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Original article

Prognostic factors affecting the surgical outcome of secondary hydrocephalus in infants

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Abstract:

Background: Acquired Hydrocephalus can develop at birth or in adulthood. It has many etiologies like obstruction by Tumors, inflammatory and infective lesions like meningioencephalitis and cerebral abscess. It may result from Hemorrhage like parenchymal hemorrhage, intra-ventricular hemorrhage, germinal matrix hemorrhage(GMH). GMH is the leading cause of acquired infantile hydrocephalus in preterms. But still the main causes of secondary hydrocephalus in the infantile age groups post-meningetic and post hemorrhagic. **Aim:** the aim of this study is to evaluate the different prognostic factors affecting the clinical and surgical outcome in cases of secondary hydrocephalus in infants. **Methods:** This is a prospective study conducted on 30 non-consecutive cases with secondary hydrocephalus who underwent surgery by variable surgical procedures at Benha University Hospital from March 2022 to June 2023. **Results:** The mean age of the included patients was 11.43 months. The distribution of underlying pathology of studied cases was (Post-meningetic 80%, Post-hemorrhagic 13.3%, Post-tumor 6.7%). Cases were followed up for 6-12 months. There was reported incidence of favorable clinical and surgical outcome of 60 % of cases with no need for any surgical procedure and adverse outcome in 40%. **Conclusion:** Secondary hydrocephalus in a premature baby, with LBW, especially if admitted to NICU for more than 1 month, with presence of systemic sepsis and CSF infection by G-ve bacilli especially with frequent CSF tapping had the worst outcome. While maturity and normal birth weight without NICU admission, and absence of sepsis with negative CSF culture predicting a favorable clinical and surgical outcome.

Keywords: secondary hydrocephalus ; CSF culture ; prognostic factors ; VP shunt ; EVD.

Introduction:

Hydrocephalus is a neurological disorder caused by an abnormal accumulation of cerebrospinal fluid in the ventricles (due to obstructed flow, excess production, or defective absorption)[1].

This causes abnormal expansion of the cerebral ventricles resulting in increased intracranial pressure, skull enlargement, and cognitive dysfunction in infants[1].

Causes of hydrocephalus are classified into Congenital Hydrocephalus which is present in the infant at birth as a result of genetic abnormalities.[2]

Acquired Hydrocephalus can develop after birth or in adulthood. It has many etiologies like obstruction by Tumors, inflammatory and infective lesions like meningioencephalitis and cerebral abscess. It may result from Hemorrhage such as parenchymal hemorrhage, intra- ventricular hemorrhage, germinal matrix hemorrhage (GMH). GMH is the leading cause of acquired infantile hydrocephalus affecting preterm infants occurring in about 15%–20% of patients weighing less than 1500 gm.[3]

In Post-hemorrhagic hydrocephalus: there is disruption of normal dynamic balance between CSF production and absorption. Clot formation following intraventricular or subarachnoid hemorrhage results in obstruction of CSF flow and acute hydrocephalus. Subsequently, adhesions in the basal cisterns and inflammation cause impaired CSF absorption and post-hemorrhagic hydrocephalus later.[4]

In about 35% of infants with intraventricular bleeding a post-hemorrhagic ventricular dilatation (PHVD) will occur, with possible evolution in about 22% in post-hemorrhagic hydrocephalus, that in about 9% will require the placement of a permanent shunt, therefore complicating the outcomes.[5]

Post-meningitic hydrocephalus refers to hydrocephalus which develops as sequelae to meningitis, which generally refers to pyogenic or tuberculous meningitis and less commonly to other specific chronic forms of meningitis.

In neonatal meningitis, two groups are recognized. The first occurring within a few days of delivery usually involves full-term infants and meningitis is often an unrecognized part of generalized sepsis. Escherichia coli and group B streptococci are equally responsible, and the source is maternal infection. In the late-onset group, meningitis is the main feature and occurs in preterm infants especially after NICU admission, and in these cases, group B streptococci and staphylococci are the offending agents. In the latter cases, the source may be maternal or nosocomial. After 3 months of age, Haemophilus influenza may be responsible for meningitis.[6]

In Post-meningitic hydrocephalus, the brain is swollen, vessels are congested, and exudates appear on sulcal vessels and in the basal cisterns. The ventricular fluid becomes turbid, and the choroid plexus and ependymal lining are covered by pus. Once the inflammation becomes basilar, fibrotic adhesions of the arachnoid may develop across the basal cisterns so the flow of CSF is obliterated in its course from the point of exit from the fourth ventricle to the site of its absorption in the arachnoid villi. Obliteration of the arachnoid villi themselves contributing to the development of hydrocephalus. [7]

Hydrocephalus, if left untreated, can cause permanent brain damage, physical and

mental impairment, and even death. Initial treatment is directed to the etiology. In cases of intraparenchymal hemorrhage or tumors, surgical evacuation may resolve the hydrocephalus. Surgical treatment is the preferred therapeutic option in patients with hydrocephalus. Most patients eventually undergo ventricular shunt placements. [8]

Alternatives to shunting include:

1. Choroid plexus coagulation
2. Opening of a stenosed aqueduct (aqueductoplasy)
3. Endoscopic fenestration of the floor of the third ventricle
4. External ventricular drain

Patients and methods:

The study prospectively conducted on 30 nonconsecutive patients who underwent surgery by variable surgical procedures of acquired hydrocephalus at Benha University Hospital from March 2022 to June 2023. This study followed the ethical committee of Banha University **{M.S.38.3.2022}.** written ethical consent had been taken from parents of the studied patients

Inclusion criteria:

- All cases with acquired (secondary) hydrocephalus
- Infantile age group ≤ 24 months.

Exclusion criteria

- Cases of congenital hydrocephalus.
- Patients' age above 24 months.

❖ A series of non-consecutive 30 cases were included in our study.

