

REVIEW PAPER

Post-Operative Complications of Ventriculoperitoneal Shunt in Hydrocephalic Pediatric Patients-Nursing Care

Efstratios Athanasakis, Nursing Student

Alexander Technological Educational Institute of Thessaloniki. Thessaloniki. Greece.

Despina Ermidou, BSc, RN

Clinical Collaborator, Nursing Department, Alexander Technological Educational Institute of Thessaloniki. Paediatrics Surgery Division. "IPPOKRATIO" Hospital, Thessaloniki, Greece.

Corresponding Author: Athanasakis Efstratios. 5 Trapezundos street, Analipsi, 54643, Thessaloniki, Greece
e-mail: stratosathanasakis@yahoo.gr

Abstract

Introduction: Hydrocephalus is the most common congenital abnormality of the central nervous system in infants. Many cases of hydrocephalic children are described since ancient times. It is characterized by excessive accumulation of cerebrospinal fluid in the ventricles of the brain. Its symptomatology during infancy or early childhood is characterized by swelling of the head, protrusion of the forehead and brain atrophy. All these symptoms appear due to increased cerebrospinal fluid volume, increased intracranial pressure and dilatation of the ventricular walls.

Aim: The aim of this paper is to describe the ventriculoperitoneal shunt complications in pediatrics patients and to point out the role of nursing staff in the prevention of them.

Methods: This includes literature search on the database Medline and relevant with that issue international hydrocephalus organizations to identify studies regarding the complications of ventriculoperitoneal shunt and the nursing care for each complication.

Results: Ventriculoperitoneal shunt is the treatment of hydrocephalic infants, rather than endoscopic third ventriculostomy. Although the success of the ventriculoperitoneal shunt's placement, the patients usually suffer from its afterwards complications. The complications involve postoperative shunt infection, shunt placement failure, shunt obstruction – malfunction, abdominal complications – peritonitis, valve complications, slit-ventricle syndrome and seizures. The role of the nursing staff is vital, particularly in the postoperative weeks.

Conclusion: A proper nursing assessment includes valid identification of complications and their prompt treatment. Also, nurses had to implement accurate nursing care, in order to prevent any complication. Finally, parental teaching from the nurses is crucial in the process of health outcomes for pediatric patient.

Key Words: hydrocephalus, children, complications, ventriculoperitoneal shunt, nursing care.

Introduction

The word hydrocephalus consists of the Greek words hydro and kephalus, which mean water and head, respectively (National Hydrocephalus Foundation, 2010). The water in this case is the cerebrospinal fluid. The knowledge about this fluid, originates since the time of Hippocrates (in the 4th century BC), Galen (in the 2nd century AD), Herophilus (300 BC) and Arabian physicians (Smith, 2001). Also, references to hydrocephalic skulls can be found in ancient Egyptian medical literature from 2500 BC to 500 AD (Aschoff et al., 1999). The evolution of

surgery of hydrocephalus divided into three stages. The first period was related to the antiquity and the second one, to the 19th century. The last period started at 1950s and is linked with the development of silicone catheters with a valve (Hirsch, 1992).

Nowadays, there is no database to count the hydrocephalic patients, so it is difficult to establish the number of them. However, it is estimated that hydrocephalus affects approximately 1 in every 500 children (National Institute of Neurological Disorders and Stroke, 2010). Another 6,000 children annually develop hydrocephalus during the first 2 years of life.

Additionally, more than 50% of hydrocephalus cases are congenital (National Hydrocephalus Foundation, 2010).

Hydrocephalus is the most common congenital abnormality of the central nervous system. It is characterized by imbalance between the absorption or production of cerebrospinal fluid, as a result the excessive accumulation of cerebrospinal fluid in the brain's ventricles (Rizvi, Anjum, 2005; National Institute of Neurological Disorders and Stroke, 2010; Fetal Hydrocephalus, 2010). However, the excess of cerebrospinal fluid results the abnormal dilation of cerebral ventricles and the increased pressure in brain's tissues. Therefore, appears increased intracranial pressure and other neurological symptoms. Usually the excess of cerebrospinal fluid cannot be drained normally, due to a pathological cause.

