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BAHIR DAR UNIVERSITY COLLEGE OF MEDICINE AND HEALTH SCIENCE DEPARTMENT OF PEDIATRICS AND CHILD HEALTH

Success Rate Of Lumbar Puncture And Associated Factors Among The Procedures Done For Diagnosis Of Meningitis In Under Five Children At Tibebe Ghion Comprehensive Specialized Hospital, Bahirdar, Ethiopia, 2024/2025

BY; Birtukan Mekete

(MD, PEDIATRICS AND CHILD HEALTH RESIDENT)

A THESIS TO BE SUBMITTED TO DEPARTMENT OF PEDIATRICS AND CHILD HEALTH, COLLEGE OF MEDICINE AND HEALTH SCIENCES, BAHIRDAR UNIVERSITY, IN PARTIAL FULFILLMENT OF THE REQUIREMENTS FOR SPECIALITY CERTIFICATE IN PEDIATRICS AND CHILD HEALTH

February

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BAHIRDAR UNIVERSITY, COLLEGE OF MEDICINE AND HEALTH SCIENCE, DEPARTMENT OF PEDIATRICS AND CHILD HEATH

SUCCESS RATE OF LUMBAR PUNCTURE AND ASSOCIATED FACTORS AMONG THE PROCEDURES DONE FOR MENINGITIS DIAGNOSIS FOR UNDER FIVE CHILDREN AT TIBEBE GHION COMPREHENSIVE SPECIALIZED HOSPITAL, BAHIRDAR, ETHIOPIA, 2024/25

Principal Investigator	**Dr. Birtukan Mekete (MD, Year III pediatrics and child health resident)** **Department of Pediatrics and Child Health** **College of Medicine and Health sciences** **Bahir Dar University** **Email: burtetat@gmail.com** **Tel: +251 909143385**
Advisors	**Dr. Mastewal Ambaw (MD, Assistant professor of pediatrics and child health)** **Department of Pediatrics and Child Health College of Medicine and Health sciences Bahir Dar University** **Email: mastewalambaw@gmail.com** **Tel: +251 910220530** **Gebiyaw Wudie (MPH, Asst. Professor in Epidemiology)** **Department of Epidemiology School of Public Health College Medicine and Health Science Bahir Dar University** **E-mail:fwudie@gmail.com** **Tel: +251920054599**

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Declaration

I hereby declare that the thesis entitled success rate of lumbar puncture and associated factors among the procedures done for meningitis diagnosis for under five children at Tibebe Ghion Comprehensive Specialized Hospital, Bahir Dar, Northwest Ethiopia, from June 2024 to February 2025 submitted in partial fulfillment of the requirements for the certificate of the specialty program in Pediatrics and Child Health, Department of Pediatrics, Bahir Dar University, represents an original work conducted by me. This thesis has not been previously submitted to this or any other institution for obtaining any other degrees or certificates. I acknowledge and sincerely appreciate the assistance and guidance I received during this investigation.

Principal Investigator: Birtukan Mekete, Signature: _____ Date: 03/08/17 E.C

BAHIR DAR UNIVERSITY, COLLEGE OF MEDICINE AND HEALTH SCIENCE, DEPARTMENT OF PEDIARTICS AND CHILD HEALTH

Approval for Thesis for Defense

This is to certify that I have duly supervised, read, and thoroughly evaluated the Thesis entitled "success rate and associated factors among the procedures done for meningitis diagnosis for under five children at Tibebe Ghion Comprehensive Specialized Hospital, Amhara Region, Ethiopia," authored by Dr. Birtukan Mekete.

Having reviewed the proposal, I find it comprehensive and well-prepared for scholarly examination. Dr. Birtukan Mekete has demonstrated a clear understanding of the subject matter and has applied rigorous research methods to address the research questions. The Thesis meets the standards required for a thesis to be submitted for oral defense.

I propose accepting Dr. Birtukan Mekete's thesis for oral defense as she has fulfilled the required criteria. The defense will offer a chance to delve into the depth and breadth of her research, fostering scholarly discourse and constructive feedback.

Advisor's Name	Advisor's Signature:	Date: 02/08/17 E.C
Dr. *Mastewal Ambaw*		
Gebiyaw Wudie		



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I extend my sincere gratitude to the Department of Pediatrics and Child Health, College of Medicine and Health Sciences, Bahir-Dar University, for providing me with the opportunity to undertake this research.

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Abstract

Background: Lumbar puncture is a critical procedure for diagnosing meningitis in children, as cerebrospinal fluid analysis speaks much about presence or absence of infection. A successful LP aids diagnosis and management, while failed attempts lead to empirical treatment, prolonged hospital stays, and unnecessary antibiotic exposure. No prior research has been conducted on LP success rates in this setting or country, and limited studies exist across the continent. Physicians choose the patient's position during LP subjectively, though positioning may influence success.

Objective: This study assessed lumbar puncture success rates and associated factors in diagnosing meningitis in under-five patients at Tibebe Ghion Specialized Hospital from June 2024 to February 2025.

Methods: A cross-sectional study was conducted among randomly selected under-five patients undergoing LP. Data were collected systematically from pediatric, neonatal, and emergency wards using a checklist, either in person or via phone call, after laboratory results were obtained. Collection occurred every other day over six months. Data were analyzed using SPSS version 27, binary logistic regression used to identify factors associated with LP success ($P < 0.05$)

Results: The overall, lumbar puncture success was 69.6%, with age, positioning, and provider experience being key factors. Among 204 LP procedures, 54.4% were performed by R2s, who also assisted in 45.6% of cases. The sitting position had a higher success rate (88.9%) compared to the recombinant position (56.9%). Age influenced success, with the highest failure rate in infants aged 0-3 months (38.8%) and the highest success in children aged 12-60 months (82.1%). Success rates declined with repeated attempts: 74.2% on the first, 53.1% on the second, and 44.4% on the third.

Conclusion: LP success in under five children is influenced by age, provider experience, and patient positioning. Younger infants had the highest failure rates, while older children had the highest success. Senior providers outperformed junior residents, and repeated attempts reduced success. The sitting position was associated with more successful lumbar punctures than the recombinant position. Optimizing provider training, patient positioning, and minimizing repeat attempts can improve LP outcomes. Further research should refine best practices and standardize guidelines.

