Use of Ultrasound in Detecting Optimum Position of Distal End of Ventriculoatrial Shunt in Relation to Tricuspid.

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INTRODUCTION

The ventriculo-atrial shunt operation has been used universally for the treatment of hydrocephalus. The history of the treatment for hydrocephalus by establishing a communication between the cerebrospinal fluid pathways and the vascular system began with Gärtner\(^9\) who first suggested the concept at the National Science Convention at Lübeck in 1895. Payr\(^{25}\) who published his experiences in 1908, first attempted to make ventriculo-venous anastomosis. He connected the lateral ventricle to the longitudinal sinus using a segment of saphenous or temporal vein in 3 patients, but his efforts were unsuccessful. Thereafter many surgeons\(^6,10,13,16,26\) attempted fruitlessly the ventriculo-venous shunts for hydrocephalus during the first half of this century. But as early as May, 1949, Nulsen and Spitz\(^{19}\) devised a system utilizing two ball valves connected with a rubber pump. This shunt was implanted to connect the lateral ventricle with the internal jugular vein in a 14-month-old infant with hydrocephalus. When they reported the result of this implantation in 1951, the shunt had been functioning satisfactorily for 2 1/2 years. In 1957, Pudenz et al.,\(^{27}\) published their experience with a single silicone slit-and-core valve molded into the tip of the cardiac segment of the tube. And they used their shunt in a female infant with obstructive hydrocephalus. They wrote successful use of this method requires that the valve at the end of the cardiac tube be properly located in the auricle so that it floats, as it were, in a pool of blood. Should the valve remain within the lumen of the internal jugular vein, it will be enveloped closely by the vessel wall and cease to function within a few days. After the work of Nulsen and Spitz, and that of Pudenz et al., the procedure met with a great success. Ventriculo-atrial shunt operation is now fairly universally accepted for palliation of hydrocephalus, obstructive and communicating, acquired and congenital. However, many complications of this surgical procedure have been reported. The serious complications of ventriculo-atrial shunting are major venous thrombosis and septicemia, because of inadequate placement of the end of the cardiac tube. Placement in the jugular vein results in obstruction or encapsulation of the end of the tube, and tubes passed to the areas of the tricuspid valve predispose to the development of mural thrombi and septicemia.

In the ventriculo-atrial shunt operation, the most important point to prevent for these complications to occur is, how to place the distal end of the cardiac tube accurately in the right atrium. The early methods of verification of the positioning of the cardiac tube were the roentgenographic methods\(^1,20,28\) using the metal stylet into the tube, the contrast medium injected into the tube or the radioopaque silicone tube. In 1960, Mark and Sweet\(^{15}\) reported a new method for accurate placing the cardiac

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end without x-ray control, by measuring the difference of pressure between atrium and ventricle. In 1961, Robertson et al.\(^1\) described a different method of placing the cardiac end of the ventriculo-atrial shunt with aid of the endocardiac electrocardiogram. However, even after using these methods complications because of inadequate placement of cardiac tube have been reported in the ventriculo-atrial shunt operation.

This is probably due to the fact that the position of the cardiac end determined by these methods may not always correspond to anatomical position. The author has devised the more desirable method of determining the distal end anatomically in relation to the tricuspid valve using the ultrasound. This is to obtain the echo from the tricuspid valve and measure the distance from the tricuspid valve to the ultrasonic probe tip. An ultrasonic instrument was devised by the author for this purpose. After successful experimentation in animals to obtain atioventricular valve echo, the instrument was used in clinical 22 cases during the surgical procedure, and the ultrasonic measurement of the distance between the probe tip and the tricuspid valve was compared with other methods of verification of the position of the distal tube tip such as roentgenography and endocardiac electrocardiography. This comparative study showed that positioning of the tube tip using other two methods is often incorrect due to anatomical variation in relation to the tricuspid valve. It is the purpose of this paper to describe the ultrasonic instrument, the technique and the results of the comparative study on the ultrasonic, roentgenographic and electrocardiographic methods.

**Ultrasonic Instrument**

The device is a probe, 37 cm in length, 2.5 mm or 2.8 mm in diameter at the tip, with a transducer of ultrasound located at the tip containing barium titanate, 2 mm in diameter, having operating frequency of 5 megacycles per second. The direction of the transducer is so fixed that the ultrasonic beam may travel at an angle of 35 degrees with the direction of the shaft (Fig. 1 & 2), and furthermore, the transducer has 6

![Fig. 1.—Ultrasonic probes.](image-url)