❖ Patients' demographics, preoperative clinical state, laboratory tests, imaging features, operative notes, the degree of improvement of manifestations, evaluation of postoperative outcome, and follow-up clinical and radiological findings were collected.

❖ The presence of hydrocephalus was determined by CT brain which is usually enough for diagnosis but in some cases Preoperative MRI brain needed to determine the presence of complex multi-loculations which usually need endoscopic fenestration surgery.

❖ The presence of CSF infections determined by CSF analysis and culture

Surgical technique of shunt insertion

All the operations were performed in Neurosurgery department, Banha University Hospital.

Under general anesthesia:-

- Shave the hair away from incision site.
- Clean the skin with an antiseptic
- Apply a sterile fenestrated drape over the incision sites (head, neck, chest, and abdomen)
- Make a "U or C" shaped skin incision over the entry point where the burr hole is to be performed for the introduction of the ventricular catheter. If the frontal approach will be used, then **Kocher's point** is used which is an entry point that is (11 cm superior and posterior from the nasion, 3 cm lateral to midline along the mid pupillary line, and 1 to 2 cm anterior to the coronal suture) .For a parieto-occipital approach, **Keen's point** is used which is approximately 2.5 to 3 cm superior and posterior to the pinna.
- Burr hole is performed at the desired entry point and a small entry point in

the dura is coagulated and incised.

- Ventricular catheter is introduced directed into the ventricle and cut to the appropriate pre-measured length
- CSF samples are collected
- The ventricular shunt is connected to the valve and secured with a silk tie.
- An incision in the abdomen is done to access the peritoneal cavity; the site depends on the surgeon's preference and can be done in the upper quadrant Paramedian or the midline
- Shunt passer is used to pass the peritoneal distal catheter between both incisions.
- Peritoneal catheter is connected to the valve and secured with a silk tie.
- After good distal CSF flow at the peritoneal catheter, it is introduced into the peritoneal cavity.
- Wounds are closed in anatomical layers
- The CSF sample is sent to the laboratory analysis
- The distal catheter can be placed in the abdomen (peritoneal cavity), heart via a cervical venous access, chest cavity (pleura), or rarely into the ureter or the bladder if all previous sites

Postoperative evaluation:

- Postoperatively, patients were transferred to NICU unit for at least one day, and then returned to the ward. All patients underwent computed tomography (CT) brain on the first postoperative day to evaluate shunt position for fear of bad shunt position and to exclude any ventricular hematoma or pneumocephaly.
- Postoperatively, patients were evaluated for the clinical and functional outcome of surgery done.
- Postoperatively, Patients with shunts are evaluated for evidence of manifestations related to complications or malfunction. Acute symptoms of malfunction/infection are: lethargy, vomiting, seizure, irritability, poor feeding, head enlargement, tense fontanelle, and fever. Shunt system reservoir has to be assessed manually for delayed filling or resistance and visible for evidence of redness or swelling along the shunt tubing. X rays are done to evaluate the integrity of the system. CT brain could be done
- Patients were followed up at outpatient clinic every two weeks in the first month, monthly for the next six months, and then yearly after that. CT brain was done 6 months later after operation and yearly thereafter
- Postoperative assessment of functional outcome is determined by FSS by**,** Domains of functioning included mental status, sensory, communication, motor, feeding, and respiratory categorized from normal (1) to very severe dysfunction (5).[9]

Table (1): Functional Status Score (FSS)

	1	2	3	4	5
	NORMAL	**MILD DYSFUNCTION**	**MODERATE DYSFUNCTION**	**SEVERE DYSFUNCTION**	**VERY SEVERE DYSFUNCTION**
MENTAL STATUS	Normal sleep/wake; appropriate responsivity	Sleepy but arousable to noise / touch / movement and/or periods of social nonresponsivity	lethargic and/or irritable	Minimal arousal to stimulus (stupor)	Unresponsive and/or Coma and/or Vegetative
SENSORY	Intact hearing and vision and responsive to touch	Suspected hearing or Suspected vision loss.	Not reactive to auditory stimuli or Not reactive to visional stimuli	Not reactive to auditory stimuli and Not reactive to visional stimuli	Abnormal response to pain or touch
COMMUNICATION	Appropriate non-crying vocalizations, interactive facial expressiveness, or gestures	Diminished Vocalization Diminished Facial Expression and/or social responsiveness	Absence of attention getting behavior	No demonstration of discomfort	Absence of communication
MOTOR FUNCTION	Coordinated body movements and Normal muscle control and Awareness of action and why it's being done	1 limb functionally impaired	2 or more limbs functionally impaired	Poor head control	Diffuse Spasticity, Paralysis, Decerebrate/ Decorticate Posturing
FEEDING	All food taken by mouth with age appropriate help	NPO or need for age-inappropriate help with feeding	Oral and tube feedings	Parenteral Nutrition with oral or tube feedings	All parenteral nutrition
RESPIRATORY	Room air and no artificial support or aids	Oxygen and/or Suctioning	Tracheostomy	CPAP for all or part of the day and/or Mechanical ventilator support for part of the day	Mechanical ventilator support for all of the day and night

Statistical analysis:

All data were collected, tabulated and statistically analyzed using SPSS 22.0 for windows (SPSS Inc., Chicago, IL, USA) & MedCalc 13 for windows (MedCalc Software bvba, Ostend, Belgium).

Data were tested for normal distribution using the Shapiro Walk test. Qualitative data were represented as frequencies and relative percentages. Chi square test ($\chi 2$) and Fisher exact was used to calculate difference between qualitative variables as indicated. Quantitative data were expressed as mean ± SD (Standard deviation) for parametric and median and range for non-parametric data.

Independent T test and Mann Whitney test were used to calculate difference between quantitative variables in two groups for parametric and non-parametric variables respectively.

All statistical comparisons were two tailed with significance Level of P-value ≤ 0.05 indicates significant, $p < 0.001$ indicates highly significant difference while, $P > 0.05$ indicates non-significant difference.