The causality of hydrocephalus in neonates and infants concerns genetic abnormalities and the most representative is the stenosis of aqueduct of Sylvius (Fetal Hydrocephalus, 2010). Another genetic abnormalities are including the Chiari I, II and Dandy-Walker malformation. Spina bifida and encephalocele are developmental disorders that may cause hydrocephalus (National Institute of Neurological Disorders and Stroke, 2010). Diagnosed congenital hydrocephalus presented in 40% of the cases, while acquired 30% and the other 30% was unknown etiology (National Hydrocephalus Foundation Survey, 2009).

There are various types of hydrocephalus. According to the progress of the symptoms appearance compared with the time, hydrocephalus is called acute or chronic. Hydrocephalus also, can be congenital or acquired, if it appears at the time of the birth or afterwards, respectively (National Institute of Neurological Disorders and Stroke, 2010). In cases that there is a blockage in the channel of cerebrospinal fluid, hydrocephalus formed into two types. The first is called non-communicating and means the existence of an obstruction blocking the normal flow of cerebrospinal fluid, a typical example of which is the stenosis of the aqueduct of Sylvius. The second type, is the communicating hydrocephalus and it is characterized by impaired cerebrospinal resorption, a typical example of which is normal pressure hydrocephalus (NPH) (National Institute of Neurological Disorders and Stroke, 2010; National Hydrocephalus Foundation, 2010). Finally, hydrocephalus can appear owing to diseases (such as meningitis, tumors), after bleeding, after head injury (National Institute of

Neurological Disorders and Stroke, 2010), hydrocephalus ex-vacuo and idiopathic, when the cause of it, is unknown (National Institute of Neurological Disorders and Stroke, 2010; National Hydrocephalus Foundation, 2010).

The symptomatology of congenital hydrocephalus during infancy and early childhood occurs due to increase in the cerebrospinal fluid volume, in the intracranial pressure and dilatation of the brain's ventricles. The most common, earliest and obvious sign is a rapid increase in head circumference or an unusually large head size, because the sutures have not yet closed (Chiafery, 2006; National Institute of Neurological Disorders and Stroke, 2010; National Hydrocephalus Foundation, 2010). Premature infants will have greater head growth as compared to term infants; therefore, their measurements are plotted on growth charts especially developed for premature infants (Chiafery, 2006). An important sign, which is characteristic in hydrocephalic children is the downward deviation of the eyes, called as "sunseting". Other symptoms are irritability, lethargic, decrease in appetite, recurrent vomiting (National Hydrocephalus Foundation, 2010).

Studying the relevant data, it is evident that the definitive treatment for patients with hydrocephalus is surgery (by placement of a shunt) or third ventriculostomy (Hydrocephalus Association, 2010; Fetal hydrocephalus, 2010). Relevant with the complication of the ventriculoperitoneal shunt, these are the post-operative shunt infection, shunt placement failure, shunt obstruction – malfunction, abdominal complications – peritonitis, valve complications, slit-ventricle syndrome and seizures.

A. Ventriculoperitoneal shunt

The peritoneum is the most applicable body cavity for placing a distal catheter to patients with hydrocephalus. As indicated from a recent National Hydrocephalus Foundation's survey (2009), ventriculoperitoneal shunt is the most common shunt placement (94,8%), in contrast with the other shunt placements (ventricle atrium 5,2%, lumbar peritoneum 1,7%, other 2,1%). Ventriculoperitoneal shunt is an efficient operative procedure because it has low mortality rate (Barnes et al, 2002) and is easily accessible, as opposed to the pericardial cavity and the pleural cavity, which endanger patients in endocarditis,

pulmonary embolism, pneumothorax, or respiratory distress (Chiafery, 2006).

A ventriculoperitoneal shunt is applied in the operating room by a neurosurgeon and a pediatrician, by inserting a catheter into the cerebral ventricles, where the opposite end of the catheter is discharged into the peritoneum, thus draining excess cerebrospinal fluid into it (National Institute of Neurological Disorders and Stroke, 2010). The shunt consists of three basic components. Firstly, from proximal catheter (which is inserted into the brain ventricles), a valve (which regulates the flow of cerebrospinal fluid and a distal catheter (which carries excess of the cerebrospinal fluid from the head to wherever the shunt is being diverted-the peritoneal, chest cavity, pericardium) (National Hydrocephalus Foundation, 2010; Fetal Hydrocephalus, 2010).

