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Transcutaneous Pressure Adjustable Valve for the Treatment of Hydrocephalus and Arachnoid Cysts in Adults

Experiences with 75 Cases

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Summary

The authors report a series of 75 adults treated over the last four years for hydrocephalus (69 cases) or arachnoid cysts (6 cases) by using a transcutaneous pressure adjustable valve (Sophy SU 8), the mechanism of which is recalled.

The shunt was ventriculo-atrial 46 times, ventriculo-peritoneal 23 times and cysto-peritoneal 6 times. The opening pressure of the valve was initially adjusted 56 times to the medium, 9 times to the high, and 10 times to the low position, according to each particular patient's needs. Following the evolution of the neurological status and/or the CT findings, the opening pressure was secundarily modified in 27 patients (i.e., in 36%), and in some of them several times.

It was raised 16 times: 10 times because of subdural hygroma(s) (complicated by a subdural haematoma which required surgical removal, in one case), and 6 times because of clinical symptoms of intracranial hypotension associated with hyperdrainage signs on CT.

It was diminished 20 times because of the absence of clinical improvement and persistence of dilated ventricles on CT.

In these 27 patients the Sophy SU 8 valve allowed modification of its opening pressure according to the clinical and CT evolution, without need for re-operation.

It is concluded that the patients who can benefit most from this valve system are patients with normal pressure hydrocephalus or with arachnoid cysts.

Keywords: Pressure adjustable valve; CSF shunt; hydrocephalus; arachnoid cysts.

Introduction

CSF shunt valves must satisfy certain requirements: they must be biocompatible, anti-reflux and must only open beyond a specific CSF pressure. Most of the valves available on the market up until 1984 drained CSF according to a fixed pressure gradient for each model of implantable valve. After implantation of the valve, any modification in this opening pressure – made necessary by alterations in the patient's clinical status and/or equilibrium of the CSF circulation – could only be performed by changing the valve model during another operation.

We therefore evaluated the Sophy SU 8* valve which offers the possibility of percutaneous adjustment of the opening pressure. After briefly reviewing the principle of the valve, we will present the data of our experience concerning its practical use in 75 adult patients.

In this series, after insertion of a shunt for hydrocephalus, 57 (84%) surgical patients were improved, 2 (3%) remained unchanged, and 9 (13%) continued to deteriorate, probably because of the presence of severe if not progressive cerebral atrophy. The clinical results will not be reported in detail, as this study was not designed to evaluate the neurological results of this shunt in adult hydrocephalus and arachnoid cysts, but simply to assess the practical contribution of being able to modify the opening pressure of the valve without the need for a further operation.

Material and Methods

1. Principle and Characteristics of the Valve

The principle of the Sophy SU 8 valve (Fig. 1) is based on the variation of the force exerted on CSF flow by a semicircular spring at different points of its curvature. The spring is fixed onto the extremity of a central rod (or rotor) containing two small magnets. Any rotation of the rotor displaces the point of fixation of the spring and consequently modifies the resistant moment in relation to the external site of fixation represented by the ball of the valve. The rotor is immobilized by a second spring, actually a continuation of

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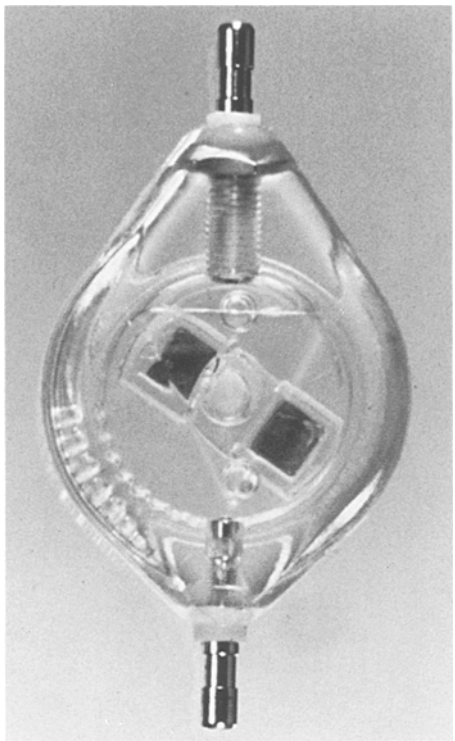

Fig. 1. The Sophy valve SU 8

the first, in eight notches in the wall of the valve corresponding to different positions of the rotor. The opening pressure is adjusted very simply by means of a special external magnet and a compass (Fig. 2).

