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A study of the prevalence of bacteria causing meningitis in newborns with neural tube defects at Ali Omar Askar Hospital

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دراسة مدي انتشار البكتيريا المسببة لالتهاب السحايا لدى حديثي الولادة المصابين بعطب الأنبوب العصبي في مستشفى علي عمر عسكر

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Abstract:
Bacterial meningitis is a life-threateing condition that affects infants and remains a major contributor neonatal morbidity and mortality,particularly aamong newborns with neural tube defects (NTDs). These congenital anomalies increase the susceptibility of the central nevous system to severe infections due to compromised structural integrity.
Objective: this study aims to investigate the prevalence and type of bacterial pathogens causing meningitis in neonates with NTDs admitted to Ali Omer Askar Hospital, Libya.
Method: A total of 33 cerebrospinal fluid (CSF) samples were collected from neonates diagnosed with NDTs over a nine-month period. Samples underwent Gram staining and were cultured on various selective media (Blood Agar, Chocolate Agar, McConkey Agar). Additional samples were analyzed from blood and wound swabs to identify bacterial pathogens.
Results: Among the cases,72% tested positive for bacterial meningitis, with a higher prevalence in females (58.3%). Hydrocephaluse was the most common NDT observed (40%), while ruptured meningomyelocele cases showed the highest infection rates. *Acinetobacter sp* was the most frequently isolated bacterium (24.4%), followed by *Staphylococcus hemolyticus* (15.1%).
Conclusion: Neonates with NDTs, especially those with ruptured meningomyelocele, exhibit a significantly elevated risk of bacterial meningitis. The findings underscore the importance of early diagnosis, targeted antibiotic therapy, and heightened clinical attention for this vulnerable.

Keywords: Bacteria, inflammation, meningitis, neonatal, neural tube defect.

الملخص:
يمثل التهاب السحايا البكتيري أحد الأسباب الرئيسية للوفيات بين الأطفال، لاسيما حديثي الولادة، حيث يؤدي إلى التهاب حاد في الجهاز العصبي المركزي، ويعد من أخطر المضاعفات المصاحبة لعيوب الأنبوب العصبي الخلقية.

الهدف من الدراسة: يهدف هذا البحث إلى دراسة مدي انتشار الأنواع البكتيرية المسببة لالتهاب السحايا بين الأطفال حديثي الولادة الدين يعانون من عيوب في الانبوب العصبي ، وذلك من خلال دراسة الحالات المسجلة في مستشفى علي عمر عسكر خلال فترة زمنية محددة بلغت تسعة أشهر.
المواد والطرق: تم إجراء الدراسة علي 33 حالة لأطفال حديثي الولادة يعانون من عيوب الأنبوب العصبي، حيت جمعت عينات من السائل النخاعي الشوكي (CSF) بواسطة البزل القطني أومن اليافوخ الأمامي، وفحصت العينات لتحليل المجهري باستخدام صبغة الجرام وفحص فيلم الدم، كما تم زراعها علي أوساط زراعية مغذية مثل Blood Agar, Chocolate Agar, (McConky Agar) بهدف تحديد نوع البكتيريا المسببة للعدوى.
النتيجة: أظهرت نتائج الدراسة أن الإصابة بالتهاب السحايا بين حديثي الولادة الدين يعانون من عيوب في الأنبوب العصبي بلغت 72%، حيث كانت الإصابة أعلي لدى الإناث بنسبة 58.3% مقارنة بالذكور بنسبة 35.5%. وتبين أن أكتر أنواع العيوب العصبية شيوعا هو الاستسقاء الدماغي هو (Hydrocephalus) بنسبة 40%،يليه المعروف بتمزق القيلة النخاعية (Ruptur meningomylocel type) بنسبة 18%، الذي ارتبط بأعلى إصابة بالتهاب السحايا البكتيري. أما من حيت العوامل الممرضة، فقد كانت بكتيريا *Acinetobacter sp* الأكثر شيوعا بنسبة 24.4% من الحالات، تليها *Staphylococcus hemolytic* بنسبة 15.1%، تم *Staphylococcus aurous* بنسبة 6.06%. كما تم رصد *Pseudomonas areuginosa* في 6.0% من الحالات، و *kebsiellapreunos* في 3.0% فقط.
الخلاصة: تشير هذه النتائج إلي أن الأطفال المصابين بعيوب في الأنبوب العصبي معرضون بشكل أكبر للإصابة بالتهاب السحايا، مما يستدعي التدخل الطبي المبكر والفحص الجرثومي الدقيق لتحديد نوع الميكروب واختبار العلاج الأنسب.

الكلمات الدالة: البكتريا ، التهاب، السحايا ، حديثي الولادة ، عطب الأنبوب العصبي.

Introduction

Each year, 1.2 million people worldwide are affected by bacterial meningitis [World Health Organization. 1988],with neonates being the most vulnerable age group. In particular, newborns with neural tube defects (NTDs) face an even higher risk of developing this serious and often fatal infection [Gotoff, et al.1996]. Neonatal meningitis is a severe condition that leads to high mortality rates and long-term neurological damage [Synnott, M.B., *et.al*.1994]. It is impact varies by geographic location and the specific bacteria involved [Grandgirard , D. and Leib , S. L. 2010]. Without treatment, bacterial meningitis can have a fatality rate up to 70%,and even with care, survivors often suffer permanent complications like hearing loss or paralysis [Kim, K.S. 2003.& Grandgirard , D., Leib , S. L. 2010]. The condition is a medical emergency requiring immediate diagnosis and antibiotic intervention [Gaschignard, J., *et al*.2011]. NTDs like spinal bifida and anencephaly affect approximately 1in every 1,000 pregnancies in the U.S., with around 300,000 cases reported globally each year [Rosenstein, N.E., *et al* . 2001]. These defects occur when the neural tube, which forms the brain and spinal cord, fails to close properly during early pregnancy [Cragan, J.D., *et al*.1985–1994]. This can lead to lifelong disabilities, including varying degrees of paralysis and developmental issues. Among these, spina bifida can result in exposed spinal nerves, while anencephaly typically results in fatal brain malformations (Fig 1) [Shibuya, K., & Murray 1998].The connection between these defects and susceptibility to bacterial infections like meningitis underscores the importance of early diagnosis and preventive care [Berry, R.J., *et al*. 1999].

