Catheterization of the Left Atrium by Ross Needle and Seldinger Wire Techniques

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Catheterization of the left atrium in patients with an intact atrial septum has a wide application in the elucidation of congenital and acquired heart disease. Simple atrial puncture permits the measurement of intra-atrial pressure and the direct injection of tracer substances. The method of left atrial puncture introduced by Cope (1959) and Ross (1959) has been widely adopted for this purpose. In this technique a stout walled tube made of plastic-coated woven nylon is passed up to the right atrium from the groin. Through this a 24-in. (61 cm.) needle with a curved tip is introduced to the right atrial cavity. The needle is manoeuvred until the tip of the plastic introducing tube is felt to lodge in the foramen ovale, the needle tip being retained within the introducer during this time. When the needle is felt to be firmly lodged, the needle tip is protruded by about 1 cm. and perforates the membranous part of the intra-atrial septum to enter the left atrium.

In 1960 Ross, Braunwald, and Morrow reported the successful investigation of 130 patients without significant complications, and by 1963 over 1000 transseptal punctures had been reported, with little morbidity (Cope, 1963). The technique may permit the measurement of the left ventricular pressure by means of a fine plastic tube which is passed through the needle and floats on into the left ventricle. The manoeuvre is successful in about 75 per cent of cases (Ross *et al.*, 1960; Nixon, 1960; Singleton and Scherlis, 1960; McGuire *et al.*, 1961; Soulié *et al.*, 1961; McGaff *et al.*, 1961). The Ross needle technique, however, is limited in scope as it is not possible to perform angiocardiology of the left heart or to investigate the effect of exercise on the left atrial pressure. Angiocardiology is possible, however, if a suitable catheter is used as an introducing catheter for the Ross needle and is

pushed on through into the left atrium (Beuren and Apitz, 1962a, b; Macdonald and Miller, 1962). The heavy Ross needle, however, is an alarming instrument for this manoeuvre, and is also somewhat short. In a patient with a long spine a catheter 23.5 in. (60 cm.) may only just reach the left atrium, and further manipulation may be impossible. Brockenbrough, Braunwald, and Ross (1962) introduced a modification of the original needle designed to facilitate catheterization of the left atrium. The technique, using this needle, has proved sufficiently dangerous in the author's hands to prompt the development of the method that is the subject of this paper.

The Brockenbrough needle is longer than the Ross needle (71 cm. long, 18 gauge tubing) and is made of steel tubing which has a thinner wall. It terminates in a short length of fine 21-gauge tubing with which the septum is punctured. The main length of the needle (which is of slightly smaller gauge than the Ross needle, as well as being of thinner steel) is passed to the left atrium by way of a plastic catheter which has been previously led into the right atrium from the groin by a special straight introducing cannula 69.5 cm. long. This cannula has no point and extends to about 1 cm. short of the catheter tip.

The Brockenbrough needle is positioned in the right atrium with the needle tip within the lumen of the catheter. The curved tip is turned posteromedially and moved up and down the interatrial septum until it is felt to lodge in the foramen ovale as in the Ross technique. The point is then protruded to puncture the septum, and the position of the tip in the left atrium is confirmed by pressure measurement, sample, and indication dilution curve. The catheter is then advanced into the left atrium. The use of the more flexible Brockenbrough needle has been associated with an increased incidence of

Received May 10, 1966.

complications. Brockenbrough *et al.* (1962) report the perforation of the aorta in one case. A similar accident has been reported in 2 cases among 158 punctures by Peckham *et al.* (1964), and 4 out of 200 investigations by Libanoff and Silver (1965). Perforation of the heart wall was reported in 9 cases by Adrouny *et al.* (1963); 3 cases by Libanoff and Silver (1965), and a similar accident which ended fatally is described by Russell, Carroll, and Hood (1964). Penetration of the catheter wall by the needle is mentioned by McIntosh *et al.* (1961) and may also occur with the original needle used by Ross if the specially made woven introducing catheter is not used (Macdonald and Miller, 1962). In one case described by Parker, West, and Fay (1964) the narrow tip of the needle became detached and was left transfixing the atrial septum.

In the author's experience the original Ross technique has given little trouble, the only difficulty being the occasional patient in whom the insertion of the needle has caused such discomfort that the procedure has been abandoned.

In the course of 20 attempts to use the Brockenbrough technique, however, the author had a number of unpleasant experiences which have been common to many others using this instrument. The plastic introducing catheter has been perforated by the fine tip of the Brockenbrough needle, either in the course of manipulation of the needle up the inferior vena cava or at the point at which the catheter becomes acutely curved in the 6 cm. proximal to its tip (Fig. 1). This accident is potentially dangerous, but may be avoided by passing a fine steel wire through the Brockenbrough needle so that it protrudes beyond it as a lead (Cope, 1963). This fine lead is withdrawn when the needle tip has reached the end of the catheter.