After localizing the center of the valve underneath the skin, the surgeon determines the position of the rotor with the compass placed over the valve, superimposing its axis to that of the valve. A magnet is then placed over the valve, superimposing their respective axes. Rotation of the magnet allows the rotor to be adjusted to the desired position; the valve then functions immediately at the newly defined opening pressure.

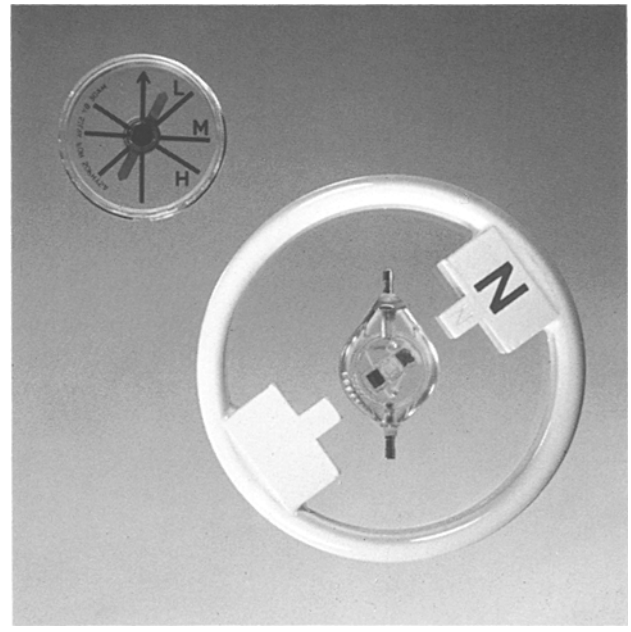

Fig. 2. Modification of the opening pressure: compass, magnet

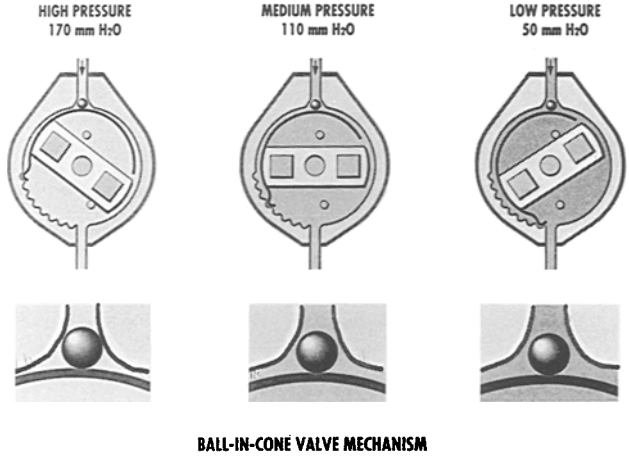

Fig. 3. Principle of the Sophy valve SU 8

Two stops, corresponding to extreme pressures of 50 mm H_2O and 170 mm H_2O, limit the range of rotation; the median position corresponds to a pressure of 110 mm H_2O (Fig. 3). These three principal pressures correspond to three "pressure-flow" curves according to the valve principle (constant pressure regardless of flow)[7]. The position of the rotor can be checked either with a magnet indicating the three principal settings (high, medium, low) or on a plain x-ray.

2. Presentation of the Series

This study was based on 69 cases of hydrocephalus (Table 1) and 6 cases of arachnoid cyst shunted over the last four years with insertion of a Sophy valve. The age range was 16 to 84 years with a mean of 47 years and the sex ratio was 1 F/2 M.

