

Mechanical failures of ventriculo-peritoneal shunts

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Abstract

Ventriculo-peritoneal (VP) shunt placement represents the most widely accepted form of treatment for most patients with hydrocephalus. Despite significant improvements in VP shunt procedures, various complications remain a common situation. The diagnosis of shunt failure can be confounded by a variety of factors, mechanical failure being the most common cause of multiple shunt revisions in a lifetime. A better understanding of mechanisms of shunt failure will cause an improvement in the management of this neurosurgical procedure.

Key words: VP shunt, shunt malfunction, mechanical failure.

The defining mechanical shunt failure is not easy, and yet the literature is often quite ambiguous. Numerous groups of patients with shunt failures that have been reported in the literature are difficult to interpret or to compare due to several reasons:

- the debate regarding what constitutes a failure of the shunt, and - types of statistical analyzes applied to these series.

While problems that are directly related to the shunt (as obstruction) are universally known as shunt complications, the problems due to its imperfect functioning (headache in different positions, subdural collection) are sometimes more difficult to interpret.

In terms of shunt malfunction, any issues that require further operation seems to be the reasonable definition of shunt complications. In fact, we can extend this concept, and say that any subsequent surgical procedure to hydrocephalus treatment is a complication of the shunt (this includes also deaths to the failures category where no intervention has occurred). In reality the shunt failure causes are in direct relationship with it arises, on the other hand an improperly connected connector or improper shunt placement will occur immediately, while a problem due tube degeneration or fracture can take many years. Because shunt complications are closely related to the time of surgery, constant supervision is required over time to adequately assess the likelihood of each failure at various time points after surgery.

Regarding the incidence of shunt failure we found that the risk of these is maximum in the first months of operation, estimated at a percentage of 18% to 40% after surgery. Later, after this critical period, the risk remains around 4-5% per year (proper functioning time of it is being at least five years).

An analysis of timing of shunt failures appearances in pediatric case series show significant differences. If some types of shunt failures tend to happen sooner or later after surgery for other risk period is slightly lower or something more long. For

a given type of failure causing factors are not always the same, for example ventricular catheter may be blocked immediately after surgery by a blood clot in the ventricles or later by choroid plexus adhesion. It is also likely that these factors differ in adult patients to children. Many variables and interactions between various factors that appear in shunt failure analyzes studied in the literature makes the statistical interpretation of the results to be questionable. Main types of mechanical failure rates are shown in Figure 1.

Shunt obstruction

As shown in studies of literature, shunt obstruction accounts for almost half of all shunt complications, especially in pediatric series. This percentage is lower in adults, but still significant. Is interesting to note that the risk for shunt obstruction varies strongly related to time, the risk being higher in the immediate postoperative period. Literature mentions that the report series of patients studied, the likelihood of shunt obstruction was approximately 7% in the first month after surgery and then decreased to 2-4% in the next four months. After the fifth month, the likelihood of complications was less than 0.5% per month for the next ten years. These variable results on the risk of failure resulting from obstruction causes are typically occurring in some periods. Impurities, blood clots in the CSF or wrong ventricular catheter placement are causes of quick obstruction, while developing choroid plexus, ependymar resection or immunological reactions are causes of late obstruction.

The shunt may be obstructed at three different levels:

- The entry point (proximal obstruction);
- At the valve system (valve obstruction);

- The distal end (distal obstruction).

Factors that influence these obstructions are still investigated, but however an analysis of potential causes of these types of failures can be made.

Proximal obstruction

Chemically inert catheter that stays in a primary cavity (clean) by liquid (pure water) has no reason to obstruct. However, silicone catheters are not completely inert CSF may contain impurities or tissue and the ventricular cavity can be so contracted at the contact point of the catheter and the wall or choroid plexus that these structure that are floating in CSF can be naturally driven along catheter CSF flow in the proximal direction (Figure 2).

Components of CSF. Cellular impurities or blood clots favor blocking of distal holes or lumen of the ventricular catheter. An external drainage or repeated lumbar punctures may be a temporary solution to this problem.

