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## Study of Hydrocephalus in Pediatric population using computed Tomography

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Hydrocephalus is a common disease that occurs in pediatrics, and it may occur in the elderly. Hydrocephalus has three different types, including non-communicating, communicating, and normal pressure hydrocephalus. The main objective of this study was to evaluate the role of computed tomography (CT) in the diagnosis of hydrocephalus disease of pediatric patients. The study was carried out in Ribat University Hospital and AL-Almal National Hospital during the period from March 2019 up to September 2019, selecting a random sample of 35 patients, 16 of them were males, and 19 were females with different ages who were transferred to CT department to make investigations. Brain ventricles were measured to determine the site of obstruction and then determine the type of hydrocephalus. The problem of the study is the increase in the number of cases with hydrocephalus. All axial images were studied by senior radiologists to diagnose the stage of hydrocephalus, types, and causes, The data were analyzed through the statistical package for social science. The results showed that hydrocephalus is more common in females (54.7 %) than in males (54.3 %), but with a small difference (0.4 %). communicating and non-communicating showed the same result (57.1) %

**Keywords:** hydrocephalus, computed tomography; pediatric patients

### 1. INTRODUCTION

Hydrocephalus is the buildup of too much cerebrospinal fluid (CSF) in the brain. Typically, this fluid cushions the brain. When it is too much, it increases the compression on the head. Hydrocephalus occurs due to acquired or congenital reasons. Acquired hydrocephalus, which can occur at any age due to head injuries, strokes, infections, tumors, and bleeding in the brain. Hydrocephalus can permanently damage

the brain, lead to physical and mental development. Congenital hydrocephalus, which is present at birth, due to genetically related problems, causes an unusually large head. Untreated hydrocephalus is usually fatal. With treatment, many people lead healthy lives with few limitations. Treatment usually involves surgery to insert a shunt. Medicinal and rehabilitation treatment can also help. ((Owler , 2009; Figaji et al., 2005, Johnston et al., 2003). Hydrocephalus is

a difficulty of inequity between the creation and drainage of the cerebrospinal fluid (CSF). On a daily average, almost 500 mm of the CSF formed within the brain daily. Once formed, CSF usually circulates among all the ventricles before it is absorbed and returned to the cardiovascular system. The average adult volume of circulating CSF is 150 ml. The CSF circulates more than three times per day. Because production is independent of absorption, reduced absorption causes CSF to accumulate within the ventricles (Golden et al. 2007). There are three different types of hydrocephalus. In the most common variety, reduced absorption occurs when one or more passages connecting the ventricles become blocked. The blockage in ventricles avert the CSF flow to the sub-arachnoid space causing non-communicating hydrocephalus. On the other hand, communicating hydrocephalus takes place due to the low absorption rate; as a result, the absorptive tissue damage. Both hydrocephalus types lead to an elevation of the CSF pressure significantly within the head, pushing aside the soft tissues. This increase in pressure resulted in soft tissue distortion and damage. Since in infants, their skull bones have not yet combined, the intracranial pressure is partly comforted by the enlargement of the skull. Finally, normal pressure hydrocephalus diagnosed by ventricle expansion without a noticeable rise in CSF pressure (Figaji et al. 2005). Hydrocephalus may be noticed its signs and symptoms; though, brain imaging is the pillar of the diagnosis of this disease. Magnetic resonance imaging (MRI) computed tomography (CT) are imaging techniques that capable of detecting the enlargement in brain ventricles and may specify a particular cause of hydrocephalus. Abnormal findings such as haemorrhages and malignant or benign tumours and can also be perceived. Small abnormalities that may not be detected using CT scans, such as cysts and abscesses, are often seen with MRI. CT and MRI can also help the neurosurgeon differentiate between communicating and non-communicating hydrocephalus. In the case of suspected normal pressure hydrocephalus, a spinal tap may help determine CSF pressure (Saladin, 2007, Tanaka et al., 1997, Klinken et al., 1995). A cistern gram evaluates the dynamics of CSF flow in the brain and spinal cord. In this procedure, the dynamic contrast medium is injected into the subarachnoid space around the brain. A series of radiographic images are taken once the contrast medium has circulated through the entire CSF path. Cisternography can travel CSF concentration,

obstruction, leakage, and pressure. In older people, pressure in the head can cause papilledema, swelling of the optic nerve.