1) Post-operative shunt infection

The greatest risk of developing any complications appears within the first three months after surgery; an infection, however, may occur at all times. Statistically, about 3-12% of patients will develop an infection (Casey et al., 1997; Davis et al., 1999). The onset of the infection was within 15 days of surgery in 53% of the cases (Odio, McCracken, Nelson, 1984). An increased incidence of shunt infection noticed by researchers in patients under 6 months old (Casey et al., 1997). For hydrocephalic children shunt infections are the common reason for repeatedly hospitalizations (Vinchon et al., 2002). The infective agents come from patient's own skin bacteria or from the exposure to other patients (Fetal Hydrocephalus, 2010). The often bacterial agents, are staphylococcus epidermidis (detected on the skin surface of the face, sweat glands, and hair follicles) and staphylococcus aureus (these two types of staphylococcus account for 90% of all infection cases). Another agents, are propianobacter (occurs rarely, only among adults), e.coli and diptheroids (Odio, McCracken, Nelson, 1984; Isaacman et al., 2003). Rainoe et al. (1994), suggested that additional transient or latent shunt infections may be the reason of pseudocysts formation, as soon as 30% of their examined cases were infected. Post-operative infections seen in such patients usually result from an infection occurring during the operation and that 80% of such infection is present during the first six months after placement (Isaacman et al., 2003).

Nursing care and prevention for patients with ventriculoperitoneal shunt infections include:

- The most fundamental and important measure to prevent infections is regular hand-washing, both before and after any manipulations of the catheter, as well as between patients, especially in the immediate post operative period (Simpkins, 2005).
- In the immediate post-operative phase, one must always wear gloves during every nursing intervention (Simpkins, 2005).
- Daily trauma care, including application of an aseptic technique while dressing and application of antibiotic ointment (Simpkins, 2005).
- The patient receives antibiotic treatment intravenously (IV), according to prescriptions (Simpkins, 2005).
- Vital signs measurement and recording, especially taking of the patient's temperature every three hours. Persistent fever that has no other possible cause, especially post-operatively, must be investigated.
- Regular control of the shunt, in order to assess any secretion or edema (early signs of shunt infection). If there is any leakage of fluid coming from the incision, strict measures must be taken to avoid development of further infection.
- One must obtain cerebrospinal fluid specimen and culture for controlling the development of any bacteria into it, which signals the occurrence of infection (Simpkins, 2005).
- In any case, the shunt infection must be treated immediately by the healthcare staff to avoid any generalized infection and spreading to the brain itself (HA, 2010).
- For a pediatric patient, what is of vital importance is training of the parents, regarding the importance of regular hand-washing and use of precautions (e.g., gloves, gown), and avoidance of any direct contact with the child.

2) Shunt placement failure

Failure of surgical treatment may occur after every surgical operation. Repeated failures to place a shunt within 6 months were 1.5 times higher than those occurring after 6 months (Tuli et al., 2000). Another survey's results shows that in pediatric patients, the shunt failure rate was almost 31% for the first year and 4.5% each year afterwards (Sherman, Wensheng, 2008). The

classic symptoms of shunt placement failure include increased contour of the head (megalcephaly), sleepiness or lethargy, irritability, vomiting, headache, swelling of the head, loss of balance and downward deviation of the eye, prominent scalp veins, loss of previous abilities, seizures, headache and loss of balance (Fetal Hydrocephalus, 2010). Shunt placement failure is common in young infants and children. In the 2 months after birth and may reach 50% of all shunts complications (Weinzierl et al., 2007).

Nursing care for patients with shunt placement failure includes:

- Paying attention to the appearance of any of the above symptoms, which may imply shunt placement failure.
- A shunt placement failure may be asymptomatic, with a simple change in the patient's behaviour or rapid appearance of the above symptoms, which suggest shunt placement failure.
- For infants in a state of constant restlessness, when the all the other needs have been met and, in case of increased contour of the head, one must suspect possible shunt placement failure (Fetal Hydrocephalus, 2010).

3) Shunt obstruction – malfunction

Obstruction of the shunt may occur at any part of the catheter. At the choroid plexuses, the catheter is blocked by the tissue of the choroid plexuses or ventricles. Among adults, this is most commonly seen at a distal part of the catheter, which is blocked. Such malfunction-obstruction may be because of the occlusion (from red blood cells or bacteria) (Hydrocephalus Association, 2010), placement of wrong equipment, or infection (National Hydrocephalus Foundation, 2010). Also, researchers observed in their examined cases of shunt malfunction over a 3-year period, that a third of the patients had an extracranial fluid collection (Gilkes, Steers, Minns, 2001).

