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Catheter Replacement of the Needle in Percutaneous Arteriography: A new technique

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FROM THE ROENTGEN DIAGNOSTIC DEPARTMENT (DIRECTOR: PROFESSOR KNUT LINDBLOM), KAROLINSKA SJUKHUSET, STOCKHOLM, SWEDEN

CATHETER REPLACEMENT OF THE NEEDLE IN PERCUTANEOUS ARTERIOGRAPHY

A new technique

by

Sven Ivar Seldinger

The catheter method of angiography has become more popular in the past few years, as it provides the following advantages over the method of injecting the contrast medium by means of a simple needle:

1) The contrast medium may be injected into a vessel at any level desired.

2) Risk of extravascular injection of the contrast medium is minimised.

3) The patient may be placed in any position required.

4) The catheter may be left in situ without risk while the films are being developed, thus facilitating re-examination if necessary.

Until recently, however, the use of the catheter method was restricted because of the lack of a suitable flexible thin-walled catheter which could be used percutaneously. FARIÑAS, in 1941, described a method in which a urethral catheter was passed up into the aorta through a trocar inserted in the exposed femoral artery. In 1947, RADNER catheterized the exposed and ligated radial artery and performed vertebral angiography and later thoracic aortography. Since then, many authors have catheterized arteries for various purposes, by surgical exposure followed by ligature or resuturing of the artery. In 1949, JÖNSSON performed thoracic aortography after puncture of the common carotid artery by means of a blunt cannula provided with an inner sharp needle. The cannula, guided by a silver thread, was then directed downwards. Later

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the procedure was abandoned, partly because it was considered that the cannula might injure the aortic wall. This percutaneous method might have proved more useful if a technique for using a flexible catheter of adequate lumen had been available at the time.

The artery exposure technique of catheterization is time-consuming, troublesome and may present certain risks. The thin-walled polyethylene tube, however, makes percutaneous catheterization possible, as reported by PEIRCE in 1951, who passed in the tubing through a large bore needle. This method was suitable for aortography via the femoral artery. In the same year, DONALD, KESMODEL, ROLLINS and PADDISON, employing a similar technique, catheterized the common carotid artery in cerebral angiography. The method necessitates the use of a large bore needle which may make puncture difficult and limits its use to comparatively large arteries, hence PEIRCE's attempts to catheterize the brachial artery were disappointing. There is also extra damage to the artery and, as the hole in the artery is larger than the catheter, haemorrhage after removal of the needle may be troublesome. To prevent bleeding, the needle may be kept in situ during the investigation; this, however, increases the risk of injury to the patient during movement.

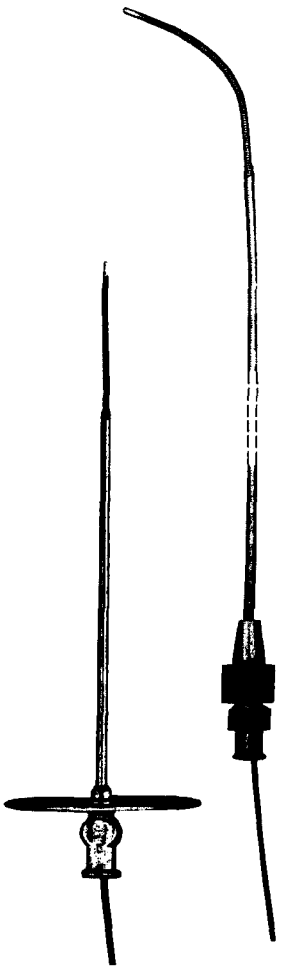


Fig. 1. The equipment. The stilette is removed and the leader inserted through the needle (left) and the catheter (right).

There is a simple method, however, of using a catheter the same size as the needle, and which has been used at Karolinska Sjukhuset since April 1952. The main principle consists in the catheter being introduced on a flexible leader through the puncture hole after withdrawal of the puncture needle. The details are as follows:

Equipment. (Supplied by A. B. Stille-Werner, Stockholm.)

1) A puncture needle with stilette.

2) A flexible rounded-end metal leader with increased flexibility of its distal 3 cm.