Papilledema can frequently be perceived while inspecting the patients' eyes. Regrettably, it typically shows well-developed hydrocephalus. In rare cases, long-standing hydrocephalus causes blindness. (Aschoff, et al. 1999, Casmiro et al., 1999). The obstruction causes CSF to build up in the brain. If the cause is congenital, symptoms such as an enlarged skull may be present at birth. Acquired hydrocephalus can develop at any age as a result of head trauma or disorder. Congenital hydrocephalus takes place during fetal growth and is present at birth. Reasons comprise internal bleeding in the brain and infection (toxoplasmosis, rubella) (Aschoff et al., 1999, Gideon et al., 1994). The congenital malformations are commonly associated with CSF obstruction, while acquired hydrocephalus can occur at any age (Aschoff et al. 1999, Tedeschi et. al., 1995).

### 1.1 Importance of the study:

CT scans provide a three dimensional (3D) transmission images of the brain by using x-rays. The X-rays images provide useful diagnostic information for bones as well as soft tissue. A CT will demonstrate the ventricles' morphological findings and clearly show any enlargement of CSF blockage.

## 2. MATERIALS AND METHODS

### 2.1 Material:

#### 2.1.1 Sample of the study:

A total sample of 35 patients with signs and symptoms of hydrocephalus were included in the study. All of the patients investigated by CT scan for justifiable clinical indications. The average patient's age was ranging from one day to 75 years.

#### 2.1.2 Area and duration of the study:

The study had been carried out during the period from March 2019 up to September 2019 at the National ribat university hospital and AL-Amal national hospital.

#### 2.1.3 CT machines:

### 2.2 Methods:

All CT procedures were performed using the same CT machine model SIEMENS SOMATOM Sensation 16 CT Scanner (Siemens, Erlangen, Germany). Fixed tube potential was used at both

hospitals, equivalent to 120 kVp. Two modes of tube current were used: medium 63 mA and low (45 mA) and 64 mA and 250 mA at the national ribat university hospital and Al-Amal national hospital, respectively.

### 2.2.1 Imaging technique:

Axial scans were obtained with slice thickness ranged from 3 to 5 mm at the base of the skull and 7 to 10 mm above the sella turcica. Axial images without contrast were obtained with gantry tilt from 10 to 15-degree angle with the radiographic baseline. Most of the infants underwent a CT scan after sedation, and a slice thickness of 10 mm was used.

### 2.2.2 Image interpretation:

All CT procedures were performed using the same CT machine model SIEMENS SOMATOM Sensation 16 CT Scanner (Siemens, Erlangen, Germany). Fixed tube potential was used at both hospitals, equivalent to 120 kVp. Two modes of tube current were used: medium 63 mA and low (45 mA) and 64 mA and 250 mA at the national ribat university hospital and Al-Amal national hospital, respectively.

### 2.2.3 Data analysis:

The data analyzed through the statistical package for social science (SPSS) version 20.

## RESULTS AND DISCUSSION

The study showed that 54.3% are male, while 45.7% are females, as in Table 1 and Fig 1. It was estimated that 8.6% of the study population with an age range from one day to one month. While 28.6% of the patients' groups'  $\leq$  one-year-old. Sixteen patients 45.7% of the patients with ages ranged from between years one month to 10 years. 11.4% of the patients their ages ranged between 11 years to 20 years (Table 2 & Figure 2). These findings reflect that children have a high susceptibility to adults because of most of the hydrocephalus incidence in infants. Comparable results were published by Davis et al. 2010, who reported that in total, 42.9% of patients diagnosed with communicating hydrocephalus, while the others 57% were diagnosed with non-hydrocephalus. The cause of hydrocephalus was in 11.2% of the patients is due to mass. 2.9% were due to aqueductal stenosis, the congenital aqueduct of Sylvius, choroid plexus papilloma. The study also revealed that 28.6% of hydrocephalus causes were due to congenital anomalies and 11.4% due to