Ventricular catheter location. This is probably one of the oldest controversies in the treatment of hydrocephalus. Conventional ventricular catheter should be placed in front of Monro foramen to avoid choroid plexus. However, a frontal ventricular catheter introduced through the occipital horn can be pulled back to choroid plexus due to increased head in children or ventricular collapse, causing migration of catheter surrounding parenchymal tissue. Moreover, there are some near choroid plexus tissue that can bloc the catheter (ependymal cells, glial tissue, connective and leptomeningeal tissue).

Statistical studies in the literature have shown that proximal catheter placement in the frontal horn of lateral ventricle has a lower obstruction rate than those placed in the occipital area. In pediatric series an

analysis of proximal obstruction by positioning instead showed some catheter obstruction to its placement in the posterior ventricle through the occipital area and when he was pushed in the direction of the frontal horn. In fact, there is probably not ideal catheter tip placement, the lowest risk being the largest ventricular area after decompression by drainage, varying from one patient to another.

Other factors involved in obstruction include catheter stiffness and method of his holes opening. Due to elasticity silicone rubber catheter does not remain rigid at a right angle, tending to straighten to the ventricular wall. There is no evidence that special catheter tip designs are able to prevent obstruction, plus they can cause choroid plexus from attaching the tubing.

Valve system obstruction

The second component of obstruction risk is the valve system. Very few obstructions are due to bad manufacturing of valve device, these being tested before implantation. Besides these manufacturing issues, valves are flow restriction creates areas more or less dependent on valve type and dead spaces that can facilitate the accumulation of dirt and colonization of tissue that eventually lead to obstruction. Limitation of supra drainage obtained through a severe restriction of flow can increase the risk to block the valve.

Valve obstruction can occur in different circumstances, so, it can occur as a result of active phenomena (bacterial proliferation, the development of immune reactions) or passive phenomena (accumulation of impurities). Valve obstruction can be prevented by improving valves designs in the sense of avoiding dead spaces (Figure 3).

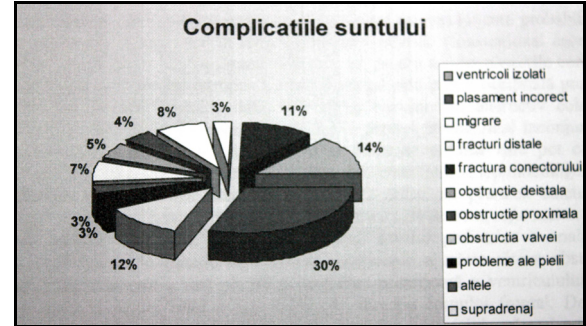


Figure 1 Percentage distribution of VP shunt failures

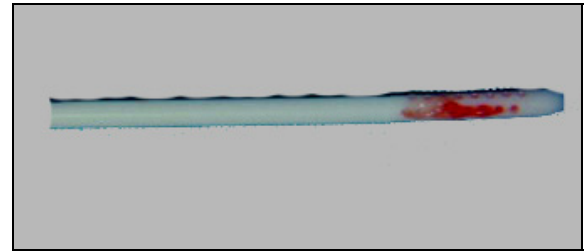


Figure 2 Proximal catheter occlusion



Figure 3 Valve occlusion

Distal obstruction

Risk of distal obstruction varies with shunt position and distal catheter's design. Distal catheter openings with closed end carry a risk of obstruction. Existence of dead space below the hole leading to the accumulation of impurities that causes catheter pulling. Risk of this type of obstruction is not currently to open-ended catheters (Figure 4).



Figure 4 Distal catheter occlusion

Distal partial obstructions may be due to reduced absorption capacity of the peritoneal cavity. Most of these phenomena have clear origin (peritoneal infection, localized tumors), however many cases still remain unclear (immune reaction to drainage device).

Conclusions

In conclusion, aside from advanced techniques, specialists should try to get a good compromise as in terms of patient and system status are guided by the following: - trying to shunt a pure and clear CSF can mean the use of alternative methods such as external ventricular drainage or transient drainage portion in patients who showed impurities during diagnosis of hydrocephalus; - proximal catheter tip location in place that is expected to remain the most widely after ventricular decompression; - selection of appropriate

features for flow pressure is to limit as much as possible the phenomenon of overdrenage and avoid placing the catheter in a collapsed cave; - shunt checking and particularly the valve in regarding the presence of impurities or clots and verification of normal flow before distal catheter insertion into drainage cavity.

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