3) A polyethylene tube, of the same diameter as the needle, with an adapter for the attachment of a syringe.

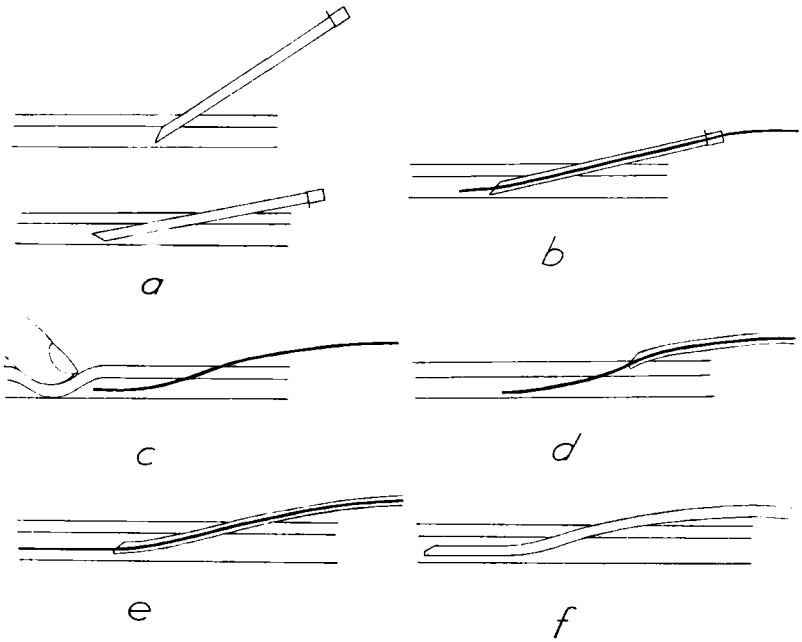


Fig. 2. Diagram of the technique used. a) The artery punctured. The needle pushed upwards. b) The leader inserted. c) The needle withdrawn and the artery compressed, d) The catheter threaded on to the leader. e) The catheter inserted into the artery. f) The leader withdrawn.

The leader should have a diameter slightly less than the bore of the needle and the catheter, so that it is capable of passing through both, and should be at least 8—9 cm longer than the latter; on the other hand it should just fit the lumen of the catheter (Fig. 1). The tip of the catheter may be cut before use as shown in Fig. 2.

Technique (see Fig. 2).

a) After local anaesthesia, the artery is punctured percutaneously at a relatively small angle.

After puncture it is best to rotate the needle 180° and push it a little into the artery using the bleeding as a guide to ensure that the needle remains in the artery. Puncture of arteries smaller than the femoral artery is facilitated by using an inner needle as a guide over which the outer needle is directed into the artery.

b) The supple tip of the leader is inserted a very short distance into the lumen of the artery through the needle.

c) The leader is held in place and the needle removed.

Fig. 3. Hypoplastic lower pole of the right kidney. Blood supply from two branches of a small aberrant artery. Catheter inserted through the right femoral artery with tip 2 cm below the renal arteries.