infection (Table 3 & Figure 3). Similar results were reported by Perdaens et al. 2003, who reported the clinical signs and symptoms of the patients showed that 54.3% of the patients with head enlargement, 22.9% headache (Table 4 & Figure 4). 2.9% due to loss of balance and 20% visual disturbance as in Table 5 and Figure 5. (10)% with dilated right and left lateral ventricle by different size in mm because if there is no dilatation in the lateral ventricle, there is no hydrocephalus as in shown in Table 6 and Figure 6. The CT is informative in demonstrating the site of obstruction, and these reflected that the third ventricle is the most common site of obstruction, as in Table 7 and Figure 7. The current results findings were comparable with the results reported by Bruwer et al., 2003. Bruwer et al., 2003 findings showed that 31.4% of the patients diagnosed with dilated 4th ventricle, while 68.6% is with normal 4<sup>th</sup> ventricle, as illustrated in Table 8 and Figure 8. According to these findings, CT has a crucial role in the assessment of hydrocephalus. Because CT can be performed for all patients age groups, and usually can identify the obstruction causes. The CT drawbacks include the radiation risk to pediatric radiation as a results of repetitive exposure for the diagnosis and follow up (Alzimami et al, 2014, Suliman et al., 2015). Table 9 shows the frequency of the dilated ventricle. The results showed that 68.6% of the patients have dilatation in two lateral and third. In contrast, the rest have dilatation in the two lateral, third and fourth (31.4%) or two ventricles (2.9%). Table 10 Cross-tabulation causes with age for various clinical indications. The Table illustrated that there is a wide range of clinical signs for hydrocephalus with 28.6 % (10 cases) without apparent clinical evidence. Table 11 presented cross-tabulation results for different causes of hydrocephalus in the study sample. , concerning the type of hydrocephalus communication or non-communicating types. In this study, 57.1% (20 patients) of pediatric patients have hydrocephalus of non-communicating kind. In comparison, 24.9% (15 patients) are diagnosed with communicating hydrocephalus. Table 12 showed cross-tabulation causes with dilated ventricles. The Table showed that 65.7% (23 patients) diagnoses with hydrocephalus in the two lateral and third ventricles. The congenital hydrocephalus incidence varied globally according to the economic level (Dewan et al., 2018). The highest of hydrocephalus was observed in Latin America and Africa (316 and 145 per 105 births, congruently). Among low-income countries, the most top causes were in Africa countries, specifically sub-Saharan countries with an

incidence of more than 750 per 105 births ( Warf et al., 2011). The lowest frequency was observed in developed western countries in North America (USA and Canada with an incidence rate of about 68 births per 105 births). For middle-income countries, the incidence was lower compared to low-income countries (123 per 105 births) (Dewan et al., 2018).In Sudan, Mahmoud et al., 2014, reported the incidence of hydrocephalus was 0.4% (20 cases) per 5000 in single gestation, pregnant women. The results showed a wide variation of

occurrence according to the geographic regions. The middle Sudan region has the highest incidence compared to the other areas. The results were within the range of this study and low compared to the Sub Saharan countries. Elzain &Salim 2017 reported that the cause of hydrocephalus was due to the late intake of folic acid for pregnant ladies in addition to the other supplements. The study linked the incidence also with malaria during pregnancy and recurrent urinary tract infection.

**Table (1). Frequency distribution of gender**

Gender	Frequency	Percent	Valid Percent	Cumulative Percent
Female	19	54.3	54.3	54.3
Male	16	45.7	45.7	100.0
Total	35	100.0	100.0	



