ACCURATE PLACEMENT OF VENTRICULO-ATRIAL SHUNT FOR HYDROCEPHALUS UNDER ELECTROCARDIOGRAPHIC CONTROL*

CAPTAIN JAMES T. ROBERTSON, MC, USAF, †ROBERT W. SCHICK, M.D., FRED MORGAN, M.D., AND DONALD D. MATSON, M.D.

Neurosurgical Service, The Children's Hospital Medical Center, and Department of Surgery, Harvard Medical School, Boston, Massachusetts

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Drainage of cerebrospinal fluid directly into the blood stream has been used with increasing frequency in the surgical therapy of hydrocephalus. Experience in our clinic, as well as that reported by others, has indicated that if the cerebrospinal fluid is to be shunted successfully from the ventricular system into the blood stream, the tip of the catheter delivering the fluid must be within the right atrium of the heart. \(^1\) This was predicted by Pudenz who demonstrated by observations in animals that if the catheter remained within the jugular vein or superior vena cava, it became surrounded by a fibrous capsule which frequently led to occlusion of the vein and blockage of the tip of the catheter. \(^5\) Clinical application has shown that these mechanical problems are minimal when the tip of the catheter is placed precisely in the mid-atrium.

Until recently this has proven difficult to carry out consistently. Measurements of the distance from the mid-cervical region or the sternoclavicular junction to the level of the right atrium have been estimated at different ages based on preoperative roentgenograms. Subsequently, an opaque medium (Hypaque) has been injected into the lumen of the silicone rubber catheter after it had been placed at the estimated depth, and portable roentgenograms have been made on the operating table. Even then it has been difficult to be certain just where the tip of the Hypaque-filled catheter actually was in the cardiac silhouette, as the tip apparently moves considerably in the heart and has not always allowed a sharp picture.

Additional objections to roentgen-ray localization of the catheter include: (1) the usual portable operative roentgen-ray facilities do not always provide clear, diagnostic films; (2) technical errors in making the films frequently prolong the operative procedure; (3) the patient and operating personnel may be exposed to radiation; (4) making numerous operative films increases the risk of contamination of the wound; (5) making additional roentgenograms involves added expense. In very young infants the right atrium is so small that incorrect placement of the catheter too far proximally or distally is indeed a common error.

It is the purpose of the present communication to describe a new method for accurate placement of the cardiac end of a ventriculo-atrial shunt which has had limited but most satisfactory trial to date in our clinic. This method involves use of the cardiac silicone rubber catheter filled with saline solution as a unipolar electrocardiographic lead. Tracings are made from this lead as the catheter is advanced down the internal jugular vein until accurate placement of the tip within the mid-atrium is assured.

ELECTROPHYSIOLOGY

This method utilizes well-established intra-cardiac electrocardiographic tracings for localization. \(^5\) The normal cardiac impulse originates in the nodal region of the heart near the entrance of the superior vena cava. The electrocardiographic apparatus is arranged so that an impulse moving from the recording electrode is recorded as a downward deflection on the tracing and vice versa. Accordingly, in the proximal great veins and high right atrium the atrial complex is predominantly a downward deflection. It becomes biphasic in the mid-atrium and an upward deflection in the low atrium as the ventricle is approached (Fig. 1). Concomitantly the ventricular complex tends to deepen, then develop an increasingly prominent R wave with varying S-T elevation. The atrial wave change is constant and most significant. The downward atrial deflection is notched slightly in recordings from an electrode in the superior vena cava just before it enters the right atrium. If the catheter slips into the right or left subclavian vein, patterns characteristic for


† Assigned as Clinical Fellow in Neurosurgery, The Children's Hospital Medical Center, and Research Fellow in Surgery, Harvard Medical School, Boston, Massachusetts.
Fig. 1. Typical normal intracardiac and intravascular electrocardiographic tracings. (1) Right internal jugular vein. (2) Superior vena cava. (3) Mid right atrium. (4) Low right atrium. (5) Left subclavian vein.

these locations appear and the amplitude decreases as the electrode moves away from the heart. If the electrode is in the inferior vena cava, a characteristic tracing for this location can be recognized at once.

Premature atrial contractions occur commonly whereas ventricular premature contractions are unusual.

It is not necessary to obtain preoperative electrocardiograms or to employ any other leads for accurate intracardiac placement of the electrode to be recognized.

METHOD

The internal jugular vein is exposed in the neck as usual. The electrocardiograph is then set up to record from a unipolar lead. Although various combinations have been tried, satisfactory tracings may be obtained by utilizing the components of standard lead I. The left-arm electrode is connected to an autoclaved Teflon-covered wire whose distal tip is connected to the side of a 15-gauge blunt intravenous needle (Fig. 2). The right-arm electrode and patient are both grounded. By using only these leads the sensitivity of the machine is easily regulated to minimize 60-cycle interference.

A 10-cc. syringe filled with isotonic saline is attached to the needle inserted into the shunt tube. The tube is filled with saline, introduced into the vein for about 4–5 cm. and an initial tracing is made.

Saline may be injected intermittently; continuous slow injection is necessary only when the Heyer valve is used. Tracings are made every 1.0 cm. as the tubing is advanced. The atrial complex becomes progressively deeper, then notched, and finally the biphasic pattern of the mid-atrium appears (Fig. 1). This may be checked by withdrawing and re-introducing the catheter if desired. The tubing is then anchored to the jugular vein in this position and the operative procedure is completed in the usual manner.

RESULTS

This method has been used to place the cardiac catheter distal to a Holter valve in 38 patients ranging in age from 1 month to 14 years. Intraoperative and postoperative roentgenograms of the chest have confirmed placement of the tip of the catheter within the atrium in each patient. In 2 patients the catheter was passed via the left jugular route, and in the others on the right side. Tributary veins were utilized when available. A Heyer valve has been used with similar recordings on one occasion.

DISCUSSION

The silicone rubber tubing filled with isotonic saline functions satisfactorily as an intracardiac electrode. This method of placement of the catheter requires minimal preparation and only a few minutes of recording during operation. The characteristic biphasic atrial wave marking correct placement of the catheter is easily recognized.

Hypertonic saline (3 per cent) has been used several times and constitutes a better electrode than does an isotonic solution. Although we have had no experience with a metallic electrode passed the length of the shunt, a small wire built within the wall of the tubing might well simplify the procedure even further. Certainly the method, as described, has proven simple, adaptable and satisfactory.

Present plans include the use of an oscilloscope which should make it easier for the surgeon to see the tracings.

SUMMARY

A method of placing the cardiac end of a ventriculo-atrial shunt with the aid of the electrocardiogram is described and the advantages are stated.