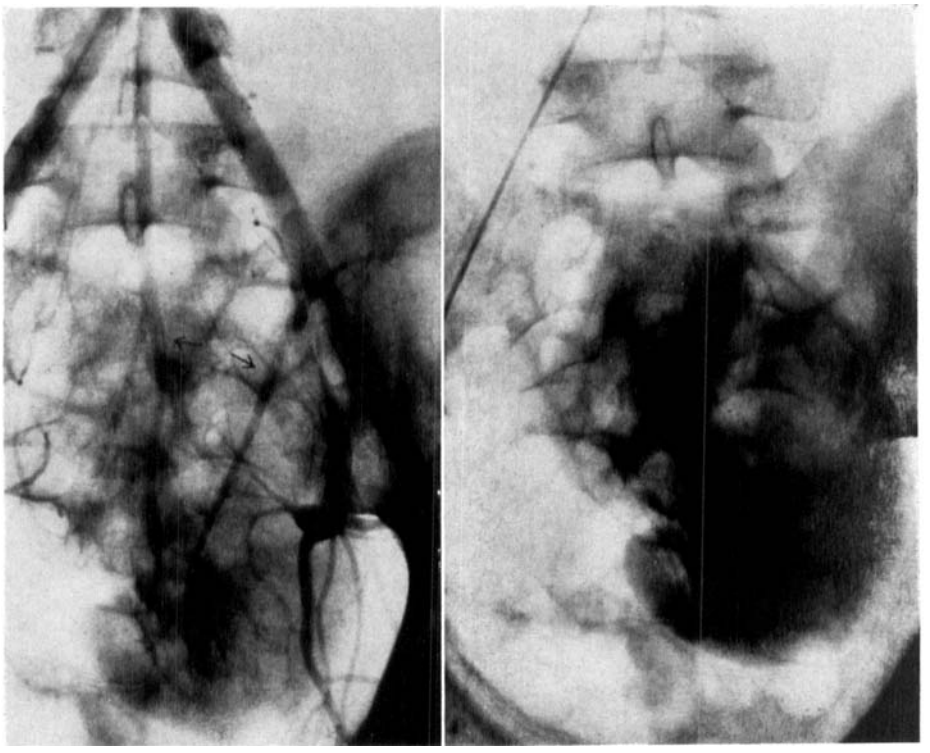
At this moment bleeding should be controlled by pressure on the artery proximal to the puncture site, because the diameter of the leader is smaller than the hole in the artery.

d) The catheter is threaded on to the leader; when the tip reaches the skin the free end of the leader must protrude from the catheter.

e) The catheter and leader are gripped near the skin through which they are inserted. The catheter enters the artery easily as an opening has already been made by the needle. The catheter and leader are pushed just far enough to ensure that the tip of the former is in the lumen of the vessel.

f) The leader is removed and the catheter directed to the level required, after good arterial bleeding through the catheter has been obtained. The unsupported catheter is usually pushed up the vessel without difficulty, but occasionally the leader must be re-introduced into the catheter in order to support it. The leader should not be passed beyond the tip of the catheter.

This technique is simpler than appears on paper and after a little practice should present no difficulties. It is important that the leader passes into the artery easily. When the tip of the catheter enters the artery, the same resistance is often felt as when puncturing is performed



a. b.

Fig. 4. Left-sided ectopic kidney in pelvis. (Right kidney absent.) Blood supply by one artery from the iliac bifurcation and one from the left internal iliac artery. Catheter inserted through the right femoral artery with tip at the bifurcation. a. Arterial phase. b. Capillary phase.

by means of a needle. However, the resistance is generally but slight or may be completely absent. If considerable resistance be encountered, it is probable that the tip of the leader is obstructed and force must therefore never be applied.

Polyethylene tubing is unfortunately not radio-opaque. For this reason, in aortography via the femoral artery, a small amount of contrast medium may be injected and followed by a test exposure. This will show the position of the catheter and also the exact situation of the renal arteries and of the iliac bifurcation. When the brachial artery is catheterized, the procedure is carried out in the fluoroscopy room and the leader used as an indicator of position; the catheter is then kept free from blood by the injection of saline solution.

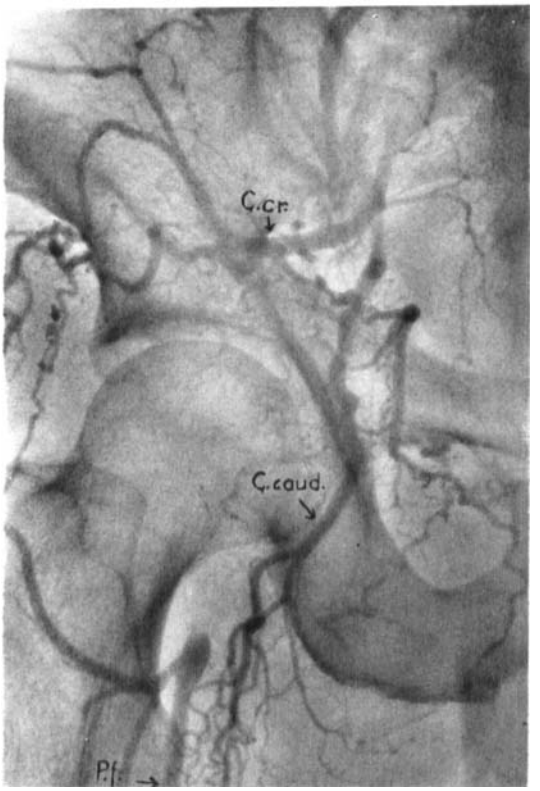


Fig. 5. Cavernous angiomas of the heel. Arterial phase. Catheter inserted through the femoral artery with tip in the popliteal artery. The difficult puncture of the popliteal artery was replaced by the easily performed catheterization from the inguinal region.