**Figure (1). Frequency distribution of gender**

Table (2). Frequency distribution of age

age	Frequency	Percent	Valid Percent	Cumulative Percent
10y	4	11.4	11.4	11.4
12y	1	2.9	2.9	14.3
13d	1	2.9	2.9	17.1
14m	1	2.9	2.9	20.0
15y	1	2.9	2.9	22.9
18y	1	2.9	2.9	25.7
1m	1	2.9	2.9	28.6
1y	1	2.9	2.9	31.4
20d	1	2.9	2.9	34.3
20y	1	2.9	2.9	37.1
22y	1	2.9	2.9	40.0
25m	2	5.7	5.7	45.7
2y	4	11.4	11.4	57.1
33y	1	2.9	2.9	60.0
3m	4	11.4	11.4	71.4
3y	1	2.9	2.9	74.3
5m	1	2.9	2.9	77.1
5y	1	2.9	2.9	80.0
6m	2	5.7	5.7	85.7
7y	3	8.6	8.6	94.3
9y	2	5.7	5.7	100.0
<b>Total</b>	<b>35</b>	<b>100.0</b>	<b>100.0</b>	

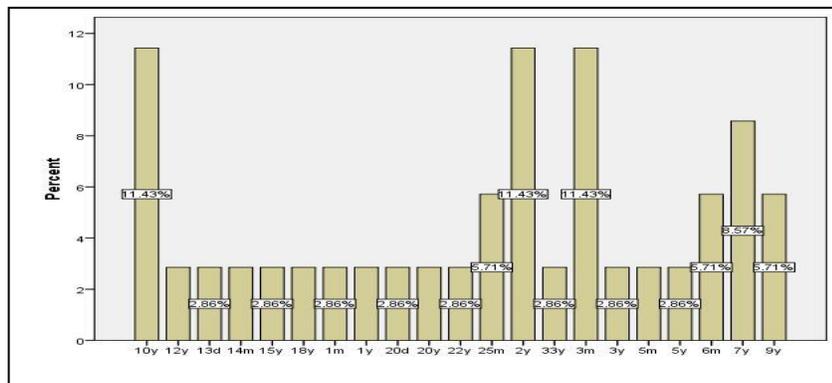


Figure (2) frequency distribution of age

Table (2) frequency distribution of age

Age group	Frequency	Percent	Valid Percent	Cumulative Percent
≤month	3	8.6	8.6	8.6
≤ year	10	28.6	28.6	37.1
≤10 years	16	45.7	45.7	82.9
11 year to 20 years	4	11.4	11.4	94.3
≥20 years	2	5.7	5.7	100.0
<b>Total</b>	<b>35</b>	<b>100.0</b>	<b>100.0</b>	

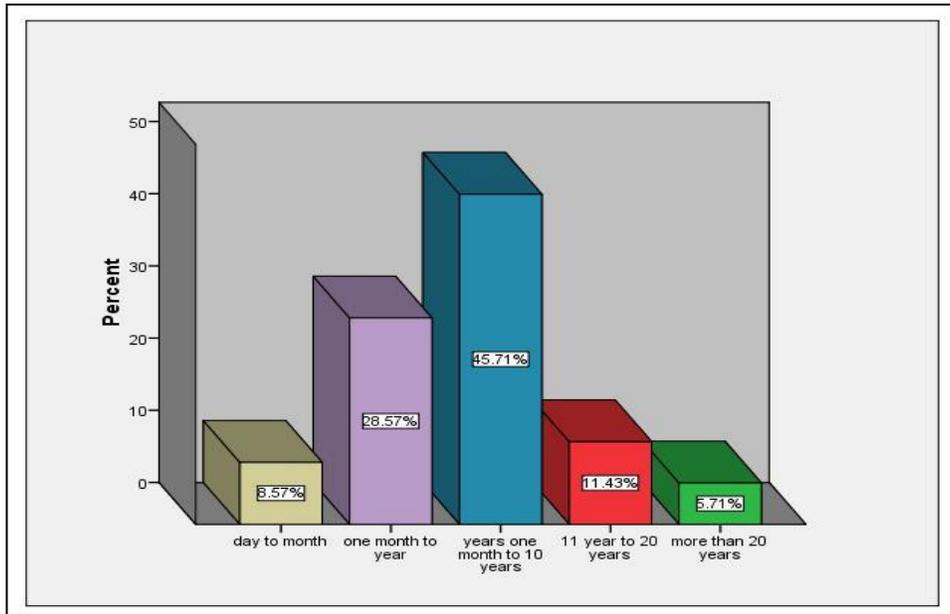


Figure (2). Frequency distribution of age

Table (3). Frequency distribution of type of hydrocephalus

Category	Frequency	Percent	Valid Percent	Cumulative Percent
<b>Communicating</b>	15	42.9	42.9	42.9
<b>Non-Communicating</b>	20	57.1	57.1	100.0
<b>Total</b>	35	100.0	100.0	