Key terms; Meningitis, Successful lumbar puncture, failed lumbar puncture, lying position, Sitting position

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List of Acronyms

- AOR……. Adjusted Odds Ratio
- CI……...Confidence Interval
- CSF…… Cerebrospinal Fluid
- CMHS……. College of Medicine and Health Science
- COR……. Crude Odd Ratio
- ETAT……...Emergency Triage Assessment and Treatment
- HIV……. Human Immune Virus
- L……. Lumbar
- LP……... Lumbar Puncture
- MRN……Medical Record Number
- PO……. Per Ous
- PI……. Principal Investigator
- RBC……. Red Blood Cell
- SPSS……Statistical Package for Social Science
- TGCSH…....Tibebe Ghion Comprehensive Specialized Hospital
- TLP……. Traumatic Lumbar Puncture
- UK……United Kingdom
- USA……...United States of America
- WBC……White Blood Cell

1. Introduction

1.1. Background

Meningitis is a condition characterized by inflammation of the meninges, the protective membranes surrounding the brain and spinal cord. Patients present with symptoms such as headache, irritability, varying degrees of reduced mental clarity, fever, or seizures.

Bacterial meningitis in under-five year old children is a significant public health problem with about 50% case fatality rate in untreated cases. Despite the availability of effective prophylaxis, and treatment, 8–15% of affected children die within 24– 48 h of the onset of symptoms. Early diagnosis, and treatment are essential to prevent long-term neurological sequelae such as brain damage, hearing loss, and learning disabilities, which are seen in 10–20% of survivors, necessitating prolonged out of hospital care, and financial burden on the families(1)**.**

Lumbar puncture is among the diagnostic procedures for the diagnosis of LP that is often performed in the emergency department to obtain information about the cerebrospinal fluid (CSF), fluid produced by the choroid plexus in the lateral, third, and fourth ventricles and circulates through the subarachnoid space between the arachnoid mater and the pia mater(2). Examination of the cerebrospinal fluid (CSF) is essential in confirming the diagnosis of meningitis **(3)**.

During the procedure the patient should be situated in a lateral decubitus or seated position with the neck and legs flexed to enlarge the intervertebral spaces. Once the patient is situated, the physician identifies the appropriate interspace by drawing an imaginary line from the iliac crest downward perpendicular to the vertebral column. Lumbar punctures are usually performed in the L3- L4 or L4-L5 interspaces, by using a 23-gauge needle after disinfection. If the obtained CSF is bloody, the physician removes the needle and performs the procedure again at another lumbar interspace. In this situation, the clinician or nurse notes in the medical records that the CSF was bloody.
If the obtained CSF is macroscopically non-traumatic or contains just a little blood, it is sent to a laboratory for a cell count and culture. If it contains a small amount of blood, the RBC is counted to correct the number of white blood cells (WBC) in the CSF using the peripheral RBC to WBC ratio, and the laboratory technician records the results in the laboratory records. If non-traumatic CSF is unable to be obtained after repeated three attempts, the procedure is discontinued(3, 4).

Lumbar punctures are occasionally complicated by what is referred to as a ‘‘traumatic tap’’, a descriptive term for RBCs introduced into the CSF as a result of needle trauma. Blood may be introduced in the CSF at many points during an LP procedure, as the needle must pass through many layers of vascular tissue to reach the subarachnoid space. Traumatic taps may lead to difficulty to diagnose meningitis, false-positive diagnoses of SAH or other cerebral vascular malformations(5).

Normal CSF is clear, colorless and contains up to 5/mm3 white blood cells, and a newborn can have as many as 15/mm3. Polymorphonuclear cells are always abnormal in a child, but 1-2/mm3 may be present in a normal neonate. An elevated polymorphonuclear count suggests bacterial meningitis(3). It is also devoid of RBCs (red blood cells). A turbid CSF contains more than 200 WBCs/dl or 400 RBCs/dl, whereas a grossly traumatic CSF contains 6000 RBCs/dl(6).
If a traumatic lumbar puncture is suspected and the peripheral WBC count is not abnormally low or high, a good rule of thumb for estimating the adjusted WBC count is to subtract 1 WBC for every 500 to 1500 RBCs measured in the CSF**(6)**.

1.2. Statement of the problem

Despite being a valuable diagnostic tool, lumbar puncture (LP) in children under five presents unique challenges due to anatomical variability, developmental considerations, and potential procedural difficulties. Understanding the success rate and identifying associated factors are crucial for optimizing patient care and minimizing risks in this vulnerable population(7).

Previous studies have reported rates of traumatic lumbar punctures ranging from 10% to 30%, influenced by factors such as the clinical setting, patient age, and the red blood cell (RBC) count threshold applied. Such bleeding can create diagnostic uncertainty, potentially leading to unnecessary antibiotic administration and hospitalization, especially in young infants. Moreover, a traumatic or unsuccessful lumbar puncture may result in the patient experiencing the discomfort of multiple attempts.**(8)**.

In addition to mortality, meningitis can result in long-term sequelae such as cognitive impairment, hearing loss, motor weakness or paralysis, incoordination, and epilepsy**(9, 10)**.

And Ethiopia is one of the countries in the ”meningeal belt”, which has the highest incidence of meningitis**(11)**. The prevalence of neonatal meningitis among suspected sepsis was 19.3%; 95% CI [13.5%-25.1%]. The prevalence of meningitis was 22.8% in Early-Onset Neonatal Sepsis and 16.8% in Late-onset Neonatal Sepsis**(12)**. Due this significantly high prevalence of meningitis usually patients are over diagnosed for meningitis due to failed LPs.

Most cases of bacterial meningitis specially in resource limited countries, like Ethiopia, are treated only empirically, and cost of treatment is high. And there is also controversy about for how long antibiotic treatment should be given ranging from 10 days to 21 days**(11)**. Had it been simple infection 7 days of total antibiotics (including PO antibiotics) is generally adequate **(10).**

In a study done in 2018 on Cost of managing meningitis and encephalitis among infants and children in the United States, the mean hospitalization cost for infants and children was $12,759 and $11,119, respectively, a study in Ethiopia in 2022 estimates it as 3,593.2 US $(12,16).

To minimize the burden of meningitis and avoid unnecessary hospitalizations, the availability of successful diagnostic techniques is vitally important**(13)**. Lumbar punctures (LPs) are a common procedure in emergency medicine, while some studies have found that failed procedure rates can be as high as 50%, other studies specify such rate as low as 10% **(5, 14)**.

While infants with failed LP had similar rate of serious bacterial infection, it is found that they will had higher hospitalization rate compared with that of infants with successful LP(**15**).

Given the severity and impact of the illness, early intervention with accurate and timely diagnosis is crucial. Lumbar puncture and cerebrospinal fluid analysis remain the most essential diagnostic tools, although success rates have been reported to vary.**(5, 14)**. Therefore, knowing the success rate and factors affecting it is the pillar.