Indications of shunt malfunction-obstruction, which are usually assessed through physical examination and history taking, include divergence of cranial sutures (newborns- infants), nystagmus, headache and neck pain, nausea and vomiting, seizures (Sherman, 2001), loss of consciousness or reduced level of consciousness, eustachian tube dysfunction, mydriasis, cushing's triad (bradycardia, widening pulse pressure – increase in the difference between systolic and

diastolic pressure, and apnea), altered level of consciousness and papilledema.

Nursing care for patients with shunt obstruction-malfunction includes:

- Thorough testing with the aim of detecting any possible external site of obstruction or valve failure.
- Vital signs measurement and recording.
- Neurological assessment. Possible occurrence of nystagmus due to the malfunctioning shunt.
- Planning another surgical operation for placing a new shunt.
- Briefing of parents for any symptoms-signs, which are indications of a malfunctioning shunt.

4) Abdominal complications – Peritonitis

Although the ventriculoperitoneal shunt has the lowest mortality rate, the main complication observed is peritonitis. As the one end of the catheter is discharged usually in the peritoneal cavity, certain abdominal complications may occur. The range of abdominal complications involves gastrointestinal perforation, ileus, peritoneal pseudocysts, loss of catheter into the peritoneal cavity, or abscesses. Rarely, there is bladder perforation and hydrocele (Ward, Moquim, Maurer, 2001) cerebrospinal fluid ascites (Popa et al., 2009), acute abdomen (Çiçek R, 2003). Perforation of the bowel is a very rare complication occurring in less than 0.1% of cases (Wilson, Beratan, 1966) and when it happens may be asymptomatic (Sathyanarayana et al., 2000). In bowel perforation cases the catheter can be removed, by pulling it through the anus, by endoscopic removal, or by surgical removal (Birbilis et al., 2009). Also, the physical examination might show false diagnosis results, such as appendicitis (Çiçek et al., 2003). Abdominal complications following ventriculoperitoneal shunt can be successfully treated laparoscopically (Popa et al., 2009). Moreover, problems like peritoneal pseudocysts, bowel perforations and hernias, needs special attention from the health professionals (Hydrocephalus Association, 2010).

Nursing care for patients with abdominal complications due to shunt placement (peritonitis) includes:

- Control of the catheter's opening for appearance of bleeding and trauma inspection, so as to timely brief the doctor.

- Taking of vital signs.
- Thorough follow-up inspection of the patency and placement of the catheter.
- Neurological assessment of the patient.
- Use of an aseptic technique in every change of dressing to avoid superinfection.
- Administration of antibiotics, according to prescriptions.
- Recommendation of follow-up examination every month and, later on, every three months.

5) Valve Complications

In order to achieve equilibrium between the cerebrospinal fluid amount inside the ventricles and the cerebrospinal fluid amount drained, the shunt valve must work properly. In some cases, the valve moves slightly, resulting in the accumulation of pressure in the cerebral ventricles. In addition, catheter moves from the part of the body that placed, as a result of the child growth. When a valve will fail appears a rare situation, called mechanical malfunction (Hydrocephalus Association, 2010).

If the cerebrospinal fluid is drained more quickly than it is produced, i.e., the valve pushes forward more cerebrospinal fluid than that produced, the result is overdrainage. (National Institute of Neurological Disorders and Stroke, 2010; Hydrocephalus Association, 2010; National Hydrocephalus Foundation, 2010). If the cerebrospinal fluid is not drained in the desirable quantity, then the catheter must be changed and a new, stable-pressure valve must be placed, or reset. Meanwhile, the intracranial pressure must be monitored before resetting the valve. As a result of overdrainage, there may be a reduction in the size of the ventricle, to such a degree that the meninges are pulled away of the skull, or there are slit ventricles formed. If blood is trapped between the meninges and the skull, subarachnoid hemorrhage develops.

6) Slit-Ventricle Syndrome

This syndrome occurs when the ventricles become extremely small, usually due to cerebrospinal fluid overdrainage. It occurs during early childhood or early adulthood. Symptoms include acute intermittent headache (typically lasting 10-90 minutes, which diminishes when the patient lies down), ventricles smaller than normal as seen in imaging studies and the patients, however, may remain asymptomatic for a long period of time (Hydrocephalus Association, 2010).