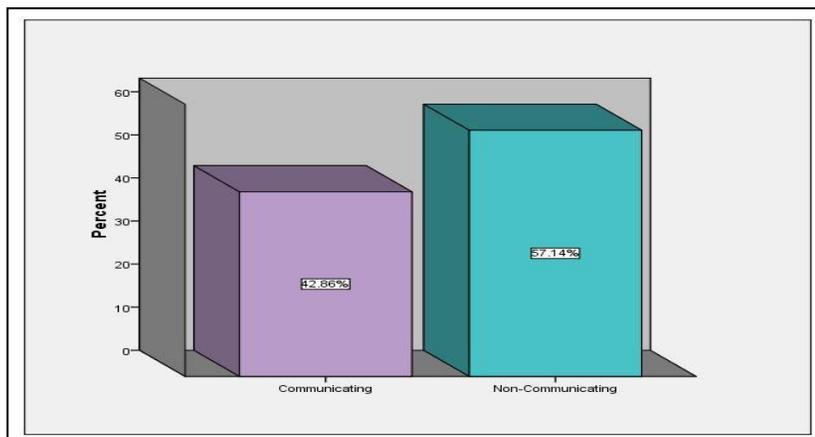


Figure (3). Frequency distribution of type of hydrocephalus

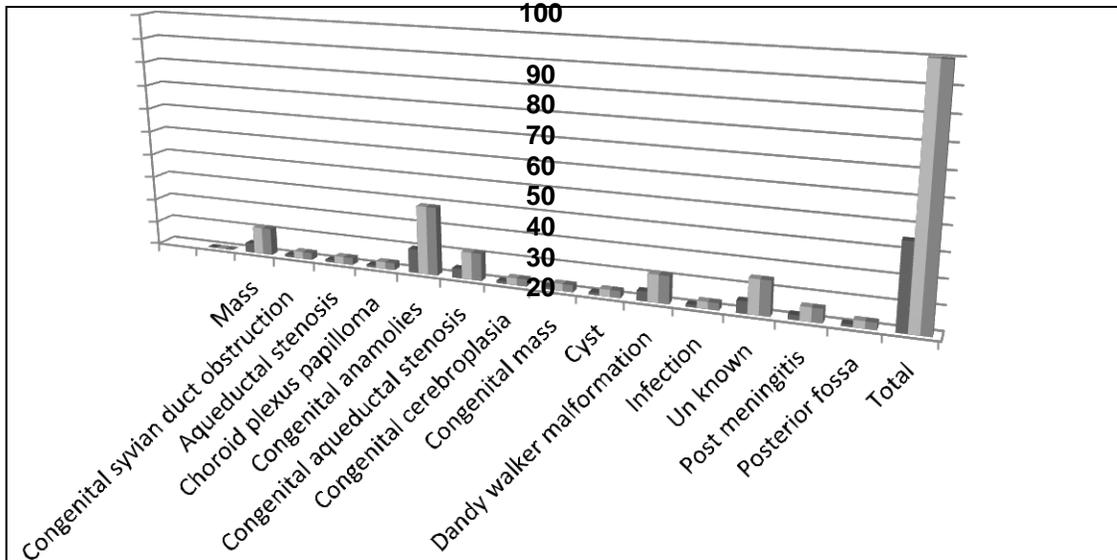


Figure (4). Frequency distribution of causes of hydrocephalus

Table (4). Frequency distribution of causes of hydrocephalus

Cause	Frequency	Percent	Valid Percent	Cumulative Percent
Mass	4	11.4	11.4	54.3
Congenital Sylvian aqueduct obstruction	1	2.9	2.9	31.4
Acquiductal stenosis	1	2.9	2.9	34.3
Choroid plexus papilloma	1	2.9	2.9	37.1
Congenital anomalies	10	28.6	28.6	28.6
Congenital acquiductal stenosis	4	11.4	11.4	54.3
Congenital cerebral palsy (CP)	1	2.9	2.9	57.1
Congenital mass	1	2.9	2.9	60.0
Cyst	1	2.9	2.9	62.9
Dandy walker malformation	4	11.4	11.4	74.3