Fig. 6. Occlusion of the right external iliac artery. Collaterals from the superior gluteal to the deep femoral artery. Inner part of the thigh supplied from the inferior gluteal artery. Catheter inserted through the left femoral artery with tip at the bifurcation. G. cr. = superior gluteal artery. G. caud. = inferior gluteal artery. P. f. = deep femoral artery.

Summary of Investigations Performed

40 arterial catheterizations have been carried out; of these, 35 were aortographies via the femoral artery, 3 subclavian arteriographies by means of puncture of the brachial artery in the antecubital fossa, and 2 catheterizations of the femoral artery in a distal direction. In no case was general anaesthesia employed. Injection was made throughout by hand. The contrast medium used was 30 cc of Umbradil in each injection with a concentration of 35 % in peripheral arteriographies and 70 % in aortographies except in those cases in which compression of the femoral arteries was used, when a 50 % solution was employed. The tubing used was in all cases No. 200 (internal diameter 1.40 mm, external diameter 1.90 mm) or No. 205 (1.57 mm and 2.08 mm). The latter seemed to be the optimal one for aortography. As the thickness of the wall of the needles available is nearly

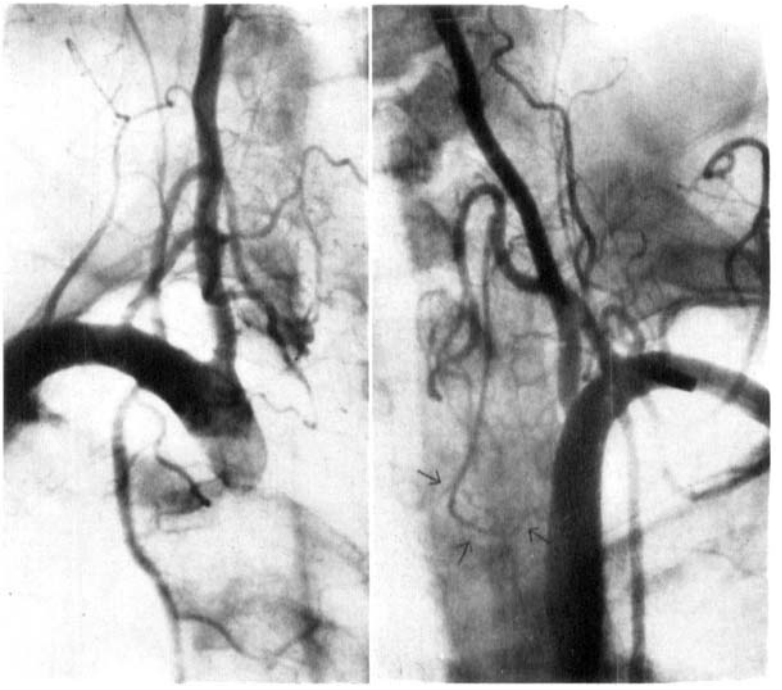


Fig. 7. Catheter inserted through the antecubital artery of both sides. The tip in the subclavian artery. (The metal tip is no longer in use.) The left inferior thyroid artery forks into two branches, the terminations of the longer and lower one of which run in a marked curve downwards and laterally as if around a tumour; examination of a resected part of the left lower lobe of the thyroid showed adenomatous parathyroid tissue in the parenchyma.

the same as that of the catheter, a needle of 2 mm outer diameter is required. If the catheter is 40—45 cm long it permits a faster injection of the contrast medium than the 12—15 mm needle of 1 mm lumen, used in this department for translumbar aortography.

25 catheterizations were performed by the author and 15 by four other workers in the department.

