years old
- **Poorly palpable sp** – where the spinous process can felt but with difficulty
- **Position**. Refers to patient position during performing the spinal anesthesia.
- **Non palpable sp** – where the spinous process can felt but with difficulty

4.10. Ethical Consideration

Following the research approval, Ethical clearance was obtained from the university with a copy to the selected public hospitals. Data was collected with verbal informed consent from respondent. Confidentiality was maintained at all levels of the study.

4.11. Dissemination of findings

The final report of the study will be submitted to Addis Ababa University, School of Medicine Department of anesthesia, to the study hospitals, to Addis Ababa Health Bureau and to Federal Ministry of Health. The result will be presented on workshops, conferences and seminars, efforts will be made to publish the findings of the study on journals and scientific publications.

CHAPTER - FIVE

5. RESULTS

5.1. Socio-demographic Characteristics of Patients

The study population included 266 adult scheduled for elective surgery who underwent spinal anesthesia, among these 135 (51%) are females and 130 (49 %) are males. The youngest age is 18 and the oldest age is 79 with a range 61. The mean age and the standard deviation are 41.66 and 16.578 respectively. Majority of the patients (59%) were under 45 years old. The number of obese patients BMI > 30 was 2.3 %.(Table 1).

Table-1. Socio-demographic characteristics of adults underwent elective surgery under spinal anesthesia

Variable	Category	Frequency (n)	Percent (%)
Gender	Female	130	50.6%
	Male	127	49.4%
	Total	257	100.0%
	Missing	9	3.4
	Total	257	100.0%
Age (years)	18 -29	80	31.1%
	30 -44	72	28.0%
	45 -59	50	19.5%
	≥60	55	21.4%
	Total	257	100.0%
	Missing	9	3.4
	Total	257	100.0%
Height in meter	1.45 - 1.59	46	17.9%
	1.60 - 1.74	174	67.7%
	1.75 - 1.84	37	14.4%
	Total	257	100.0%
	Missing	9	3.4
	Total	266	100.0
BMI (kg/m2)	< 18.5	6	2.3%
	18.5 - 24.9	184	71.6%
	25.0 - 29.9	61	23.7%
	≥30.0	6	2.3%
	Total	257	100.0%
	Missing	9	3.4
	Total	257	100.0%

BMI - Body mass index

5.2. Patient Characteristics and Technical Related Factors

From all the patients, about 60% are ASA II while 37% are ASA I. During the study period, 64.3% of the spinal anesthesia was provided by BSc anesthetist and 14.7% is provided by BSc anesthesia student. The majority (60.2%) spinal anesthesia provided were done by anesthesia providers with experience of two to five years. With respect to position during the procedure, 98.9% were done in a sitting position. In terms of palpability of spinous process, 83.1% was easily palpable while 16.2% and 0.8% are poorly palpable and non-palpable respectively.

Table 2 Patient characteristics and technical related factors

Characteristic	Category	Number (n)	Percent (%)
Patient Related			
ASA Classification	Class – I	99	37.2
	Class – II	160	60.2
Deformity of the spine	No	251	96.9
	Yes	8	3.1
Anesthesia Providers Related			
Level of education	Anesthesiologist	1	4
	anesthesiology resident	9	3.5
	MSc anesthetist	28	10.8
	MSc anesthesia student	12	4.6
	BSc anesthetist	171	66.0
	BSc anesthesia student	38	14.7
Experience	Less than two years	57	22.0
	Two to five years	156	60.2
	>5 Years	46	17.8
Technique related			
position during the procedure	sitting position	256	98.8
	Lateral position	3	1.2
Palpability of spinous process	Easily palpable	212	81.9
	poorly palpable	45	17.4
	Non-palpable	2	0.8
Site of puncture	L2 - L3	13	5.0
	L3-L4	232	89.6
	L4-L5	14	5.4

Characteristic	Category	Number (n)	Percent (%)
Needle size	18 gauge	2	.8
	21 gauge	13	5.0
	22 gauge	87	33.6
	23 gauge	76	29.3
	24 gauge	60	23.2
	25 gauge	12	4.6
	26 gauge	9	3.5
Skin infiltration before attempt	Yes	71	27.4
	No	188	72.6
sensory level assessed using	Light touch	188	72.6
	Pinprick	37	14.3
	Not assessed	34	13.1
	Total	257	100.0