Infection	1	2.9	2.9	77.1
Unknown	5	14.3	14.3	91.4
Post meningitis	2	5.7	5.7	97.1
Posterior fossa	1	2.9	2.9	100.0
Total	35	100.0	100.0	

Table (5). Frequency distribution of symptom and sign

Sign and symptoms	Frequency	Percent	Valid Percent	Cumulative Percent
Head enlargement	19	54.3	54.3	54.3
Headache	8	22.9	22.9	77.1
Loss of balance	1	2.9	2.9	80.0
Visual disturbance	7	20.0	20.0	100.0
Total	35	100.0	100.0	

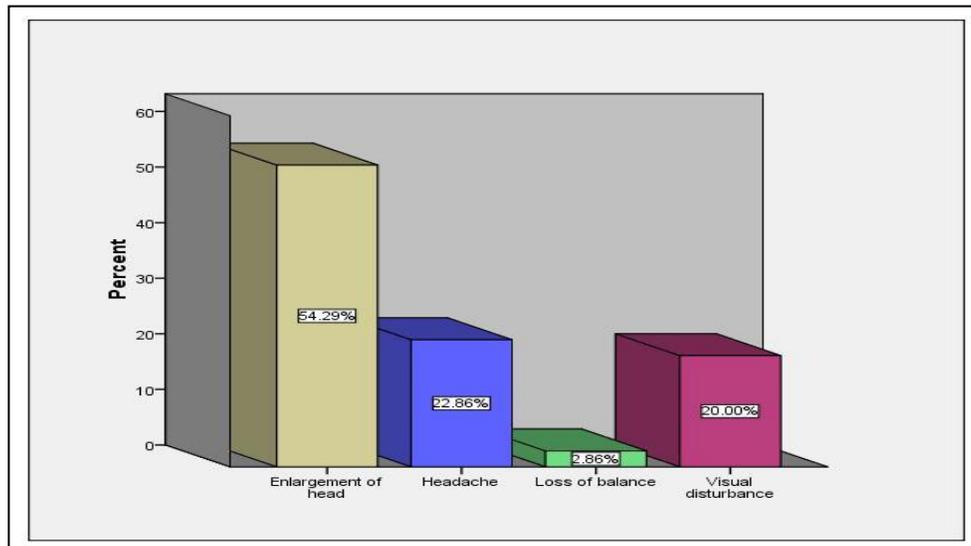


Figure (5). Frequency distribution of symptom and sign

Table (6). Measurement of two lateral ventricles

Ventricle	N	Minimum	Maximum	Mean	Std. Deviation
Lat ventricle	35	10.00	22.00	15.7429	3.61649
Lat ventricle	35	10.00	22.00	15.8714	3.56318
Valid N (listwise)	35				