The positioning of the Brockenbrough needle in the right atrium is a much less certain procedure than the manipulation of the Ross needle. The greater length and thinner material of the Brockenbrough needle result in a much greater flexibility, and the ease with which the hub will rotate without a corresponding rotation of the needle tip can be very dangerous. On one occasion an apparently satisfactory puncture of the left atrium using the Brockenbrough needle resulted in the tapping of a pericardial effusion from the right atrium. This accident was probably due to the needle tip lodging in a position too far to the right, despite an apparently medial position as gauged by the position of the needle hub. This unexpected diagnostic achievement was not followed by any ill effects, but a similar failure of the tip to rotate from an antero-medial position to a postero-medial position was responsible for the perforation of the aorta through

a sinus of Valsalva. This caused serious hæmorrhage requiring transfusion, and a temporary uraemia which responded to dialysis.

Further difficulties may occur even when the Brockenbrough needle has been correctly positioned. On one occasion it failed to puncture a tensely distended left atrium, passing up its length in a series

FIG. 1.—Perforation of left atrial catheter by the Brockenbrough needle. Both are in the right atrium.

of alarming jumps during which it was difficult to believe the atrial septum was not being scarified. Successful catheterization of the left atrium by this technique requires the simultaneous advance of both needle and catheter so that the needle point may enter the left atrium, usually to end up in a pulmonary vein. Occasionally, however, it may perforate the left atrial wall. If the catheter is advanced alone, without movement of the needle, the puncture made in the septum by the fine tip of the needle is too small to permit the passage of the catheter which pushes the septum before it until the needle tip is disengaged, whereupon the needle and catheter flick up into the superior vena cava. Not infrequently in a large right atrium even the advance of both needle and catheter is unsuccessful as the needle becomes increasingly bent until the

FIG. 2.—The Ross needle is protruding beyond the end of the introducer, and the Seldinger wire lies in a pulmonary vein. This wire is not yet far enough out into the lung to ensure that it does not slip back into the right atrium (Fig. 4 and see text).

upguarded tip flicks out of the perforation in the septum and scratches its way up the septum into the veins at the thoracic inlet.

METHOD

When the experience of left atrial puncture was considered it seemed possible that the relatively safe Ross puncture technique might usefully be combined with the techniques of Seldinger (1953) and Brockenbrough *et al.* (1962) to produce a method of left atrial catheterization which was easier than that described by Brockenbrough *et al.* The basis of the method is to use the Ross needle to pass a Seldinger wire to the left atrium, and subsequently to pass a catheter over the wire to the left side of the heart. The Seldinger wire* needed for this manoeuvre must be 180 to 200 cm. long, depending on the length of the catheter to be passed to the left atrium. Experiment with a standard wire had shown that the rough surface of the wire made it difficult to manipulate in and out of a Ross needle. Wires are wound of flattened steel wire which have a much smoother surface than the standard wires and have proved much easier to use (Verel, 1966). They

* The Seldinger wires used in this technique were made and supplied by James How & Co., 495 Blackfen Road, Sidcup, Kent.

are supplied with an outside diameter of 0.035 in. (0.09 cm.) and in lengths of 180 and 200 cm.

The technique at present adopted is as follows. The left atrium is punctured by the Ross technique, the needle usually being introduced through an open exposure of the long saphenous vein. After recording the left atrial pressure through the needle, a 180 or 200 cm. wire is passed up the needle until its end is clearly well out in the lung field (Fig. 2). The needle is then drawn back until its tip is within the introducing catheter. Needle and introducer are then withdrawn together inch by inch by passing them along the Seldinger wire, an assistant simultaneously feeding the wire in as the needle is drawn back in order to preserve the position of the wire tip unchanged (Fig. 3). It is important that too much wire does not accumulate in the right atrium as this may result in the wire withdrawing from the left atrium in the course of accommodating to the curve forming in the right atrium.

Once the needle is clear of the patient, the wire is gripped at the site of insertion and the needle and introducer drawn off. The wire is then wiped clean and a left atrial catheter (BR-70, U.S.C.C. catalogue) on a Brockenbrough introducing blunt tipped needle (BR-185, U.S.C.C. Catalogue) is threaded over the wire and passed up to the right atrium. The tip of this introducing blunt needle is bent in a similar fashion to the Ross needle. Because of its finer gauge and thinner wall it will accommodate both the wire inside it and the catheter over it. (The Ross needle is too big to pass up inside these catheters.) During the passage to the right atrium the heart is screened, and the wire neither advanced nor withdrawn, as an assistant extracts the wire from the end of the introducing needle as fast as the needle moves up the great veins. If there is any failure of this co-ordination it becomes immediately apparent. If the wire is drawn out too fast the tip of the wire in the lung field is seen to come back towards the heart. If the wire is drawn out too slowly a slight check to the progress of the needle is felt: the x-ray screen should then be moved down when the usual situation is shown in Fig. 4; here the wire has formed a loop in the iliac vein. This is easily righted by drawing the catheter back slightly before resuming onward progress. The introducing needle tends to come out of the catheter at this stage of the procedure, but by holding both the catheter and Brockenbrough introducer in the fingers of one hand this can be avoided.