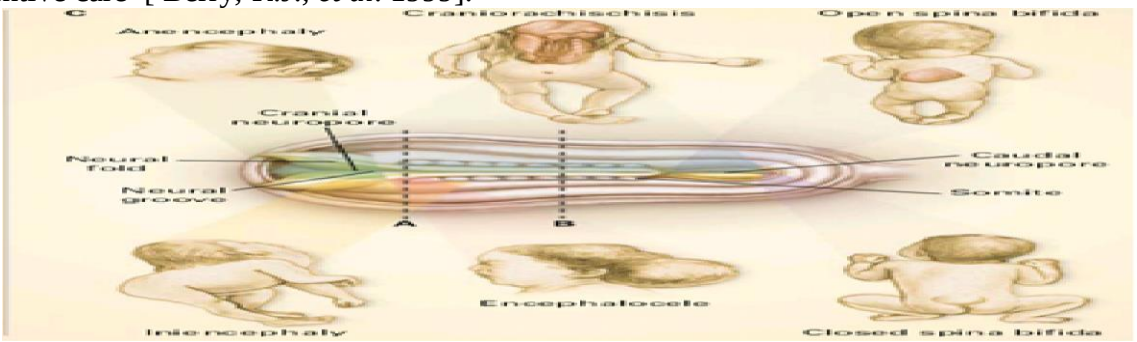


Figure 1. Features of Neural-Tube Development and Neural-Tube Defects [Lorenzo, D.,et al.1999].

Types of Neural Tube Defect (NTDs):

Open NTDs (most common) :These occur when the brain or spinal cord is exposed at birth due to defects in the skull or vertebrae :

- **Spina bifida**:

1- **Occulta**: A mild form of where there's a small gap in the vertebrae but the spinal cord and meninges stay in place (Fig2).

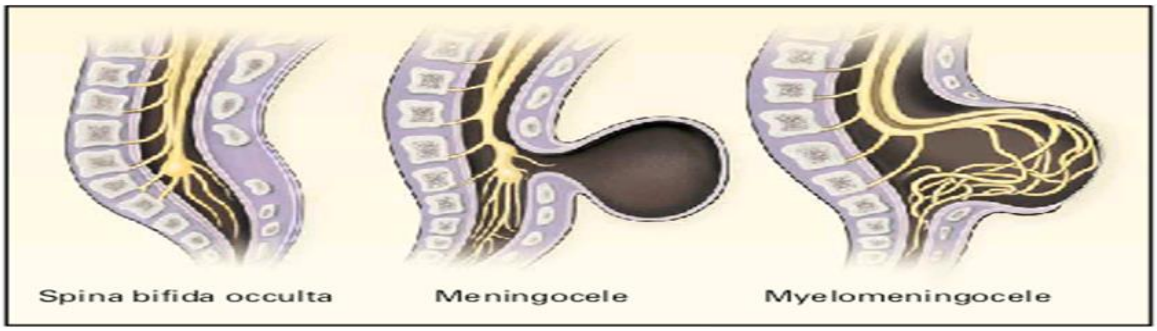


Figure2. Lateral View of the Spinal Cord in Three Types of Spina Bifida [Lorenzo, D., et al,1999].

2- **Cystica: A** Severe form of involving a visible sac.
3- **Meningomyelocele**: meninges protrude through the spinal defect.
4- **Myelomeningocele**: Both spinal cord and nerve roots protrude,making it more serious than meningocele (Fig 3,4) [Wynbrandt, J.,& Ludman, M.D. 1991].

Figure3. Mylomeningocele, [Mosby,Inc,2005].

Figure4. Meningocele,[Mosby,Inc,2005].

5- **Ruptured Myelomeningocele**: An advanced, severe form with higher risk of infection.
6- **Anencephaly**: A fatal condition where large parts of the brain and skull are absent. Infants are born without the forebrain and often don't survive(Fig 5. A) [Brender, J.D., et al, 1989
7- **Encephalocele**: A rate defect where parts of the brain and meninges bulge out through openings in the skull, usually covered by skin (Fig 5.B).

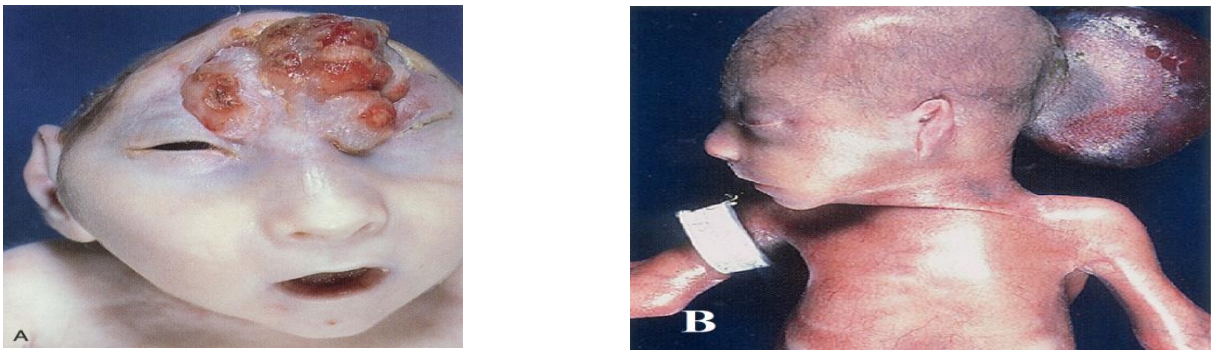


Figure 5. show one of the most sever types of neural tube defect (A) anencephaly, (B) encephalocele
[Mosby,Inc,2005].