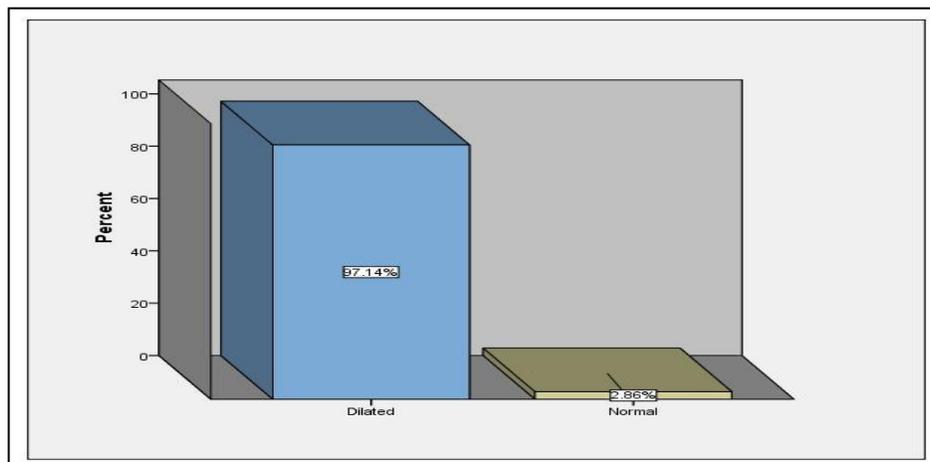


Figure (6). Measurement of third ventricle

Table (7). Measurement of third ventricle

Cause	Frequency	Percent	Valid Percent	Cumulative Percent
Dilated	34	97.1	97.1	97.1
Normal	1	2.9	2.9	100.0
Total	35	100.0	100.0	

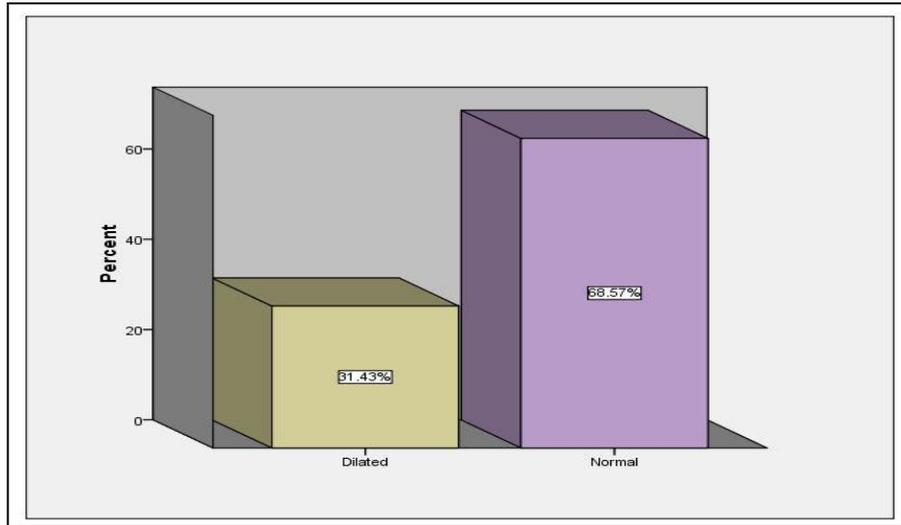


Figure (7). Measurement of fourth ventricle

Table (8). Measurement of fourth ventricle

Category	Frequency	Percent	Valid Percent	Cumulative Percent
Dilated	11	31.4	31.4	31.4
Normal	24	68.6	68.6	100.0
Total	35	100.0	100.0	

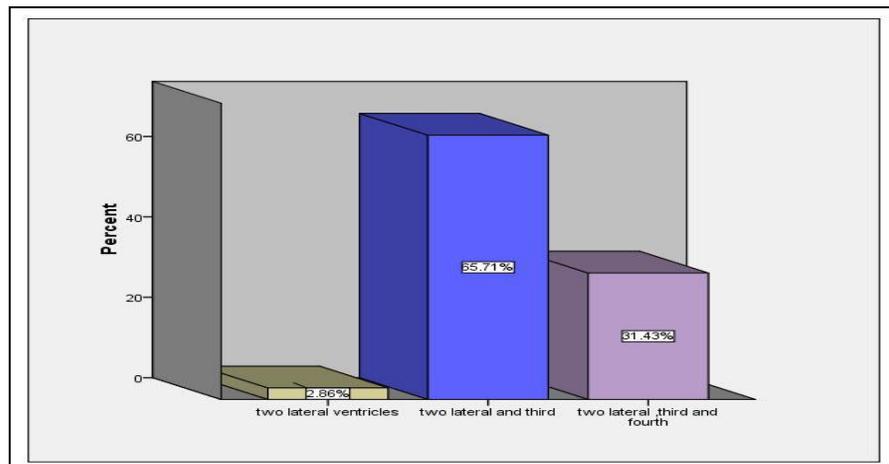


Figure (8). Frequency of dilated ventricles

Table (9). Frequency of dilated ventricle

Category	Frequency	Percent	Valid Percent	Cumulative Percent
Two lateral ventricles	1	2.9	2.9	2.9
Two lateral and third	23	65.7	65.7	68.6
Two lateral ,third and fourth	11	31.4	31.4	100.0
Total	35	100.0	100.0	