5.3. Frequency of success and failure among surgical procedures

From the surgical procedures during this study period, urologic, caesarian section, orthopedic surgery, general surgeries and Gynecologic surgery accounts for 27.2%, 28.0%, 19.1%, 18.3% and 7.4% respectively. Among these, failure was highest in Orthopedic Surgery and Caesarian Section with a failure rate of 28.9% and 28.6% respectively.

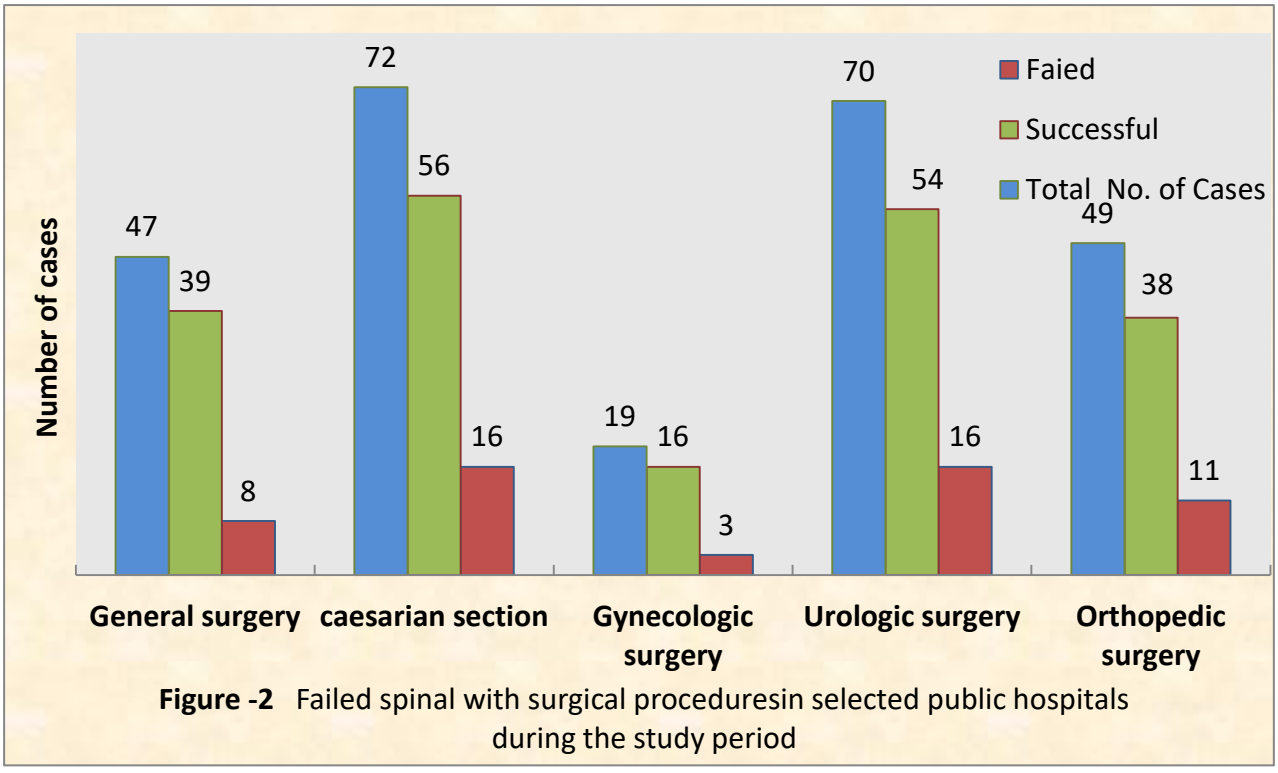

Figure -2 Failed spinal with surgical proceduresin selected public hospitals during the study period

5.4. CSF characteristics during spinal anesthesia procedure

During spinal anesthesia procedure, the appearance of clear CSF accounts 82.7% whereas bloody CSF and dry tap were 15.4% and 1.9% respectively.