Current literature provides limited data on the success rates and factors influencing successful lumbar puncture (LP) procedures in this specific age group. This study seeks to fill this gap by examining the success rates of LP procedures in children under five years old and identifying the factors that contribute to either success or failure. Understanding these factors will help improve procedural outcomes, inform clinical guidelines, and enhance the overall quality of care for pediatric patients undergoing lumbar puncture.

1.3. Significance of the study

This study evaluates the success rate of diagnostic lumbar punctures performed on patients under five years old at TGSH and identifies the factors associated with success.

This study benefits stakeholders at multiple levels. For patients, it reduces discomfort and the risk of healthcare-associated infections (HAIs). At the hospital level, it supports the development of local protocols and helps reduce costs. On a global scale, its publication will serve as valuable evidence for future research.

1. Literature review

Success rates of lumbar puncture

A clinical study conducted at the Tokyo Metropolitan Children's Medical Center in Tokyo, Japan, examined the proportion of successful lumbar punctures in infants under three months old. Among 121 patients, 69% were classified in the successful LP group, while 29% were categorized in the traumatic LP group. Clear cerebrospinal fluid (CSF) was obtained on the first attempt in 60%, and CSF was collected in 88% regardless of red blood cell (RBC) presence or the number of attempts (16).

In a 10 years retrospective study published on May 1, 2019 at Queensland Children's Hospital, Queensland, Australia concluded that TLP can occur in approximately 20% of LPs(17).

In another local study in UK in 2023, at the Leeds children hospital, Outcomes for infants younger than 3 months undergoing LP were retrospectively analyzed over a period of 2 months, where 21 samples were taken. In total out of all documented procedures, there were 14 (52%) unsuccessful attempts, 6 (22%) traumatic samples and 7 (26%) successful samples obtained. The single important factor thought to be affecting the procedural success was good handling technique from the assistant (18).

A study done in Red Cross War Memorial Children's Hospital, Cape Town, South Africa in 2016, the prevalence of unsuccessful (traumatic or dry) was 32.3%(19).

Studies indicate that in much of Sub- Saharan Africa, LPs are performed less frequently than indicated. In a study done in Zambia, LPs were performed in 72% of adults and 33% of children with suspected meningitis among patients with HIV(20).

It is difficult to deal about the success rate because of lower procedural performance from different reasons. In an article by Zambia university, Zambia, 2022, LP uptake is a complex sociocultural process influenced by patient, healthcare and community-level factors. It mentions that LP enablers included patient/caregiver perceived LP utility, provider comfort with LP and in-person counselling, and concluded that Interventions to improve uptake must address multiple barriers to be successful(21).

Factors associated with lumbar puncture success

A 4 years' retrospective study in 2018 in Melbourne, Australia found that the conventional palpation guided lumbar puncture was to be successful in 72% and suggested that the success rate might be higher with ultrasound guided procedure(22).

A study done by Li et al at Department of Emergency Medicine, Shengling Hospital of China Medical University, China in 2022 found that ultrasound guided LP had shorter time to perform, fewer attempts, higher first LP success rate, lower risk of post procedural lower back pain and paresthesia (23).

A 10 years retrospective study done in 2019 in Queenland Children's Hospital, Australia, concluded that children under 12 months especially newborns are at a higher risk of TLP, with a peak after 8 pm. The reason behind this was explained to be because of infants were found to be calm in the morning due to the level of stress hormone, important for regulation of mood and alertness and physicians are energetic and likely to be less busy by the earlier time of the day (24).

In an article published by European Geriatric Medicine in 2023, most residents in geriatrics reported having received insufficient training during their second cycle of medical school and advocated for the need for additional LP lumbar puncture training. Simulation was associated with a significant gain in self-confidence. The post-training success rate of the residents in real-life clinical practice was good (85.8%) (25).

In a single retrospective study done in US in 2022 to evaluate Pediatric Resident LP success, although the study showed a stable proportion of success, further research is needed for a better conclusion (26).

Another retrospective study done in 2023 at Department of Medicine, University of Carolina, USA, found that the experience of trainees in the procedure was among the significant factor in the success of LP(27).Practically, senior residents are expected to have better techniques of the procedure than the juniors, so that in our setup usually when LP done by junior resident fails a senior resident will be called for the next repetition of the procedure.

In a study done at Neonatal Intensive Care Unit, Santa Maria Nuova Hospital, Reggio Emilia, Italy in 2021, aiming to evaluate safety and success rates of lumbar puncture (LP) and to identify factors associated with adverse events or failure of LP in infants with different birth weight and clinical stability (relatively stable or in severely distressed infants needing mechanical ventilation), failure of LP occurred in 38.2% of cases. But neither of the factors were associated with the findings (28).

Researchers from Oxford Population Health's National Perinatal Epidemiology Unit in 2022 have found that holding babies in a sitting position when carrying out a lumbar puncture was significantly more successful than a lying position. A first LP was achieved in 63.7% in the sitting group and 57.6%. In addition to that infants allocated to the sitting position were less likely to show moderate-to-severe struggling at needle insertion and their oxygen levels and heart rates were more stable when held in the sitting position (29).

A study done in UK, in 2022 on a majorly term new born to assess the position of lumbar puncture for success showed that success rates were improved when sitting rather than lying. And sitting LP is safe, cost neutral, and well tolerated (30).

While other studies done more recently speaks different.

A retrospective study done in USA, and UK hospitals in 2022 on success rates of lumbar puncture positions in infants < 3 months of age found no evidence that there is a difference in rate of LP success nor the proportion of traumatic LP the sitting position compared to the lateral decubitus position (31).

In a systematic review conducted in January 2023, from different trials in different parts of the world (USA, China, Spain, and the UK) found that compared to sitting position, lateral decubitus position may result in little to no difference in successful LP procedure at the first attempt (32).