RESULTS

A series of 30 patients were included in our study. The mean age was 11.43 months with standard deviation 6.28. Regarding gender, there was male predominance about 53.3% (16 of 30) males and 46.7% (14 of 30) were females. Regarding maturity at birth, 53.3% preterm and

46.7% full-term .Regarding the weight at birth 56.7% were underweight (birth weight < ٢kg) , 36.7% were normal weight at birth (4.0 kg > birth weight ≥ 2 kg) and 6.7% were overweight (birth weight ≥4.0 kg). In our study, there were 70% (21 of 30) of the patients admitted to NICU for variable causes, ٢٠% stayed there for less than one month and the other 50% stayed for more than one month and 30% of patients (9 of 30) not admitted to NICU after birth. we detected that There were 73.3% of the patients had systemic sepsis by continuous fever (above 38.5 °C , elevated CRP and positive blood cultures) that acquired due to either septic focus (infection) or acquired from NICU admission. And the other 26.7 % patients had no sepsis markers. As in table 2.

Regarding dominant clinical manifestations patients presented by, there were 43.3% of the patients presented mainly with enlarged head (increased head circumference), 33.4% presented mainly with vomiting, 13.3% presented mainly with fits, 6.7% presented mainly with disturbed conscious level, and 3.3% presented mainly with abnormal gaze (6th nerve palsy). As in table 3.

In our evaluation, after taking a sample of CSF from anterior fontanel we detected by physical, chemical and cytological analysis that 20% of the patients had normal CSF parameters according to CSF proteins, glucose and WBCs, while the other 80% showing signs of CSF infection involving elevated protein contents, low glucose content in some cases denoting consuming of it by bacteria mainly and elevated WBCs contents with predominant cells either lymphocyte that mainly increased by viral infection 20% or neutrophils 60% that denoting bacterial infection. CSF culture and sensitivity after physical and chemical analysis detected that, there were 40% of patients' samples showing no growth for bacterial microbes while the other 60% of patients' samples cultured for bacterial microbes There were 55.5% of the patients whose their CSF sample cultured organisms showed gram -ve bacilli which are most virulent like (Enterobacter, Klebsiella, Pseudomonas aeruginosa, Acinetobacter, tenotrophomonas Escherichia), 33.3% showed gram +ve cocci like (Staphylococcus aureus, Streptococcus pyogenes, and Strep pneumoniae, Staph. epidermidis,Staph.saprophyticus and Enterococcus faecalis., and 11.1% were gram -ve cocci (diplococci Neisseria gonorrhoeae, Neisseria meningitidis, and Moraxella catarrhalis).. Which is useful for determining the proper antibiotics by sensitivity test.As in table 4.

In our study, there were 64.4% of cases underwent surgery within 1 month after diagnosis of the condition and 36.6% underwent surgery after 1 month due to being unfit for surgery. 2 cases operated with CPC followed by VP shunt, 2 cases operated with ETV,15 cases operated with EVD followed by VP shunt, 3 cases operated with repeated EVD insertion and 8 cases operated with VP shunt only As in table 5

There were 33.3% of the patients with good outcome including improvement of presented manifestation with no need for any surgical procedure , 26.7% were with fair outcome that needed help either with oxygen or AEDs and any other conservative treatment till reaching the expected result , and 40% of patients were poor outcome as a result of post-operative complications that needed another

procedure to resolve it.

During follow up of the patients for a period of time after surgery, 40 % (12of 30) of cases came with complications varying from mild to severe up to death.

*obstructive complications: happened in 2 (16.6%) patients with ventricular end obstruction in 1 case (delayed filling shunt reservoir) and distal end obstruction in 1case (resistant shunt reservoir)

*infective complications : appeared in 4 (33.3%) patients, 1 patient had scalp wound infection with skin slouphage over reservoir, 2 patient had brain abscess, 1 patients had ventriculitis..

* Abdominal Complications happened in 2(16.7%) patients, 1 patients had Abdominal pseudocyst, 1 patient had incisional hernia

*iatrogenic complications: happened in 2(16.7%) patients, in 2 patients there was ventricular mal position of shunt that required revision

*Death : 2 (16.7%) case died from intraventricular hemorrhage caused by ventricular end insertion

Table (2): Demographic data and NICU admission distribution of the studied patients

Clinical characteristics	**Number of patients (%)**
Gender	
Male Female	16 (53.3%)
	14 (46.7%)
Mean age (years)	11.43
Weight at birth	
Normal	11 (36.7%)
Overweight	2 (6.7%)
underweight	17 (56.7%)
Prematurity at birth	
Pre-term	16 (53.3%)
Full-term	14 (46.7%)
NICU admission	
-Admitted to NICU	21 (70%)
Less than 1 month	6 (20%)
More than 1 month	15 (50%)
-Not Admitted to NICU	9 (30%)
Systemic sepsis	
Present	22 (73.3%)
Absent	8 (26.7%)

Table (3): Main Presenting manifestation of the studied patients

Main presenting symptoms	**Number of patients (%)**
Abnormal gaze	1 (3.3%)
Disturbed conscious level	2 (6.7%)
Increasing head circumference	13 (43.3%)
Fits	4 (13.3%)
Vomiting	10 (33.4%)

Table (4): results of CSF analysis and culture distribution of the studied patients.

CSF analysis	Number of patients (%)
Normal CSF parameters	**6 (20%)**
Proteins & WBCs mainly lymphocytes	**6 (20%)**
Proteins & WBCs mainly neutrophils	**18 (60%)**
CSF culture	
No growth	**12(40%)**
Positive	**18 (60%)**
Csf culture organisms	
Gram –ve bacilli	**10(56%)**
Gram –ve cocci	**5 (33%)**
Gram +ve cocci	**3 (11%)**

Table (5) : distribution of studied patients according to time of surgery applied.