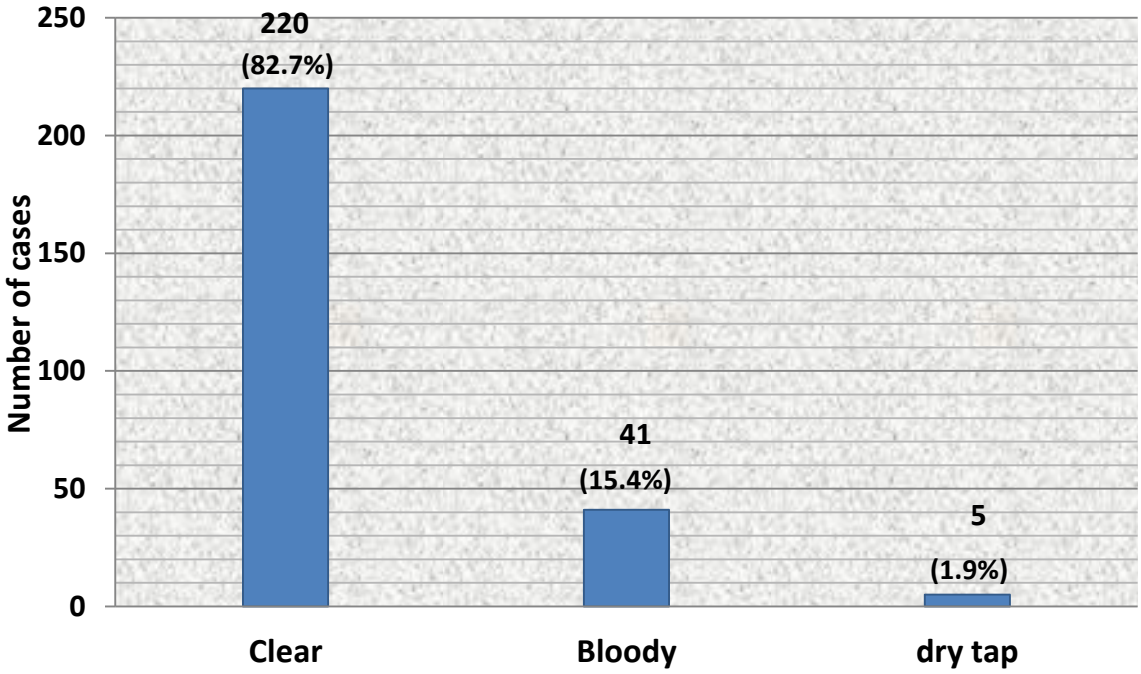

Figure 3 - CSF characterstic during spinal procedures at selected public hospitals from January 31st to April 30th, 2021

5.5. - Number of attempts during spinal procedures

During the study period, about 56% of the anesthesia providers had made more than two the dural puncture attempts while about 44% made less than or equal to two attempts.

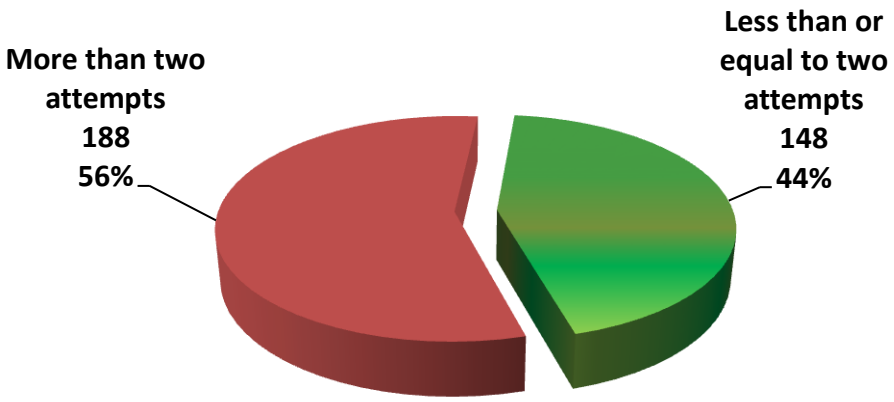

Figure 4 - Number of attempts during spinal procedures at selected public hospitals from January 31st to April 30th, 2021

5.6. Local Anesthetic Drugs Used

Drug used during the study period was only Bupivacaine 0.5%. Among the total cases, about two third (67.3%) of patients had been given 3.0 ml of 0.5% Bupivacaine. In terms of baricity 94.4 % was hyperbaric and 5.3%was isobaric (table 3)

Table 3 - Local Anesthetic Drugs by Type ,Dose and Baricity.