Closed NTDs (**Less commen):** Here, the defect is covered by skin. Examples include: Lipomyelomeningocele, Tipomeningocele, Tethered cord syndrome.

Common complication : Hydrocephallus (fluid buidup in the brain): Frequently occurs with severe forms like myelmeningocele (Fig6) [Mulle, F.,& O'Rahilly, R.1996].

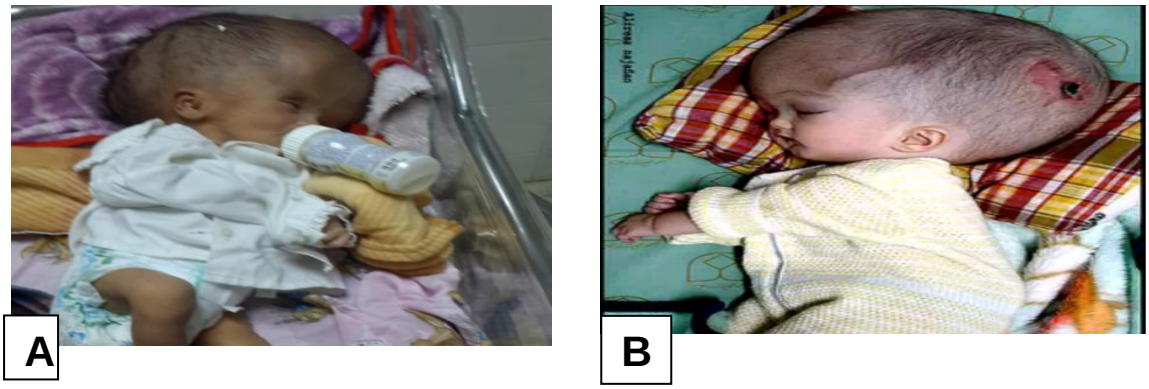


Figure 6. A ,B show a Hydrocephalus [Mosby,Inc,2005].

Literature review

The study by Murszko et al. (2011) highlighted that children with neural tube defects, particularly encephalocele and myelomeningocele,are at a heightened risk of developing bacterial meningitis, especially when CSF(cerebrospinal fluid) leakage or local wound infection are present. These findings align with our current study.

Likewise, Khan and Sankh (2003) emphasized that delayed surgical intervention and insufficient postnatal care significantly increase the risk of meningitis, which is consistent with our results.

In the same context, Al-Farsi et al. (2010) identified *Klebsiella Pneumoniae*, *Pseudomonase aeruginosa*, and *Group B Streptococcus* as the common bacterial pathogens in neonatal meningitis, which corresponds to the microbiological findings in our patient group.

These results highlight the critical importance of early diagnosis, timely surgical management, and adequate postnatal care to prevent serious neurological complication associated with bacterial meningitis in neonates with neural tube defects.

Material and Method

Temporal and spatial limitations: The study was conducted on a sample of patients with neural tube defect in Ali Omer Askar Hospital in the period of time (from 10 -Sep -2017 to 30 -May- 2018).

Sample :The total sample consisted of (33) samples of neonates have neural tube defect and infected with meningitis , where they ranged in age Less than two months.

Data collection tools and samples :

- For the theoretical study, the descriptive approach was adopted in the systematic study through references, books, publications and reports through the information network.
- Ethical approval was accepted by Omar Ali Asker Hospital for conducting the questionnaire. Questionnaire to study the general features of the research sample.

Materials requirement:

1. Microscope
2. Centrifuge
3. Slid , cover slid and Loops
4. Incubator
5. Media for culture [MacConkey agar , Blood agar , Chocolate Agar and Mueller Hinton Agar] and Antibiotic for sensitivity test .

Method performed on CSF samples :-

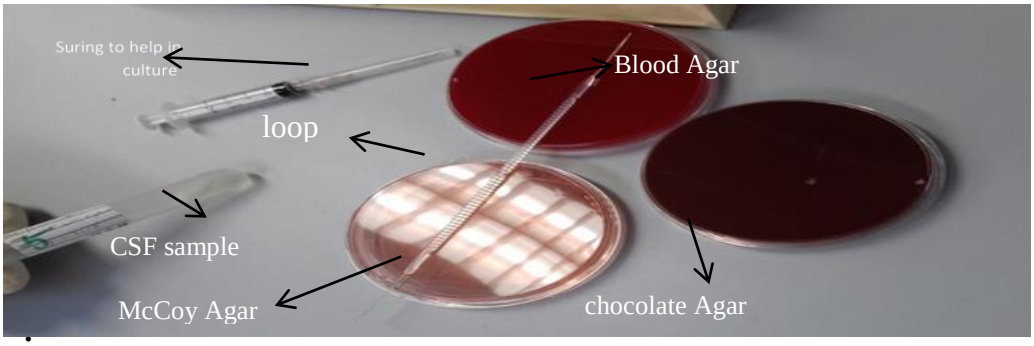
Methods for Collection of sample: The procedure used to obtain cerebrospinal fluid samples collected from two places (lumber) called Lumbar Puncture, and from Anterior Fornix (Fontanel) it is the most place for collection.

Figure 7. Show CSF samples in Congenital Hydrocephalus Cases it collected from (Fortanile)

Methods for analysis samples of CSF : CSF is collected into three sterile tubes which do not contain anticoagulant. The tubes are numbered in the order in which they were collected and are then distributed to the appropriate laboratory for testing:

Microbiology department : The samples is immediately divide for test each of:

1- **Culture Examination Of CSF (tube #1) :** Grown on the sample on each of flowing agar :Blood Agar, Chocolate Agar, McConky Agar.