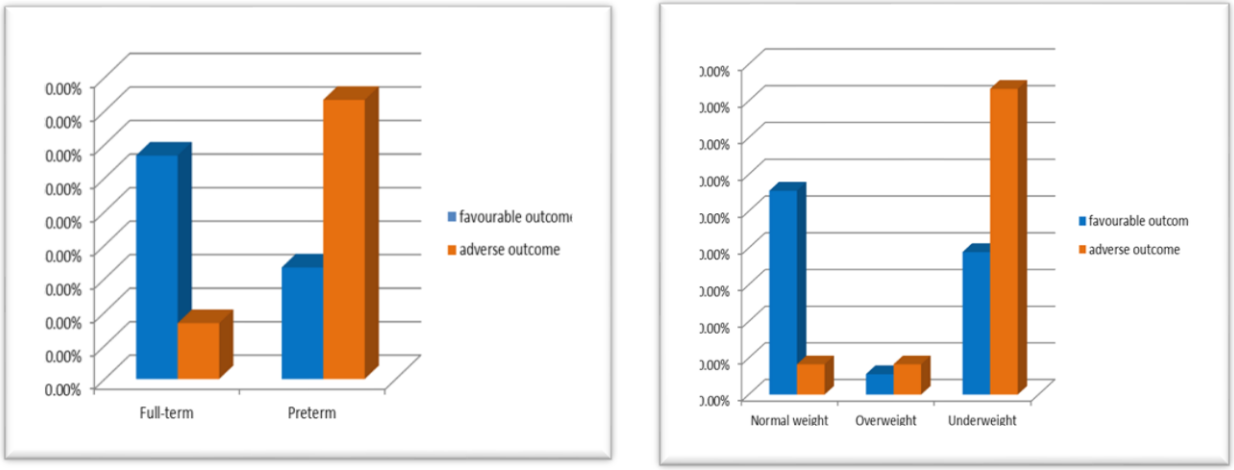
Time of surgery after diagnosis	Number
within 1 month from diagnosis	**19 (64.4%)**
after 1 month from diagnosis	**11 (36.6%)**
Type of surgical procedures applied	
CPC followed by VP shunt	2
ETV	2
EVD followed by VP shunt	15
Repeated EVD insertion	3
VP shunt only	8

Table (6): Comparison between patients' parameters according to clinical and surgical outcome.

Variable		*Favorable Outcome (N=18)*	*Adverse outcome (N=12)*	*Test X2/FET*	*P value*
Age (months) Mean ± SD		**12.89 ± 5.99**	**9.25 ± 6.31**	**1.6**	**.122**
Sex	***Male***	**10 (55.6%)**	**6 (50%)**	**.089**	**.765**
	Female	**8 (44.4%)**	**6 (50%)**		
Maturity at birth					
Full-term		**12 (66.7%)**	**2 (16.7%)**	**7.23**	**.007**
Preterm		**6 (33.3%)**	**10 (83.3%)**		
Weight at birth					
Normal weight		**10 (55.6%)**	**1 (8.3%)**	**6.97**	**.031**
Overweight		**1 (5.6%)**	**1 (8.3%)**		
Underweight		**7 (38.9%)**	**10 (83.3%)**		
NICU admission					
yes		9 (50%)	12 (100%)	8.57	.003
no		**9 (50%)**	**0**		
No NICU admission		**8 (44.4%)**	**1 (8.33%)**	**5.4**	**.005**
NICU duration					
< 1 month		**5 (27.8%)**	**1 (8.3%)**	**14**	**.001**
> 1 month		**4 (22.2%)**	**11 (91.7%)**		
Presence of comorbidities		**2 (11.1%)**	**10 (83.3%)**		
Presence of systemic sepsis					
Present		**10 (55.6%)**	**12 (100%)**	**7.27**	**.007**
Absent		**7(38.8%)**	**1(8.3%)**	**4.6**	**.0002**
Positive CSF culture		**7 (38.9%)**	**11 (91.7%)**	**8.36**	**.004**
CSF organisms					
Gram -ve bacilli		**٢(11.1%)**	**٨(66.6%)**	**7.6**	**.006**
Gram -ve cocci		**١(5.5%)**	**١(8.3%)**		
Gram +ve cocci		**٤(22.2%)**	**2(11.1%)**		
Time of surgery after diagnosis					
within 1 month from diagnosis		**14 (77.7%)**	**5 (41.6%)**	**6.1**	**.005**
after 1 month from diagnosis		**5 (27.8%)**	**6 (50%)**		

In the end of our study, after evaluation of all studied patients, we discovered that 66.7% of full- term patients had a favorable surgical and clinical outcome while most of preterm babies (83.3%) had the worst outcome. (P<0.05)

In the end of our study, after evaluation of all studied patients, we discovered that 55.6% of normal birth weight patients had a favorable surgical and clinical outcome while most of underweight babies (83.3%) had bad outcome (P<0.05) with no significant difference between overweight babies