The aetiologies* of *hydrocephalus (69 cases)* are summarized in

* The *6 arachnoid cysts* were treated by cysto-peritoneal shunt (Table 2)

Table 1. *Aetiologies of Hydrocephalus*

Hydrocephalus	Number of cases
Normal pressure	12
Post-traumatic	8
Post-haemorrhagic	17
Neoplastic	22
Malformative	10

Table 2. *Site of Shunts*

Shunts	Number of cases
Ventriculo-atrial	46
Ventriculo-peritoneal	23
Cysto-peritoneal	6

Table 1. The hydrocephalus was normal pressure and idiopathic (i.e., no apparent cause) in 12 cases, post-traumatic in 8 cases, post-subarachnoid haemorrhage in 17 cases, obstructive due to a tumour in 22 cases and secondary to a congenital malformation decompensated during adulthood in 10 cases. These patients underwent ventriculo-atrial shunt in 46 cases and ventriculo-peritoneal shunt in 23 cases (Table 2). Two shunts had to be inserted in one patient, one on the right and one on the left, with interposition of a Sophy SU 8 valve on each side. The 6 arachnoid cysts were treated by cysto-peritoneal shunt (Table 2).

At the time of insertion, the valve was adjusted to a medium setting in 56 cases, a high setting in 9 cases and a low setting in 10 cases. The choice of the initial pressure at the time of insertion was based on clinical criteria [aetiology, obstructive or communicating hydrocephalus, mode of onset of hydrocephalus (rapid or progressive), severity of the signs of intracranial hypertension] and computed tomographic criteria (size of the ventricles, visibility of the cortical sulci, severity of the periventricular low density images as well as the estimated degree of cerebral atrophy).

Results

1. Nine *intercurrent complications* were encountered:

a. Three patients developed mechanical dysfunction: one from proximal obstruction of the catheter by an intraventricular tumour and the other two due to defective connection of the body of the valve to the catheter (proximal in one case and distal in one case).

b. Three patients developed meningitis (including one case in which the micro-organism responsible could not be identified). In all three cases, the shunt was drained externally. Two of these patients had to be reshunted with a Sophy valve and had no subsequent infectious complications. The clinical status of the third patient did not require further shunting.

c. Three patients died, but none of these deaths was directly related to the shunt or the valve. All patients were very elderly (80, 81, and 84 years). The first two were considered to have normal pressure hydrocephalus, while the third had post-haemorrhagic hydrocephalus. The causes of death were electrolyte disturbances, myocardial infarction and decubitus complications related to the previous bedridden state, respectively.

2. The clinical and computed tomography follow-up of these patients led us to *modify the opening pressure of the valve* in 27 cases (i.e., 36% of cases). The pressure was changed twice in 7 patients and three times in one patient at intervals of several months.

The possibility of easily adjusting the opening pressure of the valve was used in a total of 36 cases.

a. The opening pressure was *increased* in 16 cases:

– in 10 cases because of the development of hemispheric detachment (unilateral or bilateral) visible on CT scan and indicating excessive drainage. The position of the rotor was modified from medium to high: 8 cases, from low to high: 1 case, and from low to medium: 1 case. In 8 of these patients, the detachment resolved following the increase in the opening pressure. In another patient, in whom the pressure was increased due to the clinical observation of deterioration in the level of consciousness with detection of a bilateral hygroma on the follow-up CT scan, the valve had to be adjusted from a low position to a high position as the medium position was not sufficient to obtain resorption of the hygroma and normalization of the clinical condition. In the last case, despite adjustment to high pressure, evacuation-drainage of a chronic subdural haematoma had to be performed due to persistence of the haematoma and absence of clinical improvement.

– in 6 cases, the opening pressure was increased because of the development of clinical signs of intracranial hypotension consisting of headache and instability accentuated by standing (and disturbances of consciousness in one case). The CT scan showed signs of rapid drainage of the arachnoid cyst in 3 cases or the ventricular volume in 3 cases. The position of the rotor was adjusted [from medium to high: 3 cases; from low to medium: 2 cases; and from low to high: 1 case (the patient with disturbance of consciousness)]. In every case, adjustment of the pressure was followed by resolution of the symptoms responsible for this adjustment.

b. In 20 cases, due to the absence of clinical and CT improvement during the week following insertion of the shunt, the opening pressure was *decreased* to a

lower setting in 15 cases and to a medium setting in 5 cases (from medium to low in 11 cases, from high to low in 4 cases, and from high to medium in 5 cases).

