Ammar shunt: an option to overcome shunt complications in premature and term neonates

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Abstract It has been hypothesized, and generally accepted, that the final outcome of the treatment of hydrocephalus is to a great extent related to the earliness of intervention and treatment. However, there is special concern regarding the higher risk of infection and shunt malfunctions in neonates as compared with older infants. Therefore, two new shunt systems have been designed specifically to tip the balance in favor of early shunting. The first shunt is made for premature neonates and the second for neonates in general. The general characteristics of these two shunts are: (1) the entire shunt is a low-pressure valve, with double distal slit valves; (2) the shunts are made of soft silicon material; (3) they are of very small configuration, without any compressing elements which may lead to skin necrosis over the shunt; (4) no metal has been used in them, so they are MRI compatible.

Key words Complications - Hydrocephalus - Infant - Neonate - Premature - Shunt

Introduction

Hydrocephalus is one of the oldest known brain anomalies, and used to carry a bad prognosis [13]. Improvement in the results of treatment were only obtained after the introduction of shunt surgery in the early 1950s [6, 13]. Presently there are more than 20 different types of shunts available for surgery. Whilst most of these shunts were designed to control the flow of CSF, some were designed to overcome special problems associated with shunt surgery. It is noticeable that the majority of these shunts are either for adults or for children in general. Until now very little attention has been paid to premature infants, whose numbers are rapidly increasing every year due to the improvement in the medical support of this type of neonate. In the USA alone between 2500 and 8000 infants every year have hydrocephalus and require treatment [10]. These premature infants have common problems such as underdeveloped skin, underdeveloped liver and lungs, a high risk of infection, and neural cells that are still in the process of developing [1, 3, 12, 14, 16]. It is therefore necessary to develop a new shunt system designed specifically for these patients, taking into consideration all of their problems.

So far, the normal procedure has been to insert a shunt that can last for as long as possible without being replaced. The aim of the new shunt is to reduce the risks from shunt surgery during the critical early period of life, the shunt then being replaced by a conventional one when the infants reach the age of 10–12 months. By reducing the risk of early complications, the brain has a better chance of developing normally once the ICP is controlled.

Materials and methods

General characteristics of the shunts

The shunts\(^1\) are unishunts soft of a silicon material (Fig. 1). The flow of CSF through the shunt is controlled by the physical characteris-
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**Fig. 1 Ammar shunts for premature (a) and term neonatal infants (b)**

Characteristics of the shunt, i.e., length, diameter, and resistance to flow, as well as by the ICP. The internal diameter is 0.75 mm, the external diameter 1.50 mm. At the ventricular end the eyes are located in the proximal 2 cm of the shunt and oriented at a 90° angle. Two slit valves are located at the distal end. The shape and hold butterfly is a 1-cm tube with a hard base and open top and two wings, serving the dual purpose of holding the shunt in position whilst preventing kinking and nipping at the site of the burr hole. It slides over the shunt near the ventricular end and bends over the edge of the burr hole, the wings are fixed to the periosteum to keep the shunt in place. The shunt is low pressure. There are several radio-opaque dots on both ends to facilitate visualization of the shunt if X-ray studies are performed. The Ammar Premature Shunt is 30 cm in length and the Ammar Neonate Shunt 40 cm in length with a small elliptical-shaped reservoir of soft silicon placed 10 cm from the ventricular end.

**Operative technique**

The operative technique is the same as has been previously described as the routine for other shunt systems [11]. However, special consideration should be given to making the burr hole as small as possible, with a diameter of 2 mm; neither the dural opening nor the opening in the peritoneal membrane should exceed 2 mm. The length of the ventricular end should be carefully estimated with the help of CT scanning. The butterfly can then be slid along the shunt to the predetermined length of the ventricular end needed for insertion into the ventricle. After ensuring satisfactory functioning of the shunt, the peritoneal end is inserted into the peritoneal cavity. The wings are then fixed to the periosteum, immediately below the burr hole. A burr stitch is used to loosely fix the shunt to the periosteum, in order to reduce the risk of the shunt doubling back on itself and migrating into the thorax.

The operating time is approximately 30 min from skin to skin. Blood loss is negligible.

**Results**

In the past 12 months 16 patients have been treated using the Ammar shunt. The first patient was treated 12 months ago. All of the patients have demonstrated an early reduction in the size of the ventricles and none has showed any signs of slit ventricle syndrome.

**Discussion**

The early detection of hydrocephalus in utero using high-resolution ultrasonography challenged neurosurgeons to save the growing brain by early treatment of hydrocephalus. Unfortunately, the early trials for intrauterine intervention are not encouraging [4]. A lot of research needs to be done to improve this method of treatment [5, 6, 15]. As an alternative, some centers adopted the policy of performing elective cesarean section at 32–36 weeks, followed by ventriculoperitoneal shunt [10]. However, several authors have reported their experiences showing a higher risk of infection and shunt malfunction in the first 3 months of life of such babies. Thus, the balance between on the one hand providing the best conditions for the neural cells to grow and protecting them from irreversible damage due to high ICP, and on the other avoiding the complications of shunting, is very delicate and must be judged from case to case. As well as being a speedy procedure, greatly reducing the risks related to anesthesia, the Ammar system is designed to deal specifically with the most commonly encountered complications of shunting procedures in neonates.

**Skin necrosis and infection**

Since neonates have fragile skin, and are unable to move themselves, especially if they have an enlarged head, they are particularly vulnerable to skin breakdown, necrosis, and infection over the shunt [14, 16]. The soft nature of the new shunt, in combination with its low profile and the absence of a valve, means that the risk of skin breakdown is reduced [3].

**Shunt infection**

The most commonly found infective organism in neonatal shunt infection is *Staph. epidermidis* [14, 16]. The short operative time and reduced risk of skin breakdown lessen the risk of infection with this organism.

**Distal shunt migration**

There are commonly two types of distal shunt migration: disconnection at the valve site with subsequent migration, or migration due to shunt rigidity and or excessive shunt length [1, 7–9]. The first of these is obviously negated in