Characteristic	Category	number (n)	Percent (%)
Local Anesthetic Drugs			
Type	Bupivacaine 0.5%	266	100.0
Dose in ml	2.0	2	.8
	2.5	56	21.1
	3.0	179	67.3
	3.5	12	4.5
	4.0	16	6.0
	Total	265	99.6
Baricity	Hyperbaric	251	94.4
	Isobaric	14	5.3
	Total	266	100.0

5.7. Sensory Block Assessment after Spinal Anesthesia

During the study period, for about 72.9% of the patients, sensory block assessment were made using light touch method while for about 12.8% of the patients a pin prick method was used. The rest (14.3%) were assessed using an indirect method, by a skin pinch at the site of surgery.

5.8. Incidence of Failed Spinal Anesthesia

From the total spinal anesthesia administered during the study period the incidence of failed spinal anesthesia was 54/257 (21.01%).

Concerning failure type, majority failure was partial failure 38(70.4%) was partial failed spinal anesthesia while 16(29%) was complete failed. Failure management was by conversion to GA for 136(52.5%) of patients ,IV supplement for 81(31%) of patients and repeating the block 42(16.2).

Figure -5 Incidence of failed spinal anesthesia in selected public hospitals during the study period

5.9. Factors associated with failed spinal anesthesia

Since the predictor/independent variables are a mix of continuous and categorical variables, to measure the average relationship between the dependent variable i.e. failed spinal anesthesia and the associated factors, logistic regression model used for the research analysis.

Factors associated with failed anesthesia was analyzed using binary logistic regression model and further the significance of the predicting factors were checked using multivariate logistic regression and are reported in Table 5. Fitness of the model is assessed using Hosmer-lemeshow goodness-of- fit test.

5.9.1. Result of Binary Logistic Regression

The univariate analysis demonstrated that factors with p value < 2 are the following factors. Experience of anesthesia provider of service years less than 2 years, bloody CSF and number of spinal attempt greater than two were fitted for multivariable regression. In this study, Age, height, weight, BMI, ASA classification, procedure, level of education, position during the procedure, palpability of spinous anatomy, site of puncture, needle size, skin infiltration, and baricity were not fitted for multiple regression model.

Table - 4 Binary Logistic Regression analysis showing factors associated for failed spinal anesthesia

Variable		Failed spinal anesthesia				COR	95% C.I.for Exp(B)		P Value
		Yes(n)	%	Yes(n)	%		Lower	Upper	
Experience of Anesthesia Provider -Years	≤ 2	30	36.6%	52	63.4%	3.630	1.948	6.764	**0.000049**
	>2	24	13.7%	151	86.3%	1			
CSF characteristics	Bloody	26	37.7%	43	62.3%	3.445	1.838	6.495	**0.000118**
	Clear	28	14.9%	160	85.1%	1			
Number of attempt	>2	38	32.8%	78	67.2%	3.806	1.989	7.283	**0.000054**
	≤ 2	16	11.3%	125	88.7%	1			
Age of patients	18 – 29	15	18.8%	65	81.3%	1.209	0.516	2.833	0.662
	30 – 44	18	25.0%	54	75.0%	0.837	0.364	1.926	0.676
	45 – 59	9	18.0%	41	82.0%	1.271	0.485	3.335	0.626
	≥ 60	12	21.8%	43	78.2%	1			
ASA Classification	ASA I	23	23.2%	76	76.8%	1			
	ASA II	31	19.6%	127	80.4%	0.807	0.438	1.484	0490
BMI	< 18.5	2	33.3%	4	66.4%	1			
	18.5 - 24.9	42	22.8%	142	77.2%	1.000	0.091	11.028	1.000
	25.0 - 29.9	8	13.1%	53	86.9%	1.690	0.299	9.554	0.552
	>=30.0	2	33.3%	4	66.7%	3.312	0.519	21.131	0.205
Baricity	Isobaric	4	25.0%	12	75.0%	1.273	0.394	4.118	0.687
	Hyperbaric	50	20.7%	191	79.3%	1			
Local anesthetics dose	≤3.ml	48	20.9%	182	79.1%	0.923	0.353	2.414	0.870
	> 3ml	6	22.2%	21	77.8	1			
Site of lumbar puncture	L2-L3	3	27.3	8	72.7%	1			
	L3-L4	50	21.6	182	78.4%	0.205	0.018	2.327	0.201
	L4-L5	1	7.1%	13	92.9%	0.280	0.36	2.192	0.225