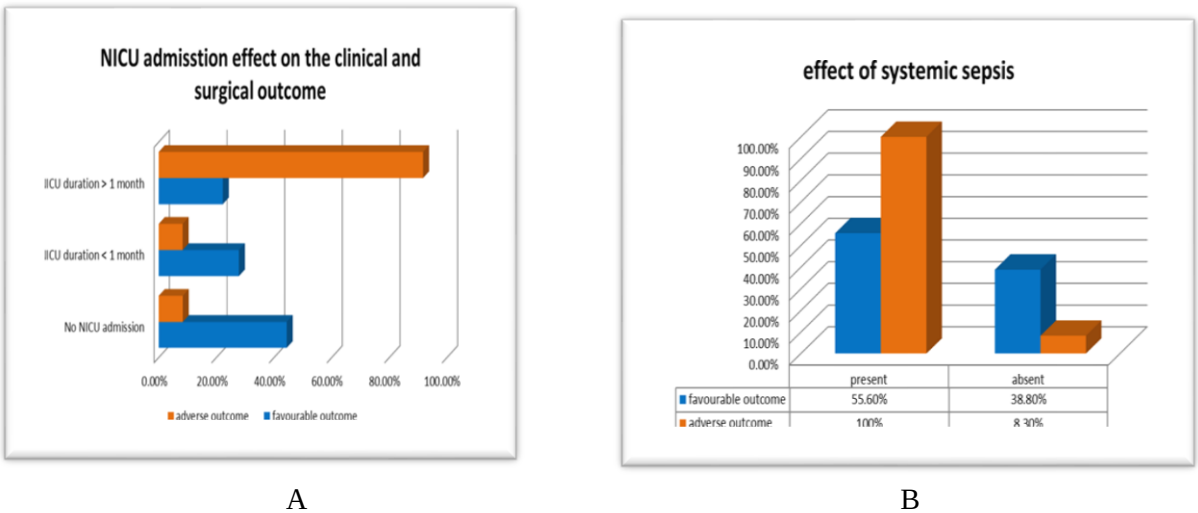


A B

Fig.(1) Effect of patients' maturity at birth abd birth weight on clinical and surgical outcome
A :Comparison between groups according to maturity at birth effect on clinical and surgical outcome..
B :Comparison between groups according to birth weight effect on clinical and surgical outcome..

In the end of our study, after evaluation of all studied patients, we discovered that 8 of 9 patients who not admitted to NICU had the best outcome among all patients while patients admitted to NICU for less than 1 month 27.8 % of them had a better outcome. But patients who admitted to NICU had the worst surgical and clinical outcome ever, 91.7% of patients with adverse outcome were admitted to NICU for a long period (more than 1 month) (P<0.05)

In the end of our study, after evaluation of all studied patients, we discovered that 55.6% of patients with adverse clinical and surgical outcome had systemic sepsis but patients who had not systemic sepsis had better outcome among all patients(P<0.05)



A B

Fig.(2): Effect of NICU admission and presence of systemic sepsis on clinical and surgical outcome
A: Comparison between groups according to NICU admission effect on clinical and surgical outcome.
B: comparison between groups according to NICU systemic sepsis effect on clinical and surgical outcome.

In the end of our study, after evaluation of all studied patients, we discovered that patients with Gram –ve bacilli in CSF culture had the most adverse impact on surgical and clinical outcome (66.6% of patients) while most of patients with Gram +ve cocci had a great favorable among all patients (P<0.05)

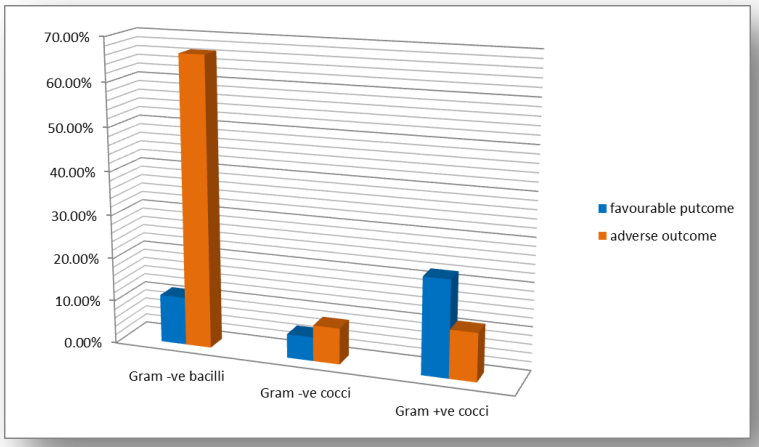


Fig.(3) Comparison between groups according to CSF culture organisms effect on clinical and surgical outcome.

In the end of our study, after evaluation of all studied patients, we discovered that 77.7% of patients underwent surgery with 1 month from diagnosis had a favorable surgical and clinical outcome while most of patients who underwent surgery after 1 month from diagnosis had adverse outcome(P<0.05)

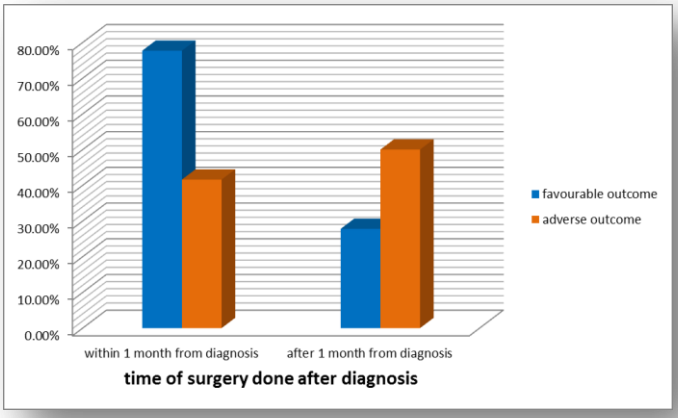


Fig.(4): Comparison between groups according to time of surgery effect on clinical and surgical outcome.

Discussion

In our study regarding the age of the studied patients: The age range was from 1 day to 24 months old, that was similar to a prospective study done 50 consecutive cases of hydrocephalus, they found that the majority of cases lies below the age of 1 year. [10]

Sixteen cases in our study were males (53.3%) and fourteen cases were female (46.7%) denoting slight male predominance with no statistical significance affecting the outcome of the surgical procedure. in a 2-year retrospective clinical study on 1200 patients proved that Gender also was not significantly associated with the presence of hydrocephalus. [11]

in our study, regarding maturity of baby at birth (gestational age) and birth weight, the study revealed that preterm babies and those with low birth weight had a higher risk of developing hydrocephalus more than full term ones or those with normal birth weight due to high risk of interventricular hemorrhage and post-hemorrhagic hydrocephalus later. It occurs in preterm infant as they usually prone to NICU admission that resulted in adverse impact on the expected clinical outcome of surgical procedures done and more liable to complications and comorbidities. In other clinical study performed on 46 of very low birth weight infants found that preterm infants with had the highest risk groups were the very low birth weight (<1000 g) infants, and those <32 weeks gestational age at birth. That was similar to our results. [12]