Show material required for culture

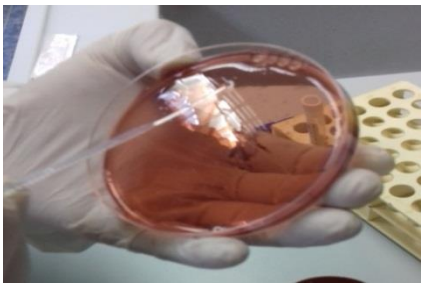


Figure 10. Show Planning on Blood Agar

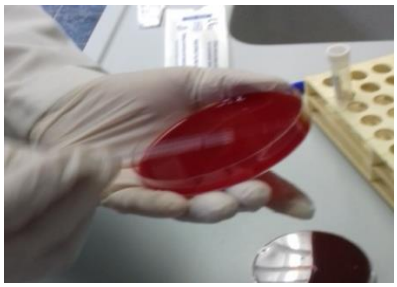


Figure 11. Show Planning on chocolate Agar

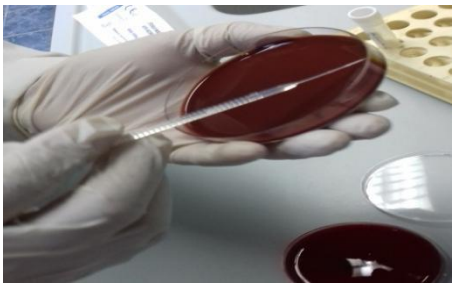


Figure 9. Show Planning on chocolate Agar

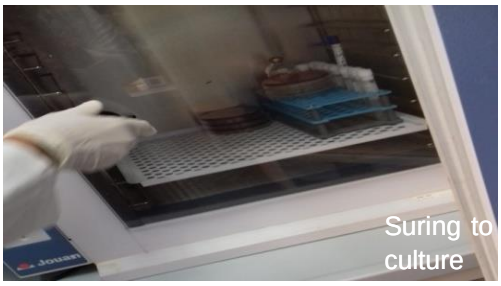
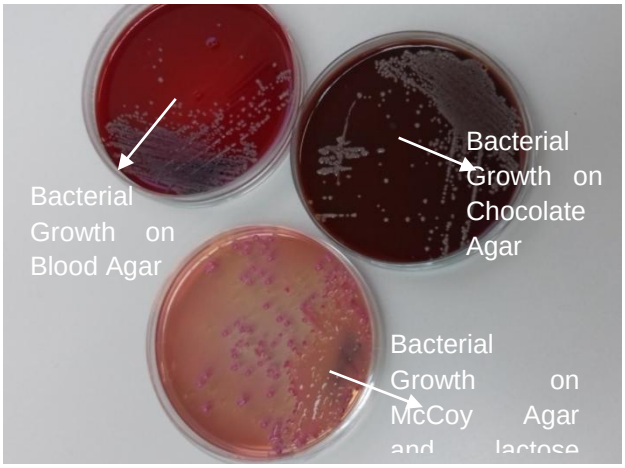


Figure 12. Show Agars in incubator

1.1 .Put the Agars in incubator in 37c .

1.2 .The following day bacterial growth and colony detection are identified under the microscope



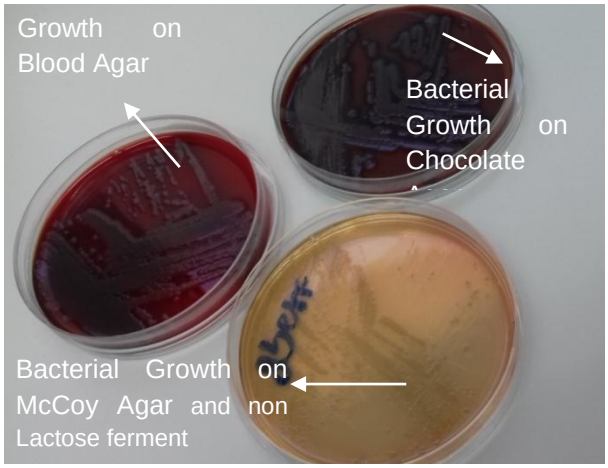
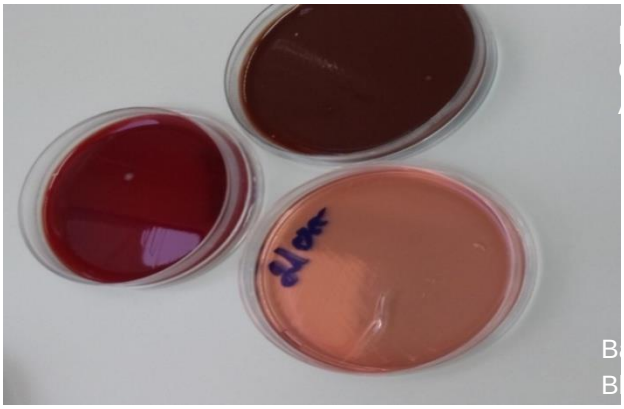


Figure 13. Show Gram Negative [-v] bacterial and Lactose Ferment.

Figure 14. Show Gram Negative [-v] bacterial and Non Lactose Ferment.



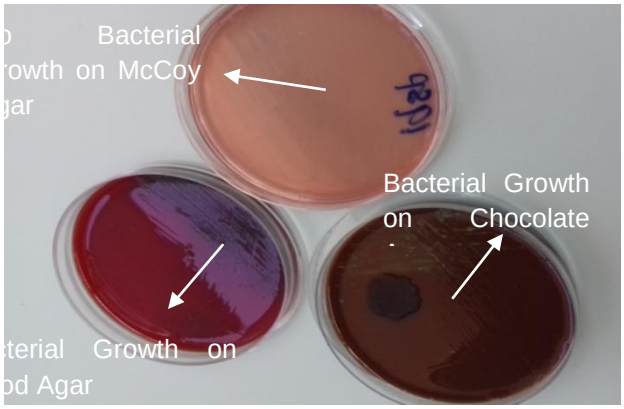


Figure 15. Show No Bacterial Growth on Agars.