3. Conceptual frame work

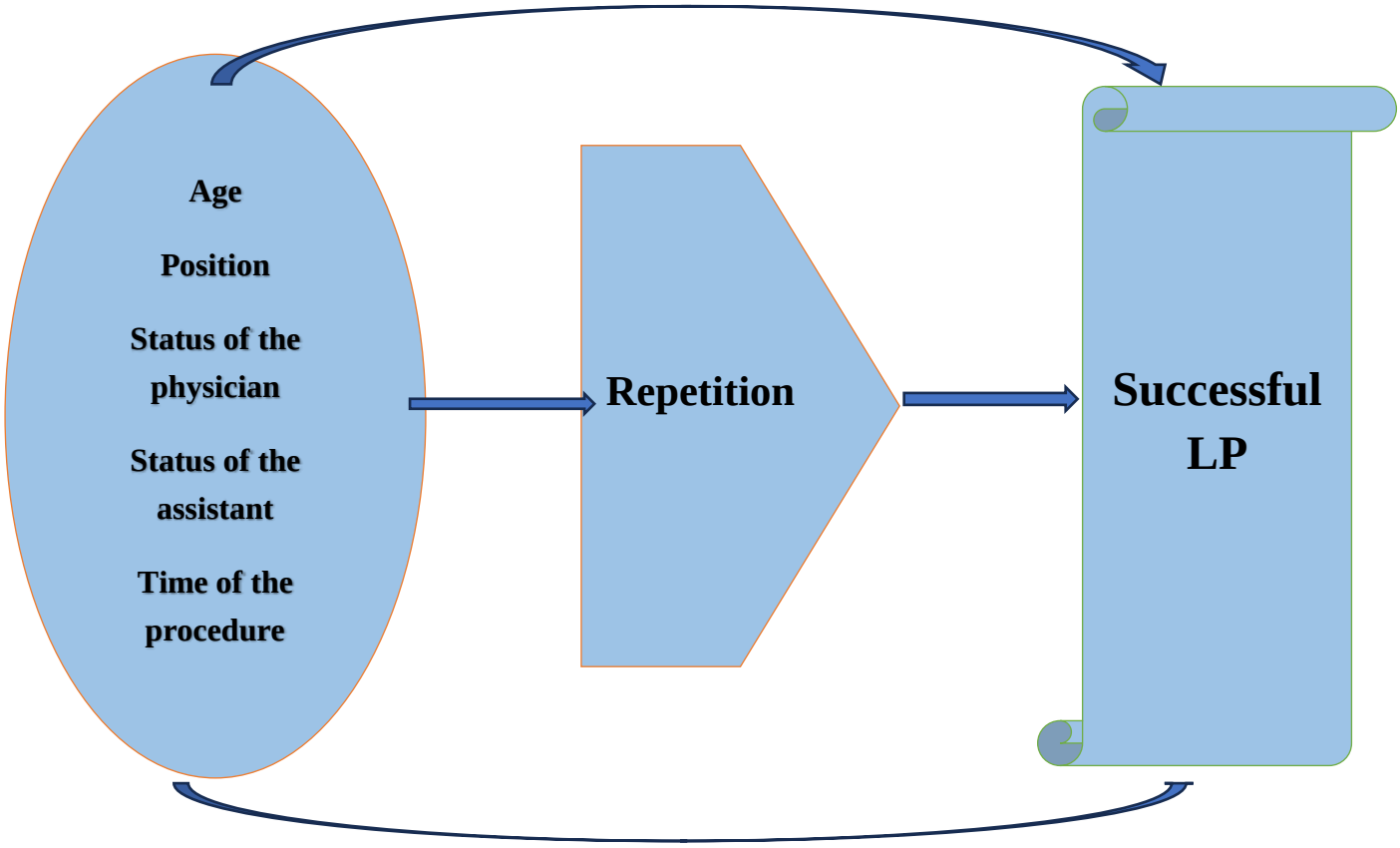


Figure 1, conceptual frame work of successful LP & associated factors **(7, 24, 26, 29, 30, 32)**

4. Objectives

4.1. General objective

- To assess the success rate of lumbar puncture and associated factors for the diagnosis of meningitis in under five patients at TGCSH, Bahir Dar, Ethiopia, 2024

4.2. Specific objectives

- To assess the success rate of lumbar puncture for the diagnosis of meningitis in under five patients at TGCSH, Bahir Dar, Ethiopia, 2024
- To determine associated factors successful lumbar puncture for the diagnosis of meningitis in under five patients at TGCSH, Bahir Dar, Ethiopia, 2024

5. Methods

5.1. Study area and period

The study was conducted at Tibebe Ghion Specialized Hospital, Bahir Dar, North Ethiopia, from June to November. Bahir Dar, the capital of the Amhara regional state, is located in the northwestern part of Ethiopia, 565 km from Addis Ababa, the capital city of Ethiopia.

Tibebe Ghion Specialized Hospital is a tertiary care teaching hospital in Bahir Dar City, founded in January 2019 GC. It is located about 10 km south of the city center and approximately 7 km from the new bus station ("Addisu Meneharia") on the highway to Addis Ababa. The hospital has a capacity of more than 450 beds and provides outpatient and inpatient services to over 94,000 clients per year(33).

The pediatric and child health unit had approximately 112 beds, divided into Emergency Triage Assessment and Treatment (ETAT), Critical and Stable Wards, the Neonatal Intensive Care Unit (NICU), and the Pediatric Intensive Care Unit (PICU). The neonatal care unit, together with the maternal side and Kangaroo Mother Care (KMC), had 55 beds. The department was staffed with 20 seniors, 40 residents, and 69 nurses.

The study was conducted in June 2024 to February 2025.

5.2 Study design

An institution-based cross sectional study was conducted among under five patients who visited TGSH and needed LP for the diagnosis of meningitis. The LPs done over 6 months were sampled and collected.

5.3 Source and Study Populations

5.3.1 source population: All under five patients visited TGCSH , department of pediatrics and child health during the study time, Bahirdar, Ethiopia.

5.3.2 study population: all under five patients for whom LP was done for the diagnosis of meningitis (to rule in/ to rule out) during the study period.

5.4. Inclusion and Exclusion Criteria

5.4.1 Inclusion Criteria: all under five patients for whom LP was done the diagnosis of meningitis (to rule in/ to rule out) in the study period.

5.4.2 Exclusion Criteria: all those patients with traumatic 1st LP and unable to repeat the procedure due to different reasons.

5.5. Sample Size Determination and Sampling technique

5.5.1. Sample Size Determination

The minimum number of samples needed for this study was determined using single proportion formula, the corrected formula for a finite population (n), as the total estimated study population is 360. This estimate is based on a pretest conducted over one week, 15 LPs/week and projected to a six-month period.

$$n_0 = \frac{z^2 p\,(1-p)}{e^2}$$

$$n_f = \frac{n_0}{(1 + n_0/N)}$$

Where; n_0 = minimum sample size in estimated sample size (at p = 50% which is 384)

N = the total estimated under five populations for whom LP will be done (360)

n_f = minimum sample size (with p of 50%)

z^2 = standard normal value with the chosen level of confidence (95% = 1.96)

p = estimated prevalence of outcome, successful LP

e = tolerable margin of error = 5% (0.05)

Sample size: n = 384/ [1+384/360] = 186

Considering incomplete charts of 10%, sample size was 186*10% = 18

Therefore, the sample size was 204.