In our study, we classified the patients according to birth weight into low birth weight (below 2 kg), normal weight (2-4 kg) and over-weight (above 4 kg). Low birth weight babies had the least favorable clinical and surgical outcome among the 3 groups. In a study conducted On 1100 cases examined the delivery records of the year 2013 in five hospitals in Northern Ghana 2015 mentioned that Weight at birth can be classified into three categories, that is normal (2.5 kg < birth weight $\geq$ 4.0 kg), low birth weight (birth weight 2.5 kg) or high birth weight (birth weight $\geq$ 4.0 kg). The last two conditions have adverse consequences on the clinical and surgical outcome of the infant. [13]

We found that the weight of patients at surgery time is directly proportional with the favorable clinical and surgical outcome with cutoff point of 2,000 kg, below it there were less favorable clinical and surgical outcomes. Another study done on neonates born between 2000 and 2005 who underwent shunt procedures and revealed that weight at the time of procedure was statistically significant between the groups with successful VP shunt versus those with failure [14].

Our study showed significance between weight at the surgery and shunts complication. However, another observational study on 839 cases research revealed that patients who weighed less than 3000 g had no statistically significant difference in infection rate. [15] Another study conducted on 466 consecutive shunt operations were analyzed retrospectively in 294 children, and 60 children were studied prospectively stated that infants aged less than six months have a higher risk of infection and complications, especially in those groups who were underweight at birth or premature. This was explained by infants' poor cellular and humoral immunity, incomplete development of skin barrier, and history of other comorbidities or procedures [16].

in our study, NICU admission for newborn after birth either due to prematurity at birth or low birth weight or respiratory distress had bad impact on developing meningitis as a hospital acquired infection and later post meningetic hydrocephalus. Also had an adverse impact on the surgical treatment applied to studied patients as it has a vital role in acquiring multi-organisms and systemic sepsis later on.

Also we found that patients kept in NICU for long period (more than 1 month) was much worse than shorter period of NICU admission in general condition and clinical and surgical outcome.

In our study according to causes of acquired hydrocephalus, post meningetic type was the most prevalent one but also it was the reason of most of the adverse outcome of surgical treatment so post hemorrhagic and post tumor ones were easily to control the condition. That was in line with a study done on 129 infants diagnosed with acquired hydrocephalus were recruited from 2008 to 2021, showed that Hydrocephalus occurs secondary to post-hemorrhage and had a favorable outcome compared with other etiologies in both preterm and full-term groups. That wasn't in line with another study conducted on total of 431 patients who underwent their first cerebrospinal fluid shunt insertion; found that the primary cause of hydrocephalus in patients with shunt placement is intraventricular hemorrhage. However, it constitutes only 13.3 % of our patients in our results [17 and18].

In our study, regarding CSF analysis of the studied patient revealed normal CSF parameters in some cases (post-hemorrhagic and post-tumor) but the other samples confirmed the presence of CSF infection through elevation of CSF protein content more than 0.2 gm. and change of glucose content with high levels of WBCs found.

We found that cases with infected CSF especially those with elevated WBCs with predominant neutrophils had more adverse clinical and surgical outcome than others. As Simple lymphocytic meningitis has an excellent prognosis with almost zero mortality. And so post infectious hydrocephalus with lymphocytes predominantly cases had the better outcome of surgical procedures done.

During our evaluation using CSF culture, cases with Gram –ve bacilli in CSF had the worst outcome among the studied patient especially those with pseudomonas and klebsilla, so obliged for several times of shunt obstruction and revision and even removal of inserted shunt and usage of EVD. Gram –ve cocci had slight favorable response and the G +ve ones had better prognosis. That was in line with a study conducted on 232 full term neonates with bacterial meningitis admitted to 3 neonatology departments in Shanghai, China. Reported that neonates with neonatal bacterial meningitis who had poorer outcomes also had higher levels of CSF protein. This indicates that high CSF protein levels in neonates with neonatal bacterial meningitis may be a good marker for more aggressive therapy. [19]

Regarding type of pathogen detected in CSF culture, we found that 60% of patients with bacterial meningitis had a confirmed bacterial etiology. patients with gram –ve bacilli and slightly gram –ve cocci in CSF sample had a more virulent course of disease and development of multiple loculi, septaions, and more adhesions as aresult of ventriculities so repeatedly reported with shunt infection and obstruction more than those with gram +ve ones.

In a study conducted on 103 patients

with a mean age of 2 years, found that Since the insertion of VP shunt over the last 60 years, infection critically affects approximately 8-10% of all shunted patients, leading to significant morbidity and mortality and generally occurring a few months following surgery .The most common pathogens reported causing shunts infection are coagulase-negative staphylococci, especially Staphylococcus epidermidis, located on the surface of a person's skin and in the sweat glands and hair follicles deep within the skin, followed by Staphylococcus aureus and a variety of gram-negative bacilli [20].

In our study, we found that the earlier the surgery done to patients (within 1 month) from diagnosis of hydrocephalus after had been diagnosed, the better the outcome before multiple septations and loculi could be formed. Patients with multiloculated hydrocephalus were at high risk of morbidity due to the recurrent nature of the pathological septations, which frequently necessitates the placement of multiple shunts and/ or redo surgeries or shunt revisions. That was similar to a study conducted on 56 patients showed that The timing of drain implantation longer than 1 month after hydrocephalus is diagnosed might be a risk factor for poor mental and linguistic developmental outcome so cutoff point of 13 days was determined for surgical intervention time in infantile acquired hydrocephalus,. Also that was in line with another retrospective study on 32 premature baby reveled early EVD is associated with lower rates of cognitive, communication and social disabilities than later EVD in infants with post hemorrhagic hydrocephalus. [21]