7) Seizures

Seizures are a late sign of increased intracranial pressure. They are not unusual in hydrocephalic people. Ali et al. (2009), found the appearance of seizures in their cases almost 5%. Previous studies have shown that children with ventriculoperitoneal shunt already in place, who present considerable mental retardation or disability, are more likely to develop seizures than those without any cognitive or kinetic disabilities. Also, such seizures may not possibly occur during shunt malfunction. The most possible explanation for the development of this disorder is the presence of congenital malformation of the cerebral cortex (Hydrocephalus Association, 2010).

Nursing care during the appearance of spasms includes:

- The patient must lie down to the side and all objects nearby must be removed.
- A suction device must be easily accessible.
- The respiratory rate must be frequently assessed, for development of apnea.
- Nothing should be put into the patient's mouth during the seizures; meanwhile, the type and duration of them should be recorded.

B. Endoscopic third ventriculostomy

A small group of patients may be candidates for an endoscopic surgical procedure (about 4% of the diagnosed hydrocephalic patients, make this procedure), which is called endoscopic third ventriculostomy, performed instead of shunt placement (National Hydrocephalus Foundation, 2009). Similar endoscopic procedures to third ventriculostomy are the choroid plexus coagulation, third ventriculostomy, septostomy, aqueductoplasty, foraminal plasty of the foramen of Magendie and foraminal plasty of the foramen of Monro (Enchev, Oi, 2008). It is applied to patients with obstructive hydrocephalus, such as stenosis or tumor in the cerebral aqueduct (Fetal Hydrocephalus, 2010) and it is safer in full term normal birth weight infants (Yadav et al., 2006). Endoscopic third ventriculostomy is an option for various forms of noncommunicating hydrocephalus (Schroeder, Niendorf, Gaab, 2002) or obstructive (Ribaupierre et al., 2007) hydrocephalus. Endoscopy is a useful treatment for imaging the ventricular ground and, though the use of special catheters, to allow cerebrospinal fluid drainage without a shunt. Complications of

endoscopic third ventriculostomy include bleeding, cerebrospinal fluid leakage, subdural hematoma, bradycardia and injuries of adjacent ventricular structures. The severe of all complications of endoscopic third ventriculostomy and also life-threatening, is the sudden death from the rapid increase of intracranial pressure (Hader et al., 2002).

Conclusions

Current treatment for hydrocephalus is endoscopic third ventriculostomy or ventriculoperitoneal shunt. The widely applicable method is the ventriculoperitoneal shunt. Despite this, the shunt infection is the most common post-operative complication. A proper nursing assessment leads to the timely identification of complications and their prompt treatment. Meanwhile, parents should be informed that monitoring of the child's condition by a neurologist (for life) will assist in the full assessment of the child's neurological status. Parents should always be vigilant about the development of the child, since there should be a change in the catheter's length, after a few years.