In one patient catheterization did not succeed, in spite of 3 attempts on the femoral arteries, as sufficient blood-flow through the catheter was not obtained. In one patient no attempt at catheterization was made as resistance to the leader was encountered. In one obese patient, introduction of the catheter into the right femoral artery failed, but was carried out without difficulty on the left side. In the other cases the catheter was inserted easily at the first puncture and the investigation resulted in good films excepting in two cases in which the tip of the catheter did not reach the level required. In one of the patients, 75 years old, resistance was encountered after 6—7 cm, and in another the deep femoral artery instead of the superficial one, was persistently catheterized.

In 6 of the aortographies and in the 3 subclavian arteriographies the catheter was fitted with a metal tip (Fig. 7), but this was abandoned because it was found easier to

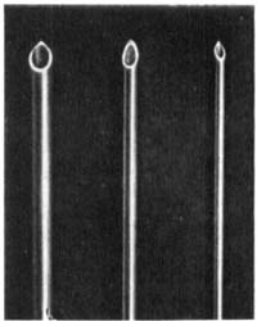


Fig. 8. Natural size. The middle needle permits, with the technique described, the insertion of a catheter (in this case No. 205) which requires a needle of the size of that pictured on the left, were it to be passed through the lumen of the needle. The same relative advantage exists between the right and middle needles.

insert the catheter without it, and the artery wall sometimes contracted around it during its removal. Furthermore, it was realized that it might damage the arterial wall as happened in one of the subclavian arteriographies, so that part of contrast medium was injected extravascularly.

As regards complications any tendency to bleed at the site of puncture was unimportant and was mostly observed in elderly patients. No haematoma of clinical consequence ever formed. No thrombosis or any kind of circulatory disturbance in the region of the artery punctured was observed. There was no case of extravascular injection except the one previously mentioned. In the unsuccessful attempts at catheterization, the leader probably passed through the posterior wall of the artery or its intima via a hole made during puncture. In these cases the needle could not be pushed far enough up into the artery. In neither did the patient suffer any ill effects. No kinking or rupture of the catheter, or arterial spasm around it occurred. After local anaesthesia, the patients felt nothing during the manipulations and following the injection of the contrast medium there was, with individual variations, only the wellknown, rapidly passing discomfort.

In one case the patient was operated on two weeks after bilateral femoral catheterization and both arteries were exposed. Traces of blood under the fascia indicated the situation, but the exact site of puncture could not be discerned.

Figs. 3—7 form representative illustrations.

Discussion

The advantage of the author's method of percutaneous catheterization is the smaller size of needle required for a given catheter. As the catheter needs a certain clearance to enable it to glide through the bore of a needle, the difference is more marked than would appear from the thickness of the material (Fig. 8).

In other words, a larger catheter can be inserted by the same sized needle. POISEUILLE's law states that when pressure and viscosity are constant, the rate of flow through narrow tubes is:

inversely proportional to the length of the tube, and

directly proportional to the 4th power of the radius of the tube.

This shows the dominant influence of the cross section of the catheter. Catheter No. 205, used here for abdominal aortography, has an inner diameter, corresponding to a heart catheter No. 9—10. If a pressure

apparatus were used, the gauge might doubtlessly be diminished considerably, *i. e.* to a size No. 160, corresponding to a heart catheter No. 8, and which may be inserted with the help of a needle, 1.5 mm in external diameter.

Though the extra manipulation with the leader is a disadvantage, it is very quickly performed. Furthermore, there is a little risk that the leader, when handled unskilfully, will pass through the posterior wall of the artery, although, no doubt, experience and improved equipment will eliminate this possible complication and avoid failure.

SUMMARY

The author describes a method by which it is possible, after percutaneous puncture, to insert a catheter of the same size as the needle used into an artery.

ZUSAMMENFASSUNG

Der Verf. beschreibt eine Methode, die es ermöglicht, nach perkutaner Punktion einen Katheter von derselben Grösse wie die benutzte Nadel in eine Arterie einzuführen.

RÉSUMÉ

L'auteur décrit une méthode qui permet, après ponction percutanée, d'introduire dans une artère un cathéter de même calibre que l'aiguille utilisée.

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