In the right atrium the tip of the introducer is turned postero-medially and the catheter gently passed up the wire until it is clearly in the left atrium (Fig. 5). The wire and needle are then withdrawn (Fig. 6), and the catheter connexion screened together. Should it be necessary to change the catheter the Seldinger wire is again passed up, a good length being preferably coiled up the left atrium (Fig. 7). The catheter is then withdrawn and another catheter is introduced using the blunt needle.

Percutaneous introduction of the catheter is easily achieved. The femoral vein is punctured by a needle introduced 2–3 cm. below Poupart's ligament with the thigh in a slightly abducted everted position (Verel, 1958). The Seldinger wire is passed well up the femoral

FIG. 3.—Position of Seldinger wire during removal of Ross needle and insertion of catheter. Note the reduced density of the tip end of the wire due to the lack of the steel cane in the terminal 5 cm. Arrow indicates the tip of the wire.

FIG. 4.—A possible hazard during the introduction of the left atrial catheter. The catheter tip has been advanced more rapidly than the guide wire has been withdrawn, with the result that a loop has formed in a pelvic vein.

FIG. 5.—The catheter and introducer have been passed up the guide wire and through into the left atrium. The ease with which the passage through the septum is achieved varies, sometimes a distinct resistance is felt, usually the position of the catheter tip is the only indication.

FIG. 6.—The catheter has been advanced up the guide wire and is in the left atrium. Catheter in the left atrium after withdrawal of guide wire. To form a coil in the atrium (Fig. 8) the loop should be increased until the tip of the left atrial catheter is inclined downwards and to the right.

FIG. 7.—Coil of Seldinger wire in the left atrium. The atrial puncture site is immediately inferior to the point at which the shadow of the wire crosses itself.

FIG. 8.—Introduction of Ross needle introducing catheter by percutaneous technique. A, Seldinger wire; B, polythene tubing; C, Ross catheter.

vein into the inferior vena cava. A 75 cm. length of P.E. 53 polythene or nylon transparent tubing is then passed over the wire into the femoral vein. This is an easy fit on the wire, and has an outside diameter slightly less than the inside diameter of the introducing catheter (U.S.C.C. T 10). The introducing catheter is then passed over the polythene sleeve until the sleeve can be gripped firmly. The introducing catheter can then be advanced into the femoral vein with little difficulty (Fig. 8).

RESULTS

Left atrial catheterization by this combination of Ross and Seldinger techniques has been attempted on 30 occasions. There have been three failures, all in the first 10 catheterizations. In one a loop of wire formed in the right atrium during the insertion of the left atrial catheter, and the guide wire came out of the left atrium. In another case the insertion of the Ross needle was abandoned as the patient complained of discomfort, and the needle was so firmly held that manipulations seemed dangerous. In the third, the introducing catheter could not be manipulated as far as the inferior vena cava, and an injection of contrast medium suggested that the main venous path was blocked.

The remaining catheterizations have been successful. In one the wire came out of the atrial puncture into the right atrium during the insertion of the left atrial catheter because a loop formed in the right atrium, but was reinserted by passing the

guide catheter back to the left atrium along the wire, removing the wire, and then repeating the septal puncture with the Ross needle, subsequently reinserting the guide wire. This accident has not recurred since the guide wire has been passed far out into the lung field before attempting to remove the Ross needle and insert the catheter. The wire has been guided to the left lung veins by inclining the Ross needle tip postero-laterally after puncturing the interatrial septum with the Ross needle inclined at about 15° from the antero-posterior plane.

With increasing practice the speed with which this catheterization can be done has increased. The removal of the Ross needle and guide catheter takes the most time. Originally they were removed separately, but it has proved easier to take them out together, the Ross needle tip being retained within the introducer, and so sheathed. With practice this removal can be done in under one minute, and the insertion of the left atrial catheter in less time.

Changing catheters has proved a simple matter. The atrial catheter is manipulated until it lies in a suitable curve and the Seldinger wire is then introduced so that it forms a coil in the left atrium. The catheter is withdrawn and a fresh one threaded up over the wire on the introducing Brockenbrough cannula. As the catheter approaches the site of the atrial puncture the wire in the right atrium is kept straight by slight withdrawals.

The Seldinger wires used in this technique are more malleable than those usually supplied and kinks can easily be straightened out. A single wire will usually serve for the percutaneous puncture and left atrial puncture. We have, however, discarded the wire at the end of an investigation.

SUMMARY

A technique for the catheterization of the left atrium by Ross needle and Seldinger wire is described. It has proved a simple and safe method for introducing a catheter into the left side of the heart.

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