5.9.2. Multivariate analysis showing factors associated

Multivariable analysis shows that spinal anesthesia administered by an anesthesia provider who had < 2 year of experience was three times more likely to fail compared with Spinal anesthesia administered by an anesthesia provider who had experience of 2< year (AOR, 3.556, 95% CI; 1.832 – 6.905).Appearance bloody CSF is about three times more likely to indicate failure compared with clear CSF (AOR,2.738,95%CI; 1.365-5.491), .Anesthesia providers who attempt more than two times are two times more likely to fail than attempted less than two times (AOR, 2.919, 95% CI; 1.458 –5.846).

Table 5 Multivariate analysis showing factors associated for failed spinal anesthesia

Variable		Failed spinal anesthesia				COR	AOR	95% C.I.for Exp(B)		P Value
		Yes(n)	%	No(n)	%			Lower	Upper	
Experience of Anesthesia Provider - Years	≤ 2	30	36.6%	52	63.4%	3.630	3.556	1.832	6.905	0.000179
	>2	24	13.7%	151	86.3%					
CSF characteristics	Bloody	26	37.7%	43	62.3%	3.445	2.738	1.365	5.491	0.005
	clear/ dry tap	28	14.9%	160	85.1%					
Number of attempt	>2	38	32.8%	78	67.2%	3.806	2.919	1.458	5.846	0.002
	≤ 2	16	11.3%	125	88.7%					

COR – Crude odd ratio CI - Confidence interval AOR – Adjusted odd ratio

Chapter - Six

6. Discussion

The overall spinal anesthesia failure rate in this study was 21.01%. A result of this study when compared with the findings of previous similar and related studies is on the high side. A thorough look at the results of previous studies showed that, for most of the studies, the incidence of failed spinal anesthesia was between 1% and 17% (9)(10). Compared to the result reported by Colish, Jane, et al (2020) 3.8% , Fuzier et al., (2011) 3.2 % and Kinsella SM (2008) 6%, our result is significantly high and the possible cause might be due to the fact that this study was done in teaching hospital where anesthesia students' performance were considered. According to this study, spinal procedures performed by anesthesia students and year of experience less than two years which is significant factor for failure of spinal anesthesia accounts 19.6% and 21.8 respectively.

Other factor reported significant in the study by Fuzier et al., (2011) reported that the absence of the use of an adjuvant medication with the local anesthetic injected is a predictor for failed spinal anesthesia (9). In our study period, the supply of adjuvant was scarce. This might be one of the contributing factors for the failure because administration of adjuvants during the procedures put the patient at ease and give a better chance for the anesthesia providers to expedite comfortably.

Descriptive result of this study shows that orthopedic and obstetrics surgeries were with highest failure rate, 23.5% and 23.0% respectively. This might be due to the gravid uterus in parturient and the pain in orthopedic patients makes optimal positioning difficult .The reported figures in these procedures, goes in line with the reports of other studies. Gill et al., (2020) pointed out that, orthopedic patients are group of patients with frequent failures due to the fact that these patients' calcified tissue complicates the procedure (18). Similarly, Yüksek et al., (2020) discussed that failures in obstetric surgeries was common, the reason for SA failure was recorded as not being able to provide adequate analgesia for surgery after a successful dural puncture (10).In addition this result was expected in these surgical group due to the gravid uterus in parturient and the pain in orthopedic patients makes optimal positioning difficult

In this study factors associated with failed spinal anesthesia was bloody CSF, repeated attempt greater than two and experience of anesthesia providers are found significant.