Figure 16 Show Gram Positive [+v] bacterial.

1.3. In the case of bacterial growth on this Agars, must read the colonies to determine the type of bacteria ,then take swabbed and planning it on Mueller Hinton Agar and the Antibiotic place on it to detect the resistance of bacteria to these Antibiotic.

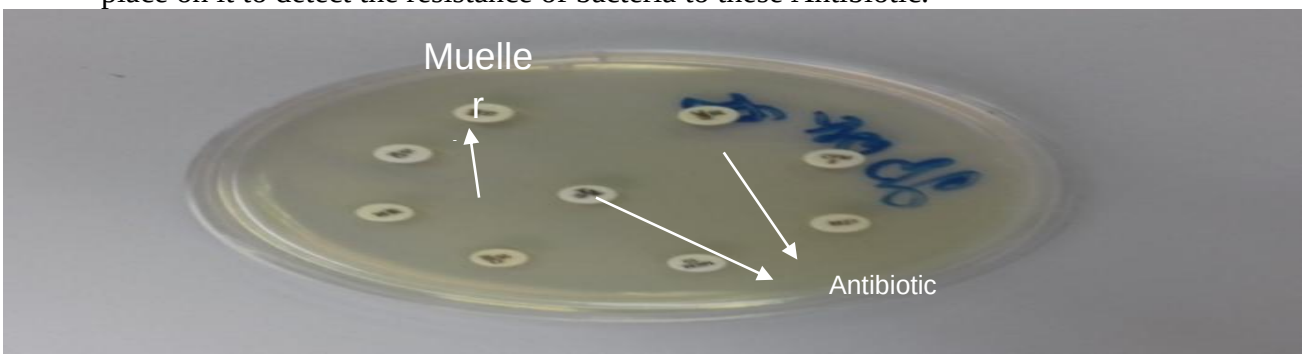


Figure 17. Show Sensitivity test to detect the effect of antibiotics on bacteria.

Then placed in incubator in 37℃ , and the following day read and measure the sensitivity of bacteria to some Antibiotics. If bacterial growth is present or not , must be confirmed by Gram stain.

1.4. Gram Stain Examination of CSF: We perform this test to confirm the presence of bacterial growth and help to identify the type of bacteria if Gram Positive or Gram Negative and whether they are cocci or bacilli.

2- Routine Examination of CSF (tube #2):

2.1.Physiological examination of CSF : Take the sample for identified and detect (Colour / Quantity / Appearance / Clot) .

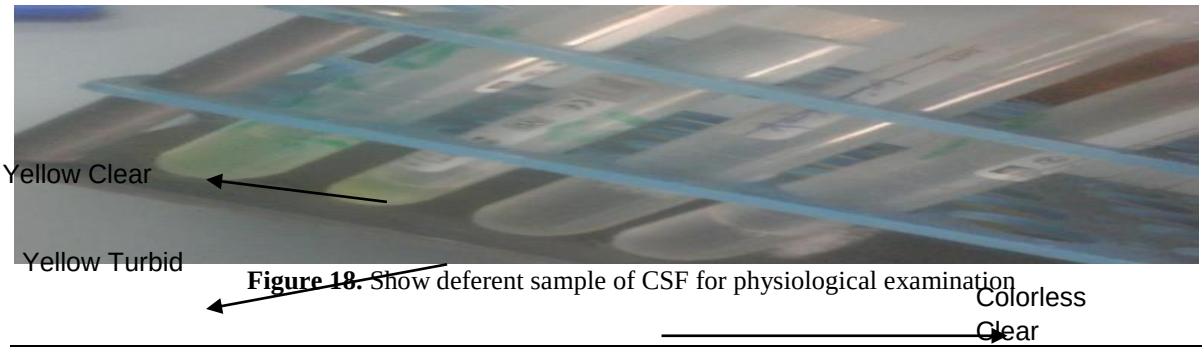


Figure 18. Show deferent sample of CSF for physiological examination

2.2. Cytological examination on CSF : This examination for detect white blood cell red blood cell and if there any other microorganisms. Cytological evaluation should be performed within 2 h after puncture, preferably within 30 min because of a lysis of both red blood cells and white blood cell.

Data Analysis Methods: The computer was used in statistical analysis by Microsoft Excel and SPSS for the calculation of the flowing :

1. Percentage of questionnaire as a means of presenting data.
2. Repetitive distribution table.
3. Measures of central tendency.

Results

This study was conducted at Ali Omer Asker Hospital between September 10, 2017, and May 30, 2018. It involved a sample of 33 neonates, aged 0- 2 months, who were born with neural tube defects (NTD) and subsequently developed bacterial meningitis.

Table (1) shows the distribution of age and Infection of disease.

age categories	Frequency	Infected	Percent
0-5 Day	7	4	16.6%
6-10	7	5	20.8%
11-15	3	1	4.16%
16-20	3	2	8.3%
21-25	4	3	12.5%
26-30	2	1	4.16%
31-35	2	2	8.3%
36-40	2	2	8.3%
41-45Day	3	3	12.5%
Total	33	24	100.0

Table (2) shows the distribution of the sample items by sex.

Sex	Frequency	Percent	Cumulative Percent
Male	13	39.4	39.4
Femal	20	60.6	100.0
Total	33	100.0	

Table 2. Show the percentage of females was higher than that of males (60.6%) and males (39.4%). This indicates that females are more susceptible to infection with NTDs.