In our study, there was 40% of cases came back by shunt dysfunction due to variable causes all of them had at least 1 factor predicting adverse outcome of surgery done before either like, prematurity, LBW, NICU admission for long time and CSF infection with high virulent organism. In a retrospective study on a total of 1719 patients reveled shunt dysfunction in childhood hydrocephalus has been reported to affect 40% of cases within 1 year and 50% of cases within 2 years. [22]

Case no (1):

4 months male infant with no history of congenital hydrocephalus. Born with Gestational age 36 weeks, underweight 1960 gm so admitted to NICU for 2 months gained meningitis with systemic sepsis. 3 weeks after being discharged from NICU, mother noticed his head enlarging (HC 42.5 cm) CSF analysis showing high infection parameters mainly neutrophils with multiple CSF cultures (multiple Gram–ve bacilli). Patient after clearance of CSF, undergoing endoscopic fenestration done then VP shunt insertion. But with no improvement of vomiting and no control of head size so shunt revised multiple times with CSF leak over reservoir of shunt. Patient is prepared for another fenestration.

Fig(5): images of illustrated case showing progression of infection and formation of multiloculated hydrocephalus with surgery done and postoperative complication.

A: CT brain showing hydrocephalus

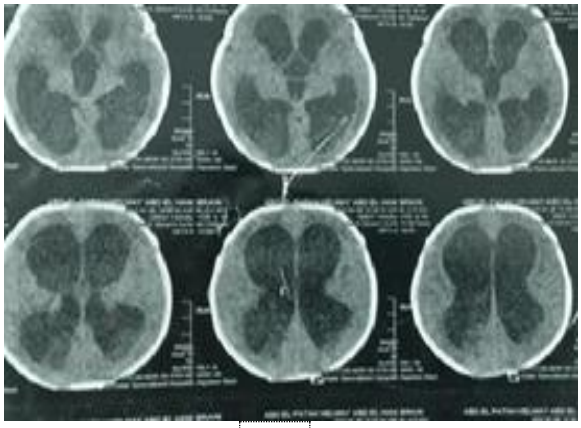
B : CT brain done after developing multi-loculations