5.5.2. Sampling technique

A systematic random sampling technique was used to select 206 samples, by dividing the estimate population for the sample size which is 1.7, and approximating it to 2. Three data collectors were assigned to three locations—the pediatric ward, neonatal ward, and ETAT. LPs performed every other day were collected over a six-month period.

5.6. Study variables

5.6.1. Dependent variables

- Success rate of lumbar puncture (Successful, Failed)

5.6.2. Independent variables

- Age
- Position during the procedure
- Status of the performing physician
- Status of the assistant
- Repetition of the procedure on the same patient
- Time of the procedure

5.7. Operational definitions

Traumatic lumbar puncture is defined by the presence of more a ratio of WBC/RBC <1/500 or grossly traumatic appearance(3).

Dry LP is when there is nothing come out through the needle during the procedure.

Success is defined when the CSF is grossly purulent (rather than being grossly traumatic), or grossly clear and no RBC on analysis(3). Successful LP is a procedure that can either rule in or rule out meningitis.

Status of the performing physician is labeled as;

- R1 (a physician who is studying the 1st year of residency)
- R2 (a physician who is studying the 2nd year of residency)
- R3 (a physician who is studying the 3rd year of residency)
- Senior (a physician who has specialized on pediatrics and Child health)

An assistant is the one who holds the patient in the appropriate position during the procedure, who can be a nurse, intern, or resident.

Position during the procedure is the position maintained by the patient during the procedure, which can be either sitting or recombinant (patient is made in a lateral decubitus position and flexed forward).

Time of the procedure is the time during which the procedure is done.

Under five children- refers to the age of 0 to 5 years, it includes the neonates (0 – 28days).

A patient with single LP means that he/she had a single successful procedure.

5.8. Data collection tools and procedures

Data was collected using a standard checklist by data collectors. Those LPs done every other day since June first were collected, either primarily or through communication via phone with the performing physician as the procedure was performed and the laboratory result was arrived. The data collector observed the position used, the performing physician, the assistant, the physical appearance of the CSF if it came out, the time during the procedure as well as the laboratory confirmatory result whether traumatic or not. This information was collected on call if it was done during overnights or weekends as the working time residents including the data collectors were not around.

5.9. Data quality assurance

To assure the quality of data, pretest was done with 5% of procedures done over 1 week period and the check list was amended. The completeness and consistency of data was being checked by the principal investigator.

5.10 Data processing and analysis

The data was coded and subsequently entered into Epi Data 3.1 where it was stored and exported into SPSS version 27 software. Descriptive statistics were employed to present the findings, utilizing frequency tables, graphs, and charts. To assess the association between the outcome variable and independent variables, a binary logistic regression model was applied. In bivariable analyses, independent variables with a significance level below 25% (p-value < 0.25) were identified for inclusion in the multivariable binary logistic regression model.

The multivariable model was used to further examine the association between the outcome variable and the selected independent variables. Adjusted Odds ratios, p-values, and 95% confidence intervals for AORs were utilized for testing significance and interpreting the results. Variables with a p-value less than 0.05, were considered statistically associated with the outcome variable.

5.11 Ethical Consideration

The data collection was conducted after obtaining Ethical Clearance from the Research Ethics Committee of Tibebe Ghion Specialized Hospital.
Confidentiality was ensured by refraining from recording patients' names.

6. Results

6.1. Socio-Demographic Characteristics

Table 1. Demographic characteristics of under five patients undertaken lumbar puncture at TGCSH from June to November, 2024, (n = 204)

Variable		Frequency	Percent
Age	0-3 months	116	56.9
	3-12 months	60	29.4
	12-60 months	28	13.7
Sex	Male	111	54.6
	Female	93	45.4

Most of patients were aged 0-3 months (116; 56.9%), followed by 3-12 months (60; 29.4%), and the smallest group was 12-60 months (28; 13.7%). In terms of sex, there were 111 males accounting 54.6% of the samples.

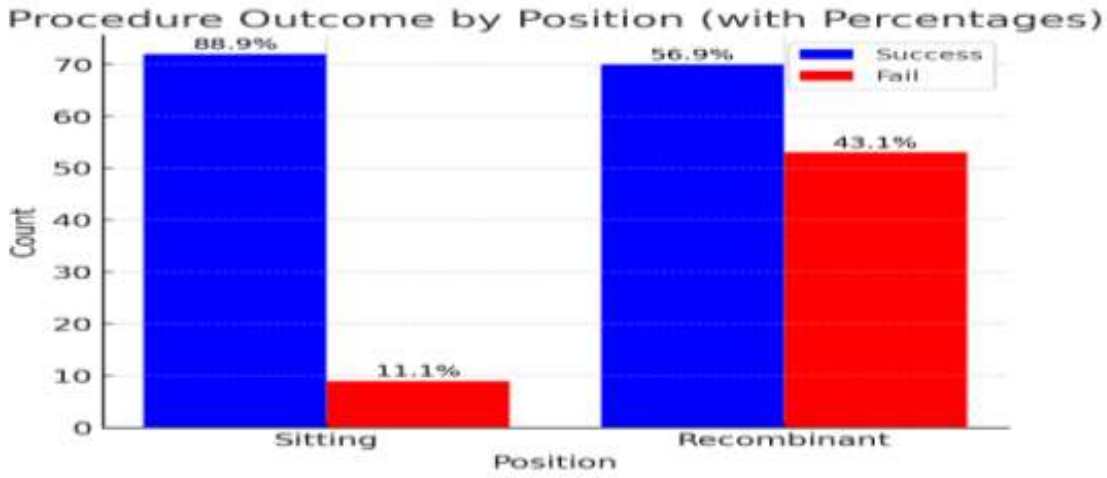
6.2. Frequency distribution of variables

Most procedures (111, 54.4%) were performed by R2s, who also assisted in 93 cases (45.6%). The recombinant position was the most commonly used, selected in 123 cases (60.3%). Of the LPs, 163 (79.9%) were performed on patients for the first time, while 41 (20.1%) were repeated (2nd or 3rd time). Most procedures occurred between 8 local day and 4 local night times.

Table 2. Frequency Distribution of variables of lumbar puncture procedures, done from June to November, 2024 at TGCSH (n=204).