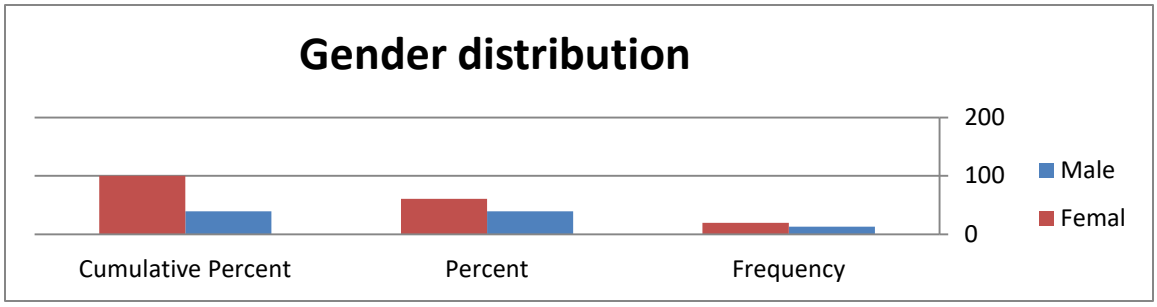


Figure 19. Shows the prevalence of glandular diseases between the sexes

Table (3). Shows the prevalence of type of neural tube defect.

Type of Neural tube defect				
Type of defect	Frequency	Percent	Valid Percent	Cumulative Percent
Meningiocele	3	9.1	9.1	9.1
Meningomylocel	1	3.0	3.0	12.1
Hydrocephalus	13	39.4	39.4	51.5
Hydrocephalus & Meningomylocel	1	3.0	3.0	54.5
Hydrocephalus & Meningiocele	1	3.0	3.0	57.6
Rupture Meningomylocel	6	18.2	18.2	75.8
Hydrocephalus & Rupture Meningomylocel	6	18.2	18.2	93.9
Encephalocele	1	3.0	3.0	97.0
Anencephaly	1	3.0	3.0	100.0
Total	33	100.0	100.0	

Table 3. Shows that 39.4% of the cases are suffer from Hydrocephalus ، 18.2% of the patients have Rupture Meningomylocel and Hydrocephalus & Rupture Meningomylocel , and 9.1% suffer from Meningiocele, and 15.0% in the remaining cases by 3.0 per case of (Encephalocele , Anencephaly, Hydrocephalus & Meningiocele, Hydrocephalus & Meningiocele , and Meningomylocel).

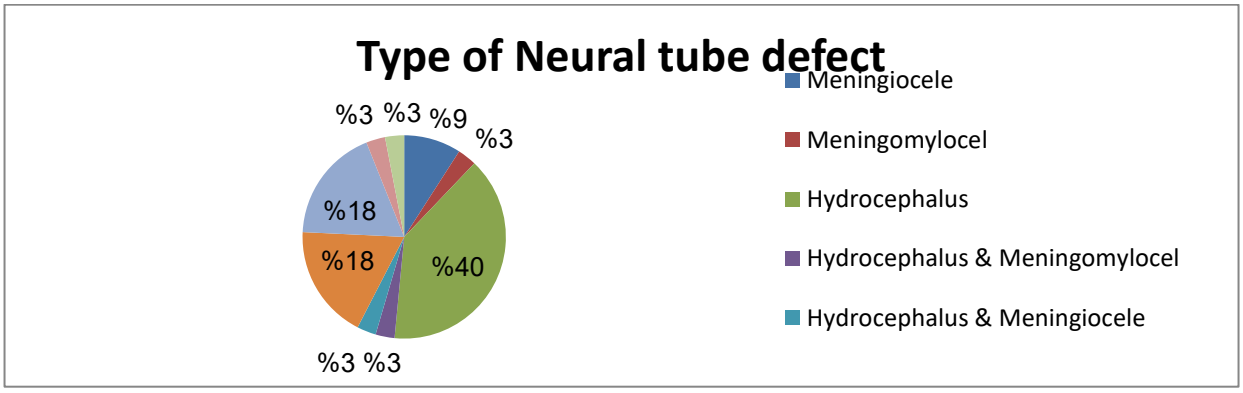
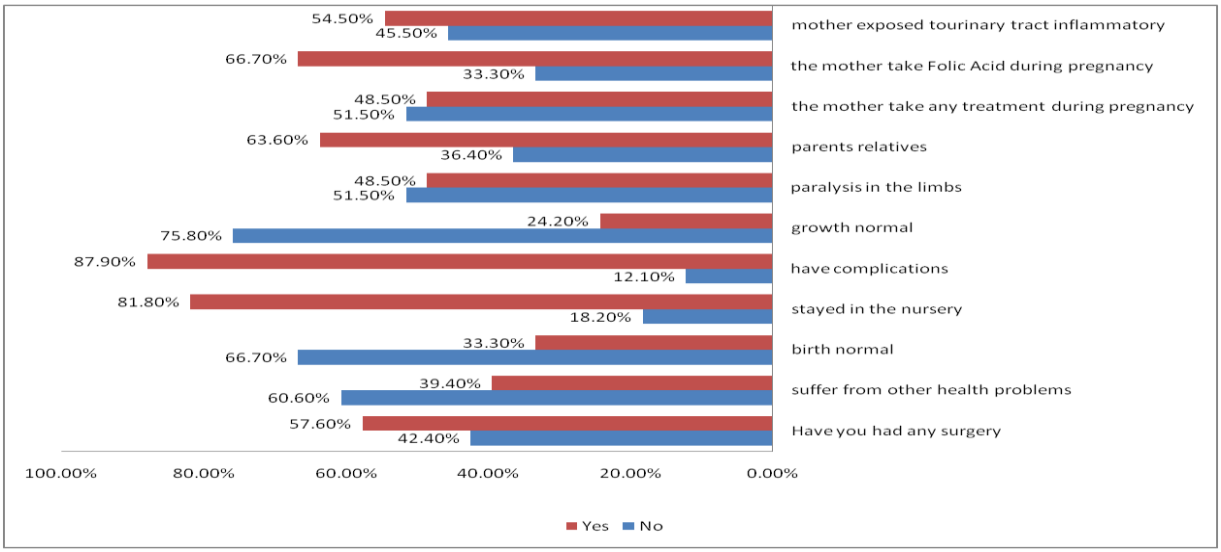


Figure 20. Shows the ratio of neural defect types.