C: MRI brain done for preparing for endoscopic fenestration

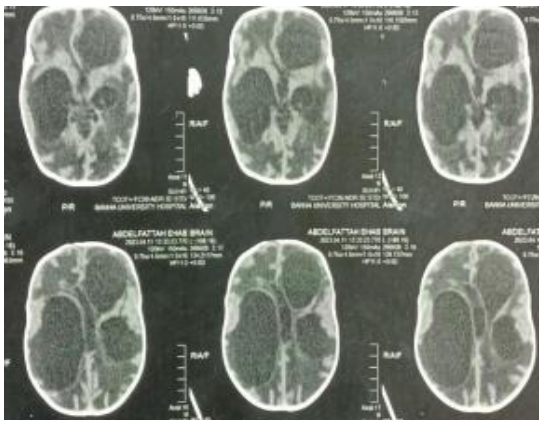
D: multiple CSF cultures

E: endoscopic fenestration

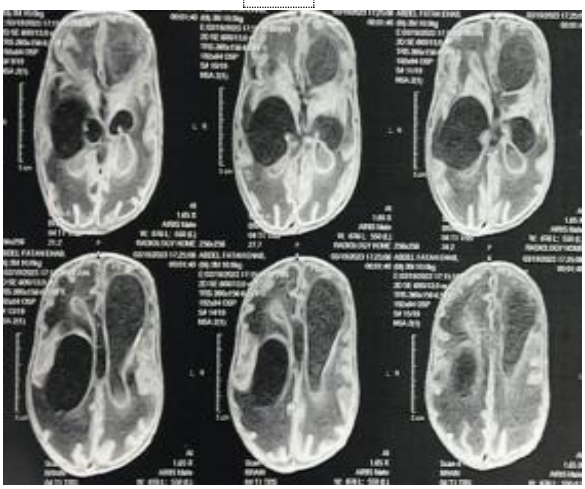
F: collection over reservoir



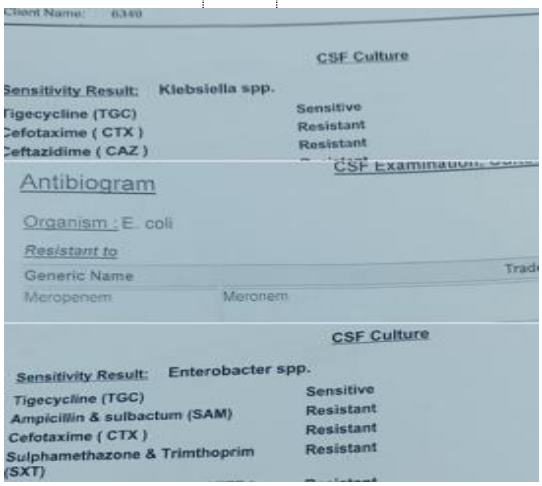
A



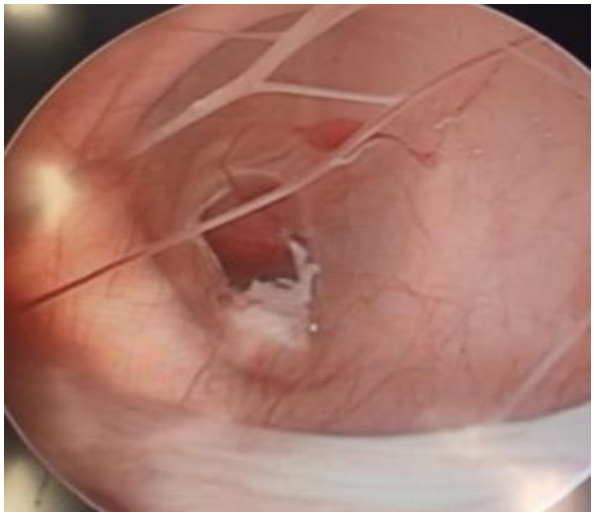
B



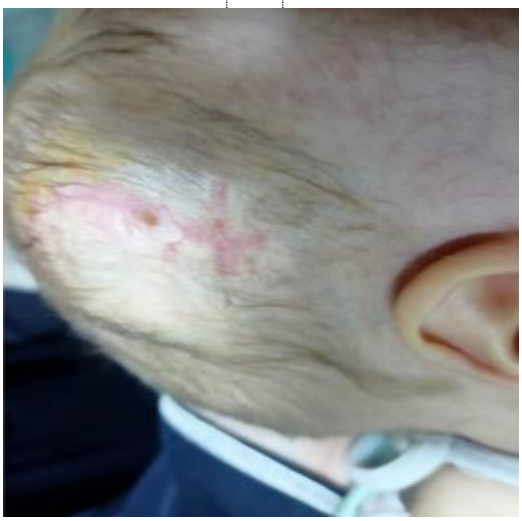
C



D



E



F

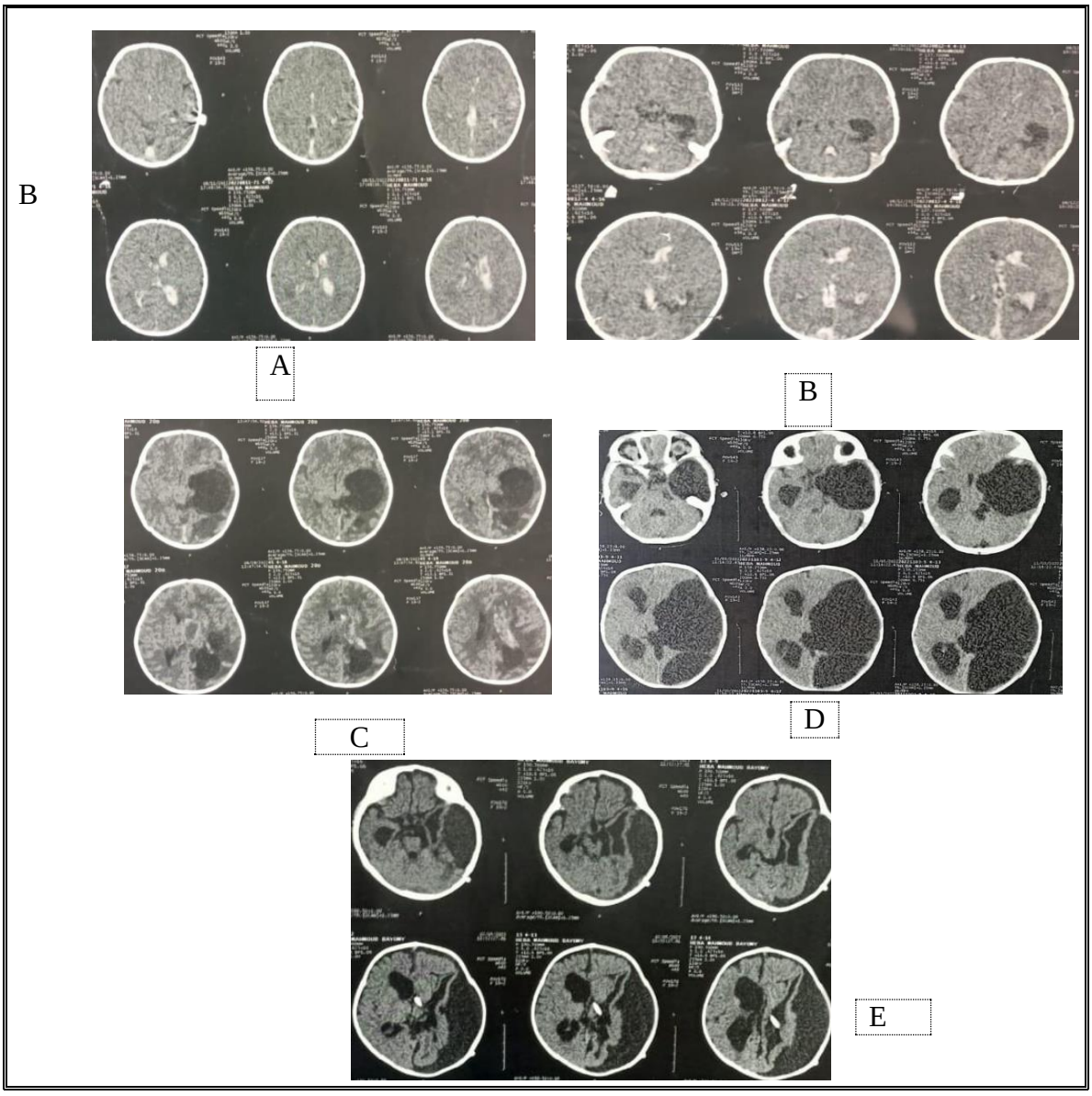
Case no (2)

7 months female infant with no history of congenital hydrocephalus, was full term at birth, normal weight (3 kg), not admitted to NICU after birth, came to ER after falling to ground by intraventricular hemorrhage and subarachnoid hemorrhage. After 1month baby came by enlarged head size and vomiting CT brain ordered and showed post hemorrhagic hydrocephalus. CSF sample taken for analysis, showed no indicators for infection .So she was operated directly with VP shunt insertion with controlling of manifestations and improvement of clinical and surgical outcome.

Fig (6) : multiple CT brain scans showing development of post-hemorrhagic hydrocephalus and postoperative scan of shunt insertion

A, B, C and D: multiple CT brain scans showing development of hydrocephalus post intraventricular hemorrhage

E: CT brain postoperative after shunt insertion



Conclusion

Secondary hydrocephalus in a premature baby, with LBW, especially if admitted to NICU for more than 1 month, with presence of systemic sepsis and CSF infection by G-ve bacilli especially with frequent CSF tapping had the worst outcome. While maturity and normal birth weight without NICU admission, and absence of sepsis with negative CSF culture predicting a favorable clinical and surgical outcome.

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