Variables	**Characteristics**	Frequency	Percent (%)
Age	0-3 months	116	56.9
	3-12 months	60	29.4
	12-60 months	28	13.7
Done by	R1	34	16.7
	R2	111	54.4
	R3/Senior	59	28.9
Assisted by	Intern/Nurse	24	11.8
	R1	83	40.7
	R2	93	45.6
	R3	4	2.0
Position	Sitting	81	49.7
	Recombinant	123	60.3
Repetition	Yes	41	20.1
	No	163	79.9
Timing	2-8day local time	61	29.9
	8day-4night local time	137	67.2
	4night-2morning local time	6	2.9

Figure 2. Shows cross tabulation of position and procedure Results



The clustered bar chart illustrates the success and failure rate in different positions. the **sitting position**, the majority of procedures were successful, accounting for **88.9%**, while only **11.1%** resulted in failure. In contrast, the **recombinant position** had a lower success rate of **56.9%**, with a significantly higher failure rate of **43.1%**. The data suggests that procedures performed in the **sitting position were considerably more successful** compared to those conducted in the recombinant position.

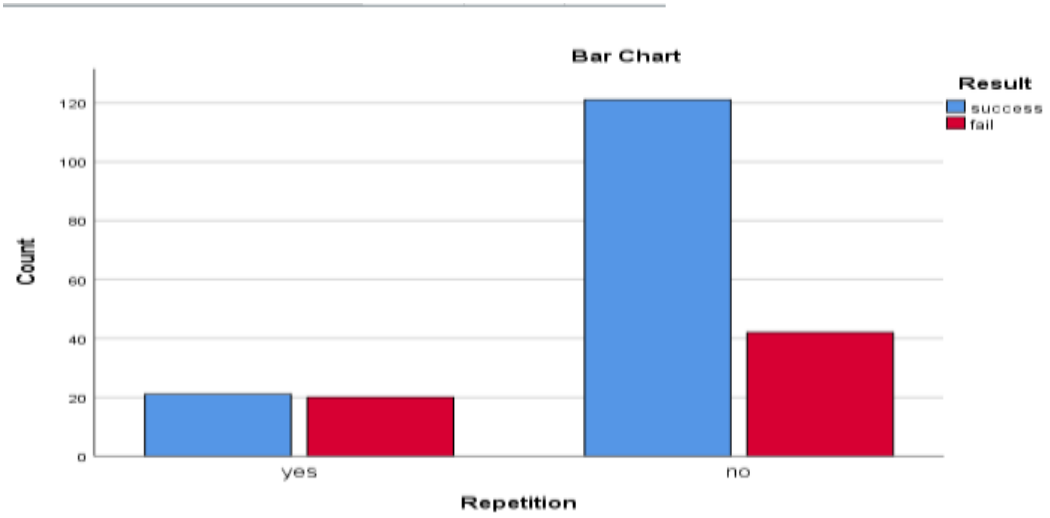
Table 3. shows Cross tabulation of age and procedure outcome

		LP out come		
Age in months		Successful	Failed	Number of cases
	o-3	71(61.2%)	45 (38.8%)	116
	3-12	48	12	60
	12-60	23	5	28
Total		142	62	204

Among infants aged 0-3 months, 116 procedures were conducted, accounting for 56.9% of the total. Of these, 71 (61.2%) were successful, while 45 (38.8%) failed. In the 3-12 months age group, 60 procedures were performed, making up 29.4% of the total, with 48 (80%) being successful and 12 (20%) unsuccessful. For children aged 12-60 months, 28 procedures were carried out, representing 13.7% of the total, with 23 (82.1%) successes and 5 (17.9%) failures.

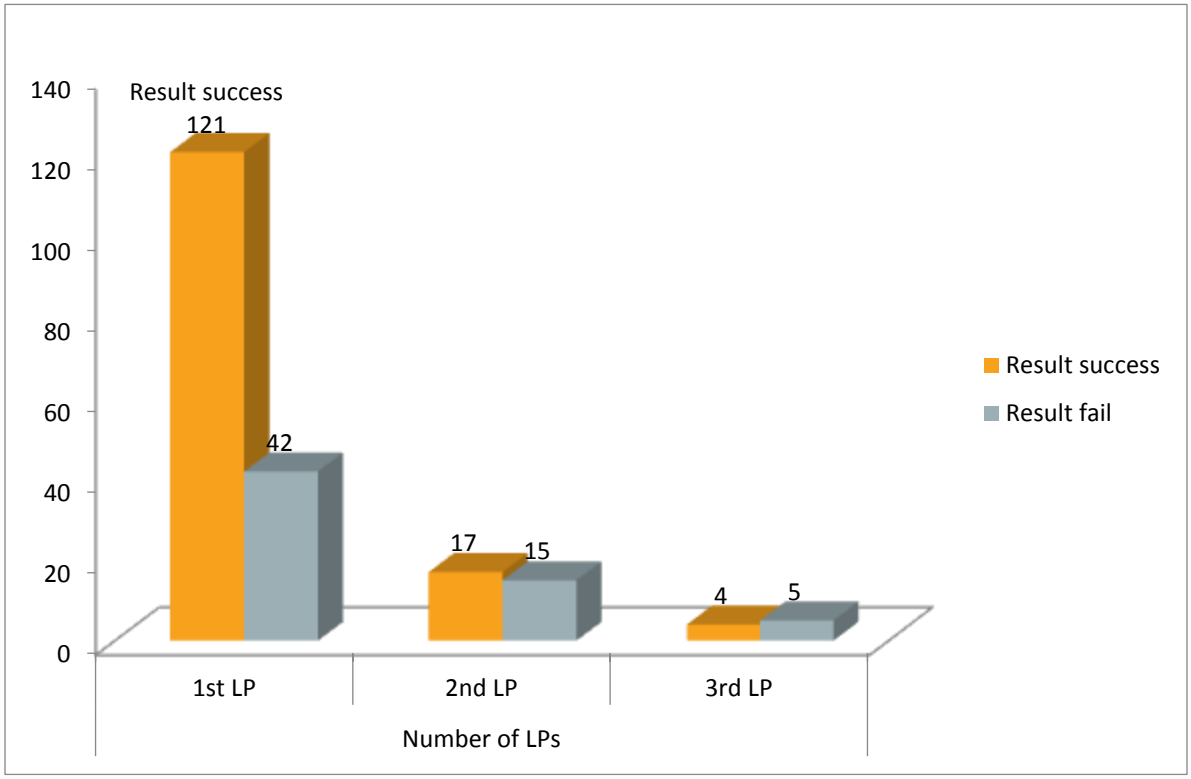
Overall, out of 204 procedures, 142 (69.6%) were successful, while 62 (30.4%) were unsuccessful. The highest failure rate was observed in the 0-3 months group, whereas the 12-60 months group had the highest success rate.

Figure 3. shows relationship between repetition of procedure and outcomes



The bar chart shows that the majority of LPs (163) were performed without repetition, corresponding to a higher success rate of 121 cases (74.2%). In contrast, 41 cases involved repeated LPs, of which 21 (51.2%) were successful, and 20 (48.8%) were failed.