Based on the result of this study, an appearance of bloody in the CSF increases the probability of failure by thirteen times (AOR=2.738; 95% CI=1.365-5.491). Some of the studies that reported that bloody CSF as a predictor for FSA were Alabi et al., (2017) , Ashagrie HE et al (2019). Bloody CSF might be due to the fact that the widely used type of spinal needle in this study group were, quincke type cutting needle which is traumatic. We also agree with the idea of Alabi et al., (2017) notify that inaccurate placement of spinal needle into blood vessel would significantly contribute for the likelihood of block failure (13) .

The second finding of this study, is that an attempt of more than two times, would contribute to failed spinal, (AOR=2.919, 95% CI =1.458 –5.846) This corresponds to the study result obtained by Fuzier R et al (2011), Alabi AA et (2017), and Rukewe et el (2015). This might be due to inability to successfully access the subarachnoid space because of poor patient positioning, incorrect needle placement or poorly palpable of interspinous space which in turn might be related to operator skill.

The other finding is that the anesthesia providers who had experience of less than two year were three times more likely to result in failure. This result is consistent with the findings of others studies results of Alabi et al (2017) and Ashagrie, H. E. (2020). In this regard, experience play a major role in all aspect of the procedure including, drug selection, optimum positioning of patients during and after spinal anesthesia procedure, appropriate judgment to prevent or rescue failure. Regardless of experience, Andrian Chin and Andre van Zundert, suggest that the conventional palpation of surface anatomy has been shown unreliable and suggests the use of ultrasound.(25)

Besides the fact that, skill is gained through practice, most literatures suggest that, a significant part of the spinal failure is due to failure of judgement such as a hasty conclusion. Since, the study area includes teaching hospitals, 19.6% of the total cases being performed by under graduates may have impact in increasing the number of failures.(19)

The analysis of this study reveals that BMI, needle size, baricity and site of lumbar puncture were not significant predictors of FSA. These results were reported as predictors in other researchers result.In this study age of patient was not predictor factor for FSA.However,Colish et al (2020),Ek Aavang et al(2018) and Fuzier et al(2011) reported that younger age is significantly associated with FSA .On the other hand a study by Ruzman et al(2014) reported that first attempt success was associated with young age .BMI in this study was not associated

with failure. Kim et al., (2015) reported, the influence of BMI on spinal anesthesia is still controversial (26). With respect to baricity and patient positioning, 94.4% were hyperbaric and 98.9% of the cases were done in a sitting position. Therefore in such situation where the variability with in independent variables became very large, it would be difficult to generalize based on the result.

From the above short review, we observe that, there are some similarity at one end and disparity and even contradictory finding on the others. Just because of the difference on both on technical settings and other relevant parameters, the observed variation may be expected.

Limitation

- Since the study involves all surgical patients, it lacks generalizability due to small sample size for each surgical procedure.
- Difficult to analyze sensory and motor block objectively using Bromage and Hallmen score because most practitioners' assesse block based on subjective judgment.

Strength

- It is a multicenter study.
- As far as known, this is the first study that tries to find out the incidence of failed spinal anesthesia encompassing all surgical procedures.

Chapter - Seven

7. Conclusion and Recommendations

7.1. Conclusion

The results of this study reveal that, the incidence of failed spinal anesthesia compared to the results of previous studies is high. The reason for this might be due to the fact that the study is done in teaching centers. The second reason might be the operational definition of the study that repeating the block is considered as failure .In addition, during the study period there were lack of adjuvant drugs such as opioid which may help to decrease latency and increase quality of block.