Fig 20. Show the high incidence of Hydrocephalus is high Up to 40% , and in some cases comes linked to other cases as Meningiocele 9% Meningomylocel 3% and the most sever one is Rupture Meningomylocel 18% .



Digram 21. Show questionnaire data analysis .

Digram (21) illustrates several points that higlight the relationship between meningitis and prevalence of NTD.

Table (4). Shows the prevalence of the most common bacterial meningitis in CSF culture .

Results	Frequency	Percent
No Deta	4	12.1
No bacterial growth	11	33.3
Bacterial growth	18	54.5
Acintobacter sp.	8	24.4
Staphylococcus aurous	2	6.06
Staphylococcus hemolytic	5	15.1
Klebsiella preunos	1	3.0
Pseudomonas areuginosa	2	6.0
Total	33	100.0

Table 4. The cases in the bacterial culture of CSF samples showed that the percentages of the 12% had no results and 33.3% did not have bacterial growth. The percentage of infected cases was 54.5% of the various bacteria. The highest percentage was 24.4% in *Acintobacter sp* and 15.1% in *Staphylococcus hemolytic* The lowest was 3.0% in *Klebsiella preunos*.

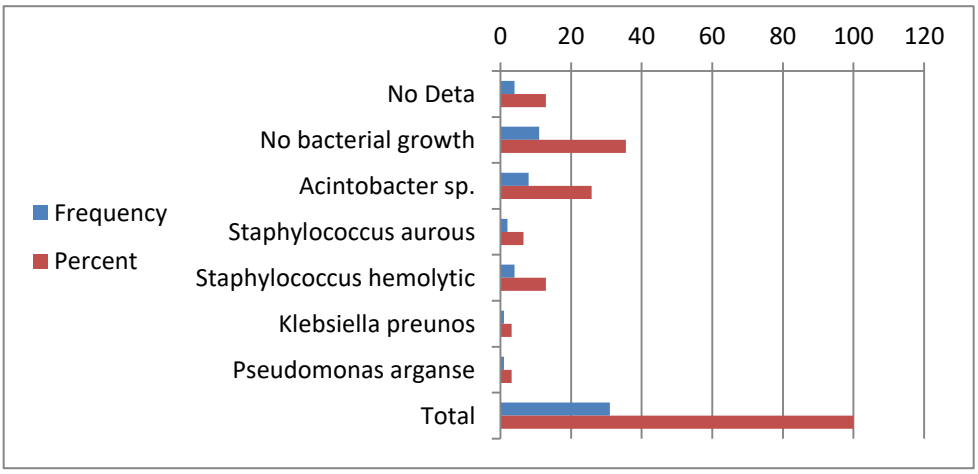


Figure 22. Show prevalence of the most common bacterial meningitis in CSF culture.

Table (5). Shows the prevalence of the most common bacterial meningitis in Blood culture.

Results	Frequency	Percent
No Deta	26	78.7
No bacterial growth	4	12.1
Staphylococcus hemolytic	3	9.09
Total	33	100.0

Table 5. Show the conclusion that the blood culture samples obtained from the *Staphylococcus hemolytic* bacteria only from 4 cases and the percentage 9.09%.

Table (6) .Shows the prevalence of the most common bacterial meningitis in Wound swap culture .

Results	Frequency	Percent
No Deta	23	69.69
Staphylococcus aurous	1	3.03
Staphylococcus hemolytic	1	3.03
Klebsiella preunos	2	6.06
Pseudomonas areuginosa	3	9.09
Escherichia coli	2	6.06
Staphylococcus coagulase negative	1	3.03
Total	33	100.0

Table 6. Show Pseudomonas out of 33 cases, we got 10 and the highest percentage of areuginosa bacteria was 9.09%.

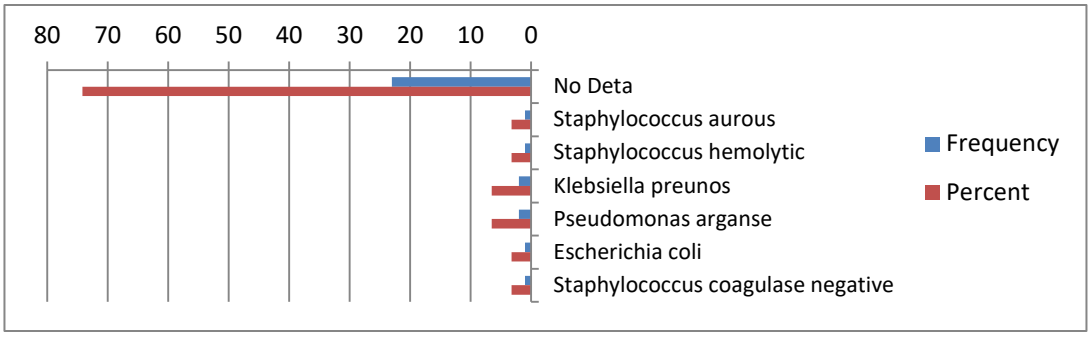


Figure 23. Shows the prevalence of the most common bacterial meningitis in Wound swap culture .

Table (7). Shows the prevalence of the most common bacterial meningitis in NTD cases .

Meningomylocel	Hydrocephalus	Hydrocephalus & Meningomyloc	Hydrocephalus & Meningiocele	P%
1	6	0	1	24.3%
2	0	5	0	21.6%
1	0	2	0	8.1%
0	5	2	0	18.9%
0	0	1	0	2.7%
2	0	1	0	10.8%
1	0	2	0	8.1%
2	0	0	0	5.4
9	11	13	1	100%

Table 7.Show the bacteria were more common in type Hydrocephalus associated with Rupture Meningomylocel.