Figure 4. Shows the Order of LP and relationship with LP Result



The bar chart depicts the number of LPs and the outcomes (success or failure). For the 1st LP, there were 163 total observations, with 121 successes (74.2%) and 42 failures (25.8%). The 2nd LP category had 32 observations, of which 17 were successes (53.1%) and 15 were failures (46.9%). For the 3rd LP, there were 9 observations, with 4 successes (44.4%) and 5 failures (55.6%)

6.3. Factors associated with LP success

To identify independent factors influencing the clinical outcomes, a dichotomy was established, categorizing outcomes as Successful and Failed base on observations after the LP procedure. Potential outcome determinants such as, age, timing of procedure, physician who did the LP, who assisted the LP, order of LP and repetition of LP were subjected to bivariable analysis. The significance level was set at a p-value less than 0.25 to select candidate variables for multivariable analysis.

Multivariable binary logistic regression was employed to explore the association between independent and dependent variables. In a bivariable logistic regression, variables like Age, physician who did LP, Position, Order of LPs and Repetition of LPs had significant association with outcome variables at 25% of level of significance.

However, upon comprehensive analysis in multivariable logistic regression, only Position during LP and Repetition of LP were found to be significantly associated with the outcome variable (Success rate) at 5% level of significance.

Accordingly, after adjusting for other covariates, position during LP (with **AOR** of 6.744, 95% CI: 2.749-16.545) and Repetition of LP procedure (with **AOR**=0.272, 95% CI: 0.121-0.611) were significantly associated with dependent variables (Table.5).

Table 4: Bivariable and multivariable Logistic Regression to identify Factors associated with success rate of lumbar puncture for the diagnosis of meningitis in under five patients, in TGSH (n=204)

Variables			Outcome frequency		COR (95%, CI)	AOR (95% CI)	P-value
			Success	failure			
Age	0-3 month		71(61.2%)	45(38.8%)	0.394 (0.189-0.822)	2.037	0.202
	3-12 months		48(80%)	12(20%)	0.343 (0.122-0.967)	0.871	0.821
	12-60months		23(82.1)	5(17.9%)	1.00	1.00	
Done by	R1		16	18	0.344(0.156-0.7600	2.671	0.056
	R2		80	31	0.251(0.101-0.626)	0.953	1.024
	R3/senior		46	13	1.00	1.00	
Position	Sitting		72 (88.9%)	9(11.1%)	6.057(2.77-13.20)	6.744(2.749-16.545)	0.000
	recombinant		70(56.95)	53(43.1)	1.00	1.00	
Repetition	Yes-	41	21(51.2%)	20(48.8%)	0.364(0.180-0.738)	0.272(0.121-0.611)	0.002
	No	163	121(74.2%)	42(25.8%)	1.00	1.00	

7. Discussion

The overall success rate of the 204 LP procedures was 69.6%, while the failure rate been 30.4%, including the 1% dry LPs and 29.4% traumatic LPs. This finding is almost comparable with the study done in Red Cross War Memorial Children's Hospital, Cape Town, South Africa, in 2016, that the prevalence of unsuccessful (traumatic or dry) was 32.3%**(**9).

This study showed that the success rate of lumbar puncture (LP) varied significantly across age groups, with younger infants experiencing greater difficulty. Infants aged 0-3 months had a lower success rate compared to children aged 12-60 months (COR: 0.394, 95% CI: 0.189-0.822), likely due to anatomical and procedural challenges. Similarly, children aged 3-12 months had reduced odds of success (COR: 0.343, 95% CI: 0.122-0.967).

Specifically with the age group of under three months, the success rate was 61.2% which is lower than in the study conducted at the Tokyo Metropolitan Children's Medical Center in Tokyo, Japan, in 2024 which examined the proportion of successful lumbar punctures in infants under three months old. Among 121 patients, 69% were classified in the successful LP group, while 29% were categorized in the traumatic LP group(16). This could be due to the different procedural materials and techniques used, in our setup the 3 cc and 5 cc syringe needles were been used rather than the standard procedural needles. In addition, topical and systemic analgesics were given prior to the procedure in the above study, as this was found to increase the success rate in the same study.

While another local study in UK in 2023, at the Leeds children hospital, found the outcomes of LP in infants younger than 3 months to be unsuccessful in 52%, and inappropriate handling technique by the assistant was found to be the single important factor **(18)**. But this study had small sample size, 21, and short period of study which was 2 months.

In contrast, children aged 12-60 months had the highest success rate (82.1%), suggesting that greater cooperation and more developed spinal structures facilitate the procedure. These findings highlight the increased difficulty of performing LPs in younger infants and reinforce the need for specialized techniques and expertise in this age group.

This study showed, Patient positioning was a significant factor influencing LP success. The sitting position had a notably higher success rate (88.9%) compared to the recombinant (lying) position (56.9%). The adjusted odds ratio (AOR) of 6.744 (95% CI: 2.749-16.545, $p < 0.001$) suggests that LPs performed in a sitting position were more than six times more likely to succeed than those performed in the recombinant position. This increased success may due to straighter spinal alignment, wider interspinous space, better CSF flow dynamics and less patient movement when the patient is seated.

Findings from Oxford Population Health's National Perinatal Epidemiology Unit (2022) support this conclusion, showing that the first LP attempt was successful in 63.7% of cases when infants were in a sitting position compared to 57.6% in a lying position. Additionally, infants in the sitting group exhibited less struggling during needle insertion and had more stable oxygen levels and heart rates, suggesting that sitting might be a more comfortable and less stressful position for the procedure (29).

Similarly, a 2022 UK study on full-term newborns found that success rates improved in the sitting position compared to the lying position (30).

However, findings from a retrospective study conducted in the USA and UK hospitals (2022) on infants under three months old did not find a significant difference in LP success rates or the proportion of traumatic LPs between the sitting and lateral decubitus (side-lying) positions (31).

Moreover, a systematic review from January 2023, analyzing studies from the USA, China, Spain, and the UK, concluded that the lateral decubitus position may result in little to no difference in first-attempt success rates compared to the sitting position (32).

These mixed findings suggest that while the sitting position generally appears to be more favorable, especially in younger patients, the impact of positioning on LP success may vary depending on factors such as age, provider experience, and patient comfort. Further research is needed to establish a clear consensus on the optimal positioning for LP procedures.

LP success rates decreased with repeated attempts. Of 163 first attempts, 121 (74.2%) succeeded, while 42 (25.8%) failed. For 32 second attempts, 17 (53.1%) succeeded, and 15 (46.9%) failed. The third attempt had the lowest success rate, with 4 out of 9 (44.4%) successful and 5 (55.6%) failed.