Discussion

This study demonstrates that the opening pressure of the valve was able to be adjusted in 27 patients in the series (i.e., 36%) without the need for another surgical operation.

Few studies to date have reported the results of the Sophy valve, available since 1984, and the evaluation of its practical advantages, which is why we decided to conduct this work. The published studies concern the use of this valve in children[2, 11] in whom the complications related to excessive or insufficient drainage are frequent and severe[3–6, 12].

The possibility of altering the level of differential pressure activating the valve certainly does not resolve the problem of immediate adaptation to a sudden variation in intracranial pressure, in contrast with the "Sigma" valve[12, 13] which, beyond a certain flow rate, behaves like a flow regulator rather than a fixed resistance valve. The Sigma valve therefore behaves like self-adjustable valve, but cannot be adjusted by the clinician. However, the role played by postural variations in the ICP (and/or during the various phases of sleep) in the pathogenesis of the various above-mentioned complications related to inadequate valve function[2–6, 8, 10–12] remains unclear. These complications may be simply due to unsuitability of the valve initially selected due to a secondary modification of local conditions. In this situation, the possibility of being able to modify the opening pressure of the Sophy valve externally allows CSF drainage to be adapted to the new conditions. Furthermore, the problem of siphoning on standing is relatively reduced with this type of Sophy valve which has a high resistance.

We do not have any experience with this valve in neonates or infants, but the definite advantages of the possibility of percutaneous adjustment in these patients would appear to be largely counterbalanced by the volume and rigidity of the valve itself, factors responsible for cutaneous complications[9]. However, this disadvantage may be reduced in children by implantation of the valve in the infra-clavicular anterior thoracic region rather than in the retro-auricular region.

On the other hand, the Sophy SU 8 valve appears to be very useful in the treatment of adult hydrocephalus, regardless of its cause, and in the treatment of subarachnoid cysts. In fact, it is difficult to precisely determine the CSF pressure and the ideal pressure at which the ventricles should be drained, even when the intraventricular pressure has already been measured[3]. Moreover, in emergency situations of intracranial hypertension, there is often not sufficient time to perform continuous monitoring of intracranial pressure and its variations.

The increased use of CT monitoring explains the growing number of reported subdural haematomas and hygromas detected after shunting[8, 10]. The same applies to intracranial hypotension and slit ventricle syndromes. In this context, the implantation of a valve, whose pressure gradient is selected on the basis of clinical and computed tomographic criteria[1], but which can be subsequently modified on the basis of these same criteria is therefore very valuable.

We also found this approach to the ideal opening pressure of the valve by successive adjustments to be very useful in subarachnoid cysts as 3 of the 6 patients in our series required two successive modifications in order to obtain not only the right level of opening pressure, but also the right level at the right time, in order to reduce the functional signs of excessive drainage to a minimum, frequently observed after shunting.

The valve function can be assessed by means of a flexible reservoir on the ventricular catheter proximal to the valve which allows tactile evaluation with the finger and valvulography, when required. However, when a standard ventricular catheter has been implanted, valve function can only be monitored by computed tomography[9].

Due to the distortions induced by MR studies, it is currently preferable to implant the body of the valve in the prethoracic region in patients with posterior cranial fossa pathology. It is also essential, after MR, to routinely make sure that the position of the bar magnet controlling the opening pressure has not been altered by the MR study by applying the compass over the valve. This constitutes a considerable practical disadvantage of this type of valve.

Overall, in this series, the Sophy SU 8 valve provided a simple solution for patients in whom the choice of the appropriate opening pressure was difficult and could only be defined by means of successive adjustments. This was particularly marked in the case of normal pressure hydrocephalus, in which excessive drainage is always dangerous, and in subarachnoid cysts in which the pressure gradient required to ensure reduction in the volume of the cyst without inducing headaches is difficult to define.

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