Table (10). Cross tabulation causes with age

Cause	Age					Total
	≤ month	≥ month ≤ year	≥ one year to ≤10 years	≥10 year to ≤20 years	≥ 20 years	
Unknown cause	1	3	6	0	0	10
Congenital Sylvian aqueduct obstruction	0	0	1	0	0	1
Acquiductal stenosis	0	0	1	0	0	1
Choroid plexus papilloma	1	0	0	0	0	1
Congenital	0	1	0	1	0	2
Congenital acquiductal stenosis	0	1	1	0	2	4
Congenital cerebroplasia	0	0	0	1	0	1
Congenital mass	0	0	1	0	0	1
Cyst	0	0	0	1	0	1
Dandy walker malformation	0	1	3	0	0	4
Infection	0	1	0	0	0	1
Mass	1	3	1	0	0	5
Post meningitis	0	0	1	1	0	2
Posterior fossa	0	0	1	0	0	1
Total	3	10	16	4	2	35

P value =0.123

Table (11). Cross tabulation causes with type of hydrocephalus

Cause	Type		Total
	Communicating	Non communicating	
Unknown cause	4	6	10
Congenital Sylvian aqueduct obstruction	0	1	1
Acquiductal stenosis	0	1	1
Choroid plexus papilloma	1	0	1
Congenital	0	2	2
Congenital acquiductal stenosis	4	0	4
Congenital cerebroplasia	1	0	1
Congenital mass	1	0	1
Cyst	0	1	1
Dandy walker malformation	1	3	4
Infection	1	0	1
Mass	1	4	5
Post meningitis	1	1	2
Posterior fossa	0	1	1
Total	15	20	35

P value =0.207

**Table (12). Cross tabulation causes with dilated ventricles**

Cause	Dilated ventricles			Total
	two lateral ventricles	two lateral and third ventricles	two lateral, third and fourth ventricles	
Unknown cause	0	7	3	10
Congenital Sylvian aqueduct obstruction	0	1	0	1
Acquiductal stenosis	0	1	0	1
Choroid plexus papilloma	0	0	1	1
Congenital acquiductal stenosis	0	2	0	2
Congenital acquiductal stenosis	0	1	3	4
Congenital cerebroplesia	0	0	1	1
Congenital mass	0	1	0	1
Cyst	0	1	0	1
Dandy walker malformation	1	2	1	4
Infection	0	1	0	1
Mass	0	4	1	5
Post meningitis	0	1	1	2
Posterior fossa	0	1	0	1
<b>Total</b>	<b>1</b>	<b>23</b>	<b>11</b>	<b>35</b>

P value =0.776

## CONCLUSION

Hydrocephalus is a disease that occurs in pediatrics, and it may occur in the elderly. The main objective of this study is to study the role of CT in the diagnosis of the disease. Hydrocephalus involves neonates and children who are below ten years, most commonly. CT is an essential imaging technology for the diagnosis of hydrocephalus. The leading cause of hydrocephalus is congenital. CT is very informative in demonstrating the cause and the site of obstruction. In some cases of congenital hydrocephalus, the cause remains unknown in this study.

## CONFLICT OF INTEREST

The authors declared that present study was performed in absence of any conflict of interest.

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## AUTHOR CONTRIBUTIONS

IA, AA, MS and AJ designed and performed the experiments and also wrote the first draft of the manuscript. SSA, AS, RA and AT performed

Analysis funding acquisition, methodology, project administration, resources, supervisory validation, visualization, writing, review & editing. All authors read and approved the final version.

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