References

- Ali M, Khan A, Khan H, Khwanzada K (2009) Short-term complications of ventriculoperitoneal shunt in children suffering from hydrocephalus. *Journal of Pediatric Neurology*, 7:165-169.
- Aschoff A, Kremer P, Hashemi B, Kunze S (1999) The scientific history of hydrocephalus and its treatment. *Neurosurgical Review*, 22 (2-3): 67-93.
- Barnes NP, Jones SJ, Hayward RD, Harkness WJ, Thompson D (2002) Ventriculoperitoneal shunt block: what are the best predictive clinical indicators? *Archives of Diseases in Childhood*, 87(3):198-201.
- Birbilis T, Zazos P, Liratzopoulos N, Oikonomou A, Karanikas M, Kontogiannidis K, Kouklakis G (2009) Spontaneous bowel perforation complicating ventriculoperitoneal shunt: a case report. *Cases Journal*, 2:8251.
- Casey AT, Kimmings EJ, Kleinlugtebeld AD, Taylor WA, Harkness WF, Hayward RD (1997) The long-term outlook for hydrocephalus in childhood. A ten-year cohort study of 155 patients. *Pediatric Neurosurgery*, 27(2):63-70.
- Chiafery M (2006) Care and management of the child with shunted hydrocephalus. *Pediatric Nursing*, 32(3):222-5.
- Çiçek R, Türkyılmaz S, Cinel A, Küçükütülü U, Mumcu S, Cakir E (2003) A case of acute abdomen due to ventriculoperitoneal shunt infection. *Ulusal Travma ve Acil Cerrahi Dergisi* 9(2):137-9.
- Davis SE, Levy ML, McComb JG, Masri-Lavine L (1999) Does age or other factors influence the incidence of ventriculoperitoneal shunt infections? *Pediatric Neurosurgery*, 30(5):253-7.
- Enchev Y, Oi S (2008) Historical trends of neuroendoscopic surgical techniques in the treatment of hydrocephalus. *Neurosurgical Review*, 31(3):249-62.
- Gilkes CE, Steers AJ, Minns RA (2001) Pressure compensation in shunt-dependent hydrocephalus with CSF shunt malfunction. *Childs Nervous System*, 17(1-2):52-7.
- Hader WJ, Drake J, Cochrane D, Sparrow O, Johnson ES, Kestle J (2002) Death after late failure of third ventriculostomy in children. Report of three cases. *Journal of Neurosurgery* 97(1):211-215.
- Hirsch JF (1992) Surgery of Hydrocephalus: Past, Present and Future. *Acta Neurochirurgica (Wien)*, 116:155-160.
- Hydrocephalus Association. Life-Threatening Complications. Available at: <http://www.hydroassoc.org/education-support/learning-about-hydrocephalus/life-threatening-complications/#infection> Access date: 22 July, 2010.
- Isaacman DJ, Poirier MP, Hegenbarth M, Lillis KA, Scarfone R (2003) Ventriculoperitoneal shunt management. *Pediatric Emergency Care*, 19(2):119-25.
- National Hydrocephalus Foundation (NHF) Available at: <http://nhfonline.org/info.php?id=definition> Access date: 22 July, 2010.
- National Institute of Neurological Disorders and Stroke (NINDS) Available at: <http://www.National Institute of Neurological Disorders and Stroke .nih.gov/disorders/hydrocephalus/hydrocephalus.htm> Access date: 22 July, 2010.
- Odio C, McCracken GH Jr, Nelson JD (1984) CSF shunt infections in pediatrics. A seven-year experience. *American Journal of Diseases of Children*, 138(12):1103-8.
- Popa F, Grigorean VT, Onose G, Popescu M, Strambu V, Sandu AM (2009) Laparoscopic treatment of abdominal complications following ventriculoperitoneal shunt. *Journal of Medicine and Life*, 2(4):426-36.
- Rainov I, Sehbefl A, Heidecke V, Burkert W (1994) Abdominal CSF Pseudocysts in Patients with Ventriculoperitoneal Shunts. Report of Fourteen Cases and Review of the Literature *Acta Neurochir (Wien)* 127:73-78.
- de Ribaupierre S, Rilliet B, Vernet O, Regli L, Villemure JG (2007) Third ventriculostomy vs ventriculoperitoneal shunt in pediatric obstructive hydrocephalus: results from a Swiss series and literature review. *Childs Nervous System*, 23(5):527-33.
- Rizvi R, Anjum Q (2005) Hydrocephalus in children. *Journal Pakistan Medical Association*, 55(11):502-7.
- Sathanarayana S, Wylen EL, Baskaya MK, Nanda A (2000) Spontaneous bowel perforation after ventriculoperitoneal shunt surgery: case report and a review of 45 cases. *Surgery of Neurology*, 54(5):388-96.
- Schroeder HW, Niendorf WR, Gaab MR (2002) Complications of endoscopic third ventriculostomy. *Journal of Neurosurgery*, 96(6):1032-40.
- Sherman C (2001) Shunt malfunctions cause most problems in hydrocephalus patients. *Pediatric News*.
- Simpkins CJ (2005) Ventriculoperitoneal shunt infections in patients with hydrocephalus. *Pediatric Nursing*, 31(6):457-62.
- Smith GK. (2001) The history of spina bifida, hydrocephalus, paraplegia, and incontinence. *Pediatric Surgery International*, 17(5-6):424-32.
- Weinzierl MR, Collmann H, Korinth MC, Gilsbach JM, Rohde V (2007) Management of hydrocephalus in children with plasminogen deficiency. *European Journal of Pediatric Surgery*, 17:124-128.
- Wilson CB, Bertan V (1966) Perforation of the bowel complicating peritoneal shunt for hydrocephalus. Report of two cases. *American Surgery*, 32: 601 - 603
- Yadav YR, Jaiswal S, Adam N, Basoor A, Jain G (2006) Endoscopic third ventriculostomy in infants. *Neurology India*, 54(2):161-3.