Table (8). Shows the prevalence of the most sensitive Antibiotic for Acintobacter sp.

Antibiotic	Frequency of Sensitivity	Percentage %
Amicacin	5	29.4 %
Gentamiin	3	17.6 %
Tobramycin	3	17.6 %
chloramphincol	1	5.88 %
Streptomycin	1	5.88 %
Tmipenem	2	11.76 %
Azithromycin	1	5.88%
Sulphamethoxazole	1	5.88 %
Total	17	100 %

Table 8. Shows the most sensitive types of the Antibiotic to *Acintobacter sp*, which was Amicacin by percentage 29.4%.

Table (9). Shows the prevalence of the most sensitive Antibiotic for Staphylococcus hemolytic.

Antibiotic	Frequency of Sensitivity	Percentage %
Amicacin	3	16.6 %
Vancomycin	6	33.3 %
Clindamiin	2	11.1 %
chloramphincol	1	5.5 %
Augmenting	1	5.5 %
Tmipenem	3	16.6 %
Cefotaxime	1	5.5%
Erythromycin	1	5.5 %

Table 9 . Shows the most sensitive types of the Antibiotic to *Staphylococcus hemolytic* . which was Vancomycin by percentage 33.3%.

Table (10). Shows the prevalence of the most sensitive Antibiotic for Staphylococcus aurous.

Antibiotic	Frequency of Sensitivity	Percentage %
Vancomycin	3	27.27 %
Meropenem	1	9.09%
Clindamiin	1	9.09%
chloramphincol	1	9.09%
Azithromycin	1	9.09%
Tmipenem	2	18.18 %
fusidic acid	1	9.09%
Erythromycin	1	9.09%
Total	11	100 %

Table 10. Shows the most sensitive types of the Antibiotic to *Staphylococcus aurous,* which was Vancomycin by percentage **27.2%.**

Table (11.) Shows the prevalence of the most sensitive Antibiotic for Pseudomonas arganse.

Antibiotic	Frequency of Sensitivity	Percentage %
Amicacin	2	20 %
Meropenem	1	10 %
Gentamiin	2	20 %
Tobramycin	1	10 %
Ciprofloxane	2	20 %
Tmipenem	2	20 %
Total	10	100 %

Table 11. Shows the most sensitive types of antibodies to *Pseudomonas areuginosa* the percentage was close in Amicacin , Gentamiin , Ciprofloxane and Tmipenem , which was 20%, while the Meropenem and Tobramycin were 10%.

Discussion of Results

This research was conducted over a period of nine months and involved 33 newborns under the age of two months at Ali Omer Asker Hospital.

The analysis provided insights into several important variables: According to Table 1, the highest rate of meningitis cases occurred in the age group of 6 to 10 days, accounting 20% of infection.

Table 2 revealed a higher infection rate in females (60.6%) compared to males (39.4%), suggesting that female newborns may be more vulnerable to bacterial meningitis.

Figure 20 highlighted that hydrocephalus was the most prevalent neural tube defect, appearing in approximately 40% of cases.in some instances, it occurred alongside other conditions such as meningocele and more sever reupture meningomyelocele, which alone made up 18% of the cases.

Diagram 21 summarized questionnaire results, showing a notable link between neural tube defects and meningitis. Specifically, 54.5% of cases also had urinary tract infections, 66.7% of mothers took folic acid during early pregnancy, and 48% received treatment during pregnancy. Furthermore, 63.6% of the parents had a familial relationship (i.e, were relatives).

Among the affected neonates,48.5% experienced paralysis in the lower limbs, only 24.2% showed normal growth, and a high 87.9% had complications. Normal delivery was recorded in 33.3% of the cases, while 39.4% had additional health problems, and 57.6% underwent surgery.

Chart 22 outlined the types of bacteria found across different sample types.

In cerebrospinal fluid (CSF) samples, *Acinetobacter* species were the most common (24.4%), followed by *staphylococcus hemolyticus* (15.1%).

Blood cultures showed fewer positive results, with only 9.0% yielding *staphylococcus hemolyticus*. Swab samples showed the highest rate for *Pseudomonas areuginosa* (9.09%).

Table 9 demonstrated that infections were more frequently associated with the hydrocephalus type of neural tube defect, particularly when accompanied by rupture meningomyelocele. When both meningitis and neural tube defect are present, the risks increase significantly. The severity of the neural damage and the type of bacterial pathogen largely determine the outcomes. Rupture meningomylocele, in particular, poses a serious risk as it leaves the spinal cord and cerebrospinal fluid highly susceptible to bacterial infections.

Conclusions

Neural Tube Defects and Meningitis are problems and increase risk when they come together ,the risk ratio determines the type of nerve damage and the bacterial pathogen, when the type of Rupture Meningomylocel is serious, the spinal Cord and the cerebral spinal fluid are susceptible to any bacteria that may be infected. And through our study on a sample is the number of (**33**) cases of newborns who did not exceed two months in a period of (**9**) months in the Omar Ali Askar Hospital and we concluded through this study that the cases of NTDs Rupture Meningomylocel type has the highest percentage of infection with meningitis and have been associated with Hydrocephalus as one of the greatest complications to which it is exposed.

Recommendations

- The researchers recommend the need to pay attention to hospitals and perform sterilization and maintain the cleanliness of the departments and provide appropriate health care, especially the Department of Neurosurgery.
- Provision of medical devices and equipment for Hydrocephalus Patients and provide health care for them.
- Strongly recommend lab laboratories in the hospital need to need attention to Cerebrospinal fluid samples and must be conducted immediately and should not be delayed.

- Spreading health awareness among the members of society, especially women, and urging them to early detection and attention to the health and health of their fetus.

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