7.2. Recommendation

- A number of similar studies and systemic review has to be made in order to have a more comprehensive understanding and better management.
- Prospective cohort study is needed.
- The anesthesia providers need to be aware of the high incidence so that they should make the best possible effort to prevent unsuccessful spinal anesthesia by careful technique at each step of the procedures.
- Drug supply like adjuvant should be easily accessible to minimize patient suffering due spinal anesthesia failure.

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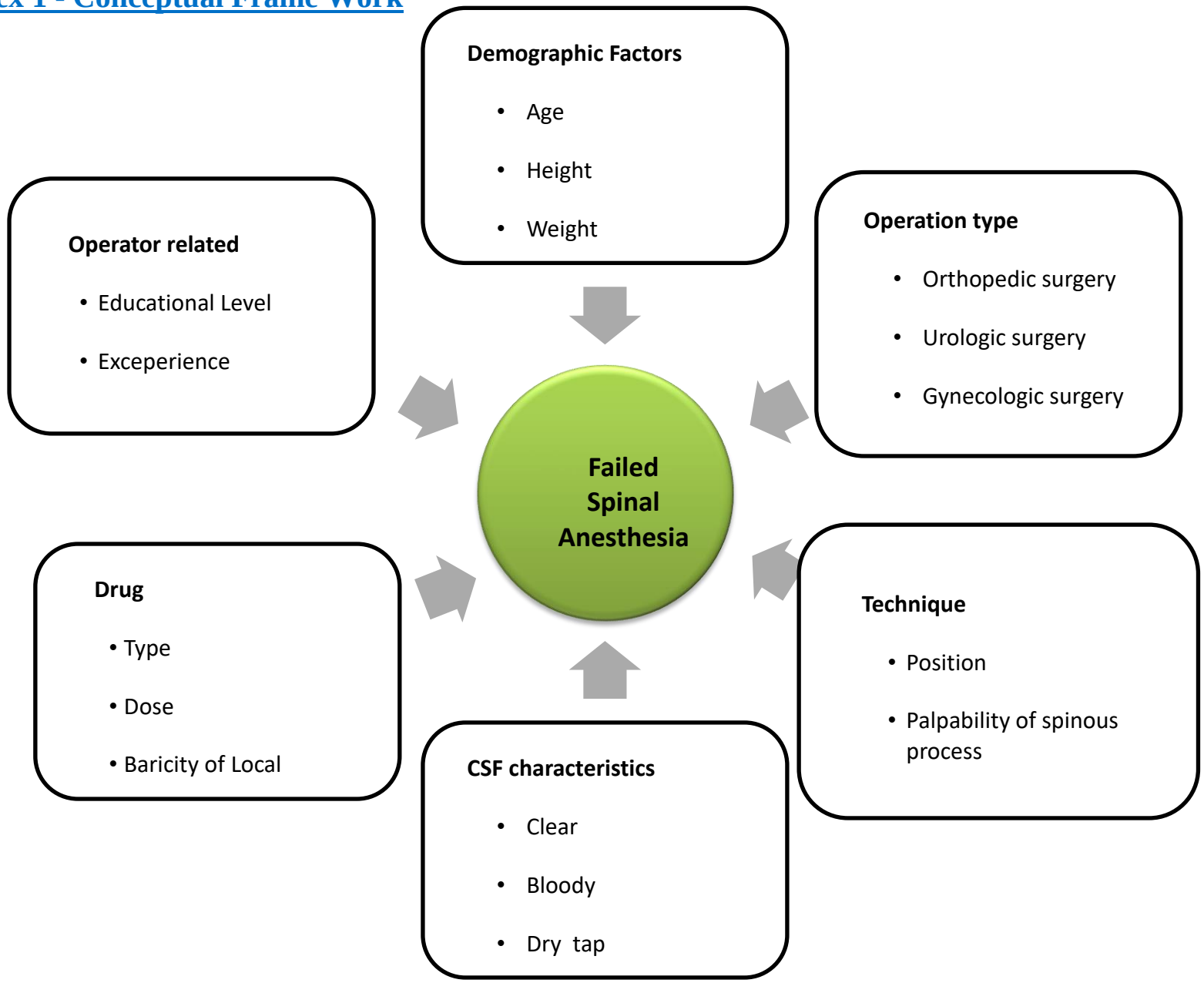
Annexes

Annex 1 - Conceptual Frame Work



Annex - 2 Informed Consent Form

Addis Ababa University

College of Health Sciences

School of Medicine Department of Anesthesia

Welcome to My Survey ,
I am _____ data collector for the study.

