Malfunction of ventriculoatrial shunts caused by the circulatory dynamics of coughing

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Three adult patients are presented in whom the atrial catheter coiled on itself after a ventriculoatrial shunt. Pressures in the jugular and subclavian veins and right atrium were measured during respiration and coughing. It is suggested that the normal pressure changes during the act of coughing facilitate coiling if the atrial catheter material is not sufficiently rigid.

KEY WORDS: hydrocephalus, cough, Holter valve, ventriculoatrial shunt

Since the introduction of the Holter valve in the 1950's, ventriculoatrial shunting has become the usual treatment for hydrocephalus in children. The number of ventriculoatrial shunts and revisions with the Holter system performed at The Columbus Children's Hospital in the last 10 years totals approximately 1250. More recently, this method of treatment has been applied to adults with aqueductal stenosis, certain brain tumors, or low-pressure hydrocephalus.

Our shunt system for children consists of the standard ventricular catheter, the Holter valve in various pressures, a type “H” cervical catheter, and a venous catheter of type “J”.* These latter two are connected by means of a metal step-down connector at the point where the catheter is inserted into the jugular vein. This “J” catheter has an inner diameter of 0.8 mm and an outer diameter of 1.2 mm. The reasons for using such a fine catheter in the vein are the experience of Sayers with infections and the assumption that the least possible amount of foreign material should be introduced into the vascular system. Moreover, we have translated our successful method of shunting in children detail for detail to adults, despite the difference in the size of the patient and the jugular vein.

However, recently we have encountered three adult cases in which this system has failed, each in a similar way, suggesting a common technical cause.

Case Reports

Case 1

A 30-year-old man with known von Recklinghausen’s disease was treated for aqueductal stenosis with a right ventriculoatrial shunt using a low-pressure valve. The operation took place on September 5, 1970, and the correct position of the various catheters was verified postoperatively by x-ray.
September 27, the patient became somnolent and was readmitted. Ventricular pressure was high, and x-ray studies demonstrated a coiled "J" catheter in the lower portion of the jugular vein. This was revised the same day and the position of the catheter verified as satisfactory by x-ray. On November 24, the patient once again became lethargic, however, and a new coil was demonstrated in the "J" catheter in the same region. Revision was performed with a shortened "J" catheter on November 25; x-ray verification in the operating room demonstrated a perfectly straight catheter. One hour later, an x-ray film taken in the recovery room showed that the catheter had recoiled at the same point (Fig. 1).

Case 2

On November 5, 1969, a 61-year-old man with known von Recklinghausen's disease was treated for aqueductal stenosis with a low-pressure Holter valve; satisfactory position of the shunt catheters was verified by x-ray. An incidental chest x-ray taken on November 9 showed the "J" catheter to be coiled at the lower portion of the jugular vein (Fig. 2).

Case 3

A simple arachnoid cyst was successfully removed from the posterior fossa of a 16-year-old boy, who continued well until the age of 21 when he developed evidence of increased intracranial pressure. Positive-contrast ventriculography revealed no evidence of a mass lesion; however, the foramina of Lushka and Magendie were apparently obstructed secondary to arachnoiditis. A ventriculoatrial shunt with a low-pressure Holter valve was inserted on May 26, 1969; position of the catheters was verified by x-ray. The patient was asymptomatic until May, 1970, when he became lethargic, and x-ray studies demonstrated the catheter to be apparently straight but much shorter than it was originally; it ended at the lower jugular vein, and even with vigorous pressure no contrast material could be made to enter the vein. At surgery on May 9, 1970, a tight knot in the "J" catheter was discovered at the level of the obstruction.

Related Clinical Studies

We began to suspect that the failure in these cases was due to the small and very...
Effect of coughing on V-A shunt

flexible "J" catheter as it lay within the large adult jugular vein. We therefore fluoro-scoped several patients with recently placed ventriculoatrial shunts in various positions, at various phases of the respiratory cycle, and with coughing. It became obvious that normally such a catheter in the atrium has a considerable mobility related both to heart action and to respiration. The most dramatic movement was seen during coughing (Fig. 2). The catheter seems to have a tendency to bend and buckle at the level of the right innominate vein.

To understand the physiology of coughing in more detail, we studied a patient with lung cancer who was undergoing a pulmonary angiogram. By means of two separate No. 7 Cordis catheters introduced via separate right antecubital veins we were able to obtain simultaneous venous pressures during various phases of the respiratory cycle and during cough. Figure 3 compares the pressures at rest in the jugular vein with those at the junction of the superior vena cava and the right atrium, and shows that during inspiration the atrial pressure becomes lower than the jugular venous pressure, favoring return of blood to the heart. Figure 4, taken during coughing, shows a dramatic rise in atrial pressure, much higher than that of the jugular pressure for a brief period of time. Figure 5 shows that the pressure in the subclavian vein during coughing does not differ greatly from that in the atrium, and therefore is greater than that in the jugular vein.

Thus, during coughing there is a pressure effect on the tip of the catheter that drives it back toward the jugular vein. There is usually a valve located at the junction of the jugular and innominate veins, but none in the proximal subclavian-innominate-superior.

![Fig. 3. Graph showing simultaneous venous pressure measurements at rest in the right atrium and right jugular vein.](image1)

![Fig. 4. Graph showing venous pressures measured simultaneously in the right atrium and right jugular vein during cough.](image2)

![Fig. 5. Graph showing venous pressures measured simultaneously in the right atrium and right subclavian vein during cough.](image3)
vena cava. The direction of flow is toward the subclavian vein. The pressure from coughing could cause the catheter to buckle at this point, spin into a coil, and even in some cases to tie into a knot, as in our Case 3. Thus, it is easy to imagine how in certain individuals the coil of catheter could wedge itself into the smaller diameter of the lower jugular vein.

As a result of these observations, we have discontinued the use of “J” catheters in adults and have substituted the larger and more rigid “A” catheter with its inner diameter of 1.2 mm and outer diameter of 2.5 mm. In two patients under fluoroscopy we have verified that the “A” catheter does not buckle appreciably with coughing. However, this catheter is not considered ideal partly because of its bulk and partly because it lacks the flange present on the “J” catheter, which serves to prevent the escape of the catheter into the circulation should a disconnection occur. We are hopeful that other materials may become available that combine thinness with greater rigidity.

References


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