The need for repeated LP attempts was strongly linked to lower success rates. Patients who required a second attempt had a 51.2% success rate, whereas those who did not need repetition achieved 74.2% success. The adjusted odds ratio (AOR) of 0.272 (95% CI: 0.121-0.611, $p = 0.002$) indicates that the probability of success was 73% lower in patients undergoing repeated attempts. This decline may be attributed to factors such as procedural trauma, heightened patient distress, increased fragility of blood vessels and difficulty in identifying landmarks due to edema from the recent procedure. Currently, no comparable published studies have been conducted to validate this association.

In this study, the success rate of LP was significantly influenced by the experience of the healthcare provider. First-year residents (R1s) had the lowest success rate, with 16 out of 34 procedures successful (COR: 0.344, 95% CI: 0.156-0.760), indicating a 66% failure rate, likely due to limited experience. Second-year residents (R2s) also had lower odds of success (COR: 0.251, 95% CI: 0.101-0.626) but performed better than R1s. In contrast, senior residents (R3s) or consultants achieved the highest success rate (46 out of 59 successful procedures, 78% though repetition is a confounding factor in most procedures done by senior residents), emphasizing the role of experience in procedural proficiency. But with multivariable binary regression it was found to be significant probably senior residents were usually involved it the repeated LPs which might be a confounding factor.

A 2022 U.S. retrospective study evaluating pediatric resident LP success reported a stable success rate, while a 2023 study at the University of Carolina identified trainee experience as a key factor in LP outcomes. These findings highlight the impact of provider skill level, though further research is needed for definitive conclusions (26, 27)

8. Limitations and Strengths of the Study

Strengths: to the best of our knowledge, there is no study conduct in Ethiopia that assess the success rate of Lumbar puncture, making this study the first in its kind. Findings align with existing research, reinforcing best practices and guiding clinical training. The evaluation of multiple variables enhances real-world applicability and highlights areas for further study.

Limitations: This study was conducted in a single healthcare setting, limiting generalizability. The small sample size in some subgroups may affect statistical power the lack of comparable studies limits external validation.

9. Conclusion

Success rates varied significantly across age groups, with younger infants (0-3 months) experiencing the highest failure rates, likely due to anatomical and procedural challenges. In contrast, children aged 12-60 months had the highest success rates, emphasizing the role of patient cooperation and spinal development.

In conclusion, age, provider experience, procedural repetition, and patient positioning are key factors influencing LP success.

10. Recommendations

Optimizing these factors through Patient Positioning specialized training – Encourage the use of the sitting position for LP procedures, as it is associated with higher success rates.

Minimize Repeated Attempts – Prioritize expertise in initial attempts to reduce the need for multiple procedures, minimizing patient distress and complications.

Further Research – Conduct larger, multi-center studies to validate findings and refine best practices for LP in young children, particularly in Ethiopia.

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12. Annex

A checklist for data collection on success rate of lumbar puncture and associated factors among the procedures done for diagnosis of meningitis in under five patients in Tibebe Ghion Comprehensive Specialized Hospital.

Name & signature of data collector _____Date__/__/__Code no_____ MRN _____

Code		Questions	Answer	Remark
		I. Demographic data		
1.1		Patient age in (days, months, Years)	1. 0 – 3 months 2. 3mo - 12mo 3. 1yr – 5yr	
1.2		Sex	1. M …… 2. F ……	
		II. Clinical Data		
2		Time when the LP was done	1. 2 - 8 day time 2. 8 day - 4 night 3. 5 night -1 morning	
3		Position during the procedure	1.Sitting 2.recombinant	
4		Number of LP done	1. once, 2. twice 3 . 3 times	
4.1		if the patient had single LP, answer the following Questions?		
	4.1.1	who did LP?	1. R1 2. R2 3. R3 4. Senior	
	4.1.2	Who assisted the LP?	1. R1 2. R2 3. R3 4. Nurse/Intern	
	3.1.3	Did CSF come out during the procedure?	1. YES 2. No	
	4.1.4	If yes, what was the appearance of the CSF	1.clear 2.Turbid 3.lightly bloody 4. gross blood	
	4.1.5	No. of WBC		
	4.1.6	No. of RBC	1. 0 2. <500 3. 500-1500 4.>1500	
4.2		If the patient had repeated, answer the following questions?		
	4.2.1	Who did the 1st LP?	1. R1 2. R2 3.R3 4. Senior	
	4.2.2	Who did the 2nd LP?	1. R1 2. R2 3. R3 4. Senior	

	4.2.3	**Who did the 3rd (if any) LP?**	**1. R1 2. R2 3. R3 4. Senior**	
	4.2.4	**Who assisted the 1st LP?**	**1. R1 2. R2 3. R3 4.Nurse/Intern**	
	4.2.5	**who assisted the 2nd LP?**	**1.R1 2. R2 3. R3 4.Nurse/Intern**	
	4.2.6	**Who assisted the 3rd (if any) LP**	**1. R1 2. R2 3.R3 4. Nurse/Intern**	
	4.2.7	**Position during the 1st procedure**	**1.sitting 2.recombinant**	
	4.2.8	**Position during the 2nd procedure**	**1.sitting 2.recombinant**	
	4.2.9	**Position during the 3rd procedure**	**1.sitting 2. recombinant**	
	4.2.10	**Was CSF come out during the 1st LP?**	**1. yes 2. No**	
	4.211	**Was CSF come out during the 2nd LP?**	**1. yes 2. No**	
	4.2.12	**Was CSF come out during the 3rd LP?**	**1. yes 2. No**	
	4.2.13	**If yes what was the appearance of the CSF during the 1st LP?**	**1.clear 2. turbid 3. lightly bloody 4. gross blood**	
	4.2.14	**If yes what was the appearance of the CSF during the 2nd LP?**	**1.clear 2. turbid 3. lightly bloody 4. gross blood**	
	4.2.15	**If yes what was the appearance of the CSF during the 3rd LP?**	**1.clear 2. turbid 3. lightly bloody 4. gross blood**	
	4.2.16	**No. of WBC of the 1st LP?**		
	4.2.17	**No. of WBC of the 2nd LP?**		
	4.2.18	**No. of WBC of the 3rd LP?**		
	4.2.19	**No. of RBC in the 1st LP?**	**1. 0 2. <500 3. 500-1500 4.>1500**	
	4.2.20	**No. of RBC in the 2nd LP?**	**1. 0 2. <500 3. 500-1500 4.>1500**	
	4.2.21	**No. of RBC in the 3rd LP?**	**1. 0 2. <500 3. 500-1500 4.>1500**	

Thank you!