Thank you for participating in this survey. Your feedback is important. Please answer the following questions as honestly as possible. These questions concern about failed spinal anesthesia.

The purpose of this survey is to help the researcher measure incidence and associated factors of failed spinal anesthesia.

I do not anticipate that taking this survey will contain any risk or inconvenience to you. Furthermore, your participation is strictly voluntary and you may withdraw your participation at any time without penalty.

All information collected will be used only for my research and will be kept confidential. There will be no connection to you specifically in the results or in future publication of the results. If you have any questions please ask investigator:

Thank you for taking part in the survey!

Signature of the observer _____ Date _____

For further questions
Investigator :- Ribka Tsegaye
Tell:- 0911 67 98 14

Annex - 3 Survey Questionnaire

Research Questionnaire

Principal Investigator:- Ribka Tsegaye (MSc Student)
Advisors: 1. Adugna Aregawi (Assistant Professor)
2. Zewotir Ashebir (Bsc , Msc Anesthesia)

Study Title: Incidence and associated factors of failed spinal anesthesia on adults undergoing elective surgery in selected governmental hospitals at Addis Ababa, Ethiopia

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Part I :- Patient Information

Card Number : _____

Age in years : _____

Sex : **Height in cm** _____

Male ☐ Female ☐

weight in kg : _____ **BMI** : _____

Part II :- Clinical Status

ASA Classification :-

ASA I ☐ ASA III ☐

ASA II ☐ ASA IV ☐

Part III :- Operation type

Orthopedic surgery ☐ Caesarian Section ☐

Urologic surgery ☐ General surgery ☐

Gynecologic surgery ☐

Part IV :- Level of Education and experience

i. Status of Anesthetist

a) BSc Student ☐

b) BSc Anesthetist ☐

c) MSc Anesthesia student ☐

d) MSc Anesthetist ☐

e) Anesthesiology Resident ☐

f) Anesthesiologist ☐

ii. Experience

a) Less than two years

b) Two to five years

c) Greater than 5 years

Part V :- Technique

i. Position

Sitting Position ☐

Lateral Position ☐

ii. Palpability of spinous process

Easily palpable ☐

Poorly palpable ☐

Non-palpable ☐

iii. Site of lumbar puncture:

L_2 - L_3 ☐ L_2 - L_3 ☐ **L4 – L5** ☐

iv. Spinal anatomy

Normal ☐

Deformed ☐

v. Needle size _____ guage

vi. Is initial intradermal local anesthesia **infiltration** performed before attempt?

Yes ☐ No ☐

Part V :- CSF characteristics

Clear ☐ Dry tap ☐

Bloody ☐

Part VI :- LA Drug

Dose

Bupuvacaine (0.5%) _____ ml

Lidocaine (5%) _____ ml

Lidocaine (7.5%) _____ ml

Adjuvant , if yes, specify _____

Baricity

Hyper baric ☐ Hypobaric ☐

Isobaric ☐

vii. Number of spinal attempts

1 Attempt ☐

2 Attempt ☐

> 2 Attempt ☐

viii. Sensory level assessed using

Temperature sensation ☐

Light touch ☐

Pin prick ☐

Not assessed ☐

ix. Sensory block using a modified Hollmen scale

Grade 1 = full sensation ☐

Grade 2 = weak sensation ☐

Grade 3 = Recognized as light touch ☐

Grade 4 = Loss of sensation ☐

x. Degree of Motor blockade based on the Bromage scale ;

1=unable to move feet or knees

2= able to move feet only

3=just able to move knees

4=full flexion of knee and feet).

xi. Was the spinal block adequate for surgery?

Yes ☐

No ☐

xii. If the answer is No for the above question, is it ;

Partial failure? ☐

Complete failure? ☐