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PERCUTANEOUS SELECTIVE ANGIOGRAPHY OF THE MAIN BRANCHES OF THE AORTA

(Preliminary Report)

by

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The usual method of obtaining visualization of one of the branches of the aorta is to inject contrast medium into the aorta itself near the point of origin of the vessel concerned.

The commonest type of these examinations is the so-called renal angiography, in which the aim is to render the vessels of the kidney visible by injection of contrast medium into the abdominal aorta. Similar methods have also been described for, *e. g.*, the coeliac artery with its branches (RIGLER et coll., et alios), and the arterial trunks arising from the aortic arch (HELMSWORTH et coll., et alios).

The last-mentioned group of vessels may also be examined angiographically by retrograde catheterization with contrast injection (HELMSWORTH et coll., RADNER, SELDINGER, et alios) and retrograde injection only (FREEMAN and MILLER). The subclavian artery may be examined by direct puncture of the vessel.

Contrast medium introduced into the aorta, whether the injection is performed through a catheter or a needle, is essentially distributed with the blood stream, that is, fairly arbitrarily. Hence, the possibilities of directing the solution to a certain region, so that the major portion enters one special vessel, are small. Comparatively large amounts of contrast medium in a relatively high concentration have therefore to be used in angiographic examinations of this type. This involves the risk of contrast solution in a toxic concentration entering sensitive vascular areas, particularly the brain and the kidneys. This fact has lately been brought to attention by BROMAN and OLSSON, IDBORN and BERG, ALWALL et coll., et alios.

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Angiographic examinations of the type outlined above are further unsatisfactory in that not only the aortic branch concerned but also other vessels become filled with contrast medium. A radiopaque substance in irrelevant branches of the aorta often obscures the pathologically changed structures it is desired to demonstrate. This effect is especially disturbing in lumbar aortography, in which in many cases almost all the branches arising from the abdominal aorta are filled with contrast medium.

A selective angiographic method aiming at visualization of each branch of the aorta separately, seems therefore to be desirable.

BIERMAN et coll. have tried such a procedure in a total of 24 cases. It was performed according to the following principles:

A radiopaque cardiac catheter with a fixed curve at the tip is used. The catheter is inserted into the arterial system by exposure of a suitable artery of sufficiently large size and incision of its wall through which the tip of the catheter is introduced into the lumen of the vessel. The catheter is then passed further along the arterial system under fluoroscopic control. By diverse manipulations it can then be advanced into any one of the branches of the aorta. In catheterization of the arterial branches that arise from the abdominal aorta the catheter should be inserted intra-arterially via the carotid or the brachial arteries. In order to be passed into the branches of the aortic arch it should be introduced via either femoral artery. After the tip of the catheter has been placed in the vessel concerned contrast medium in a suitable dose is injected.

The method of BIERMAN et coll. requires surgical measures under sterile precautions. This not only makes the catheterization procedure itself difficult but also seems to involve some risk. Thus, in four cases the exposed artery was occluded or otherwise not viable for various reasons (surgical errors, postoperative thrombosis, or wound infection). Such complications followed by paralysis were reported to have occurred in three cases in which the catheter was inserted via one of the carotid arteries. Hence, it can hardly be considered advisable to use these arteries in intra-arterial catheterization. Alternating with the common carotid artery, the brachial artery was used, a procedure which is probably less hazardous, although postoperative thrombosis is reported to have occurred in one case. However, it seems to be fairly difficult to guide a catheter from one of the brachial arteries, especially the right, into one of the branches of the lumbar aorta. Such a procedure is likely to be rendered still more difficult by the fact that the intra-cardiac catheters become soft and pliable at body temperature and hence do not retain a preformed curve and become less dirigible.

TILLANDER has proposed a similar technique, which also requires exposure and incision of a suitable artery for insertion of the catheter

into the arterial system. His catheter, however, is of a special design, its distal part consisting of "small steel-links connected to one another by ball and socket joints". These links can be guided by means of a strong magnetic field so that the tip of the catheter may be passed under fluoroscopic control into one of the branches of the aorta.

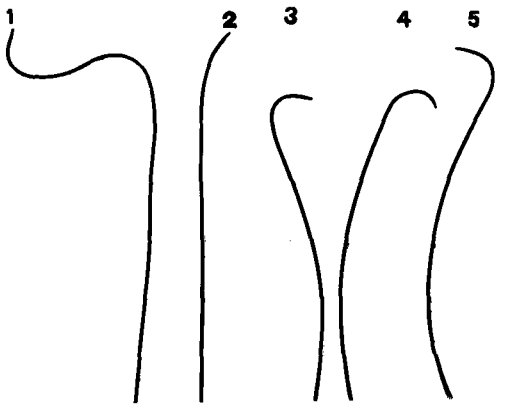


Fig. 1. Types of opaque polythene catheter for angiography of: innominate artery (Type 1), left subclavian artery (Type 2), coeliac artery (Type 3), renal artery with insertion of the catheter via the ipsolateral femoral artery (Type 4), and renal artery with insertion of the catheter via the contralateral femoral artery (Type 5).

This technique may, in practice, be regarded as a variant of the one devised by BIERMAN et coll. The possibilities of manoeuvring the catheter are probably greater with TILLANDER's than with the original method. On the other hand, the apparatus required in TILLANDER's procedure is probably complicated and difficult to handle, and consequently the catheterization itself will hardly be easier to carry out with this technique.

A percutaneous technique for selective angiography of the main branches of the aorta has been tried by the writer since the autumn of 1954. It is based on the following principles:

A radiopaque polythene catheter is used. (This was described in a paper read at the Swedish Association of Medial Radiology, 4 December, 1954, a review of which has been published in Nordisk Medicin. Further details concerning this type of catheter will be published later.) Like the polythene tubing available on the market this type of catheter may be shaped by immersion in hot water (above 72° C) so that it loses its elasticity. It is then cooled quickly so that it resumes its ordinary elastic consistence while it is fixed in the desired curved shape. In this way a polythene catheter may be moulded into any suitable shape. The type of catheter used does not become soft at body temperature but retains its preformed curve even after it has been introduced into the vascular system.

For use in selective angiographic examinations, radiopaque polythene catheters have been moulded in such a way that their shapes are suitable for the branch of the aorta it is desired to examine (see pp. 6 to 9). The ordinary distal bore of the catheter is narrower than the rest of the lumen, and close to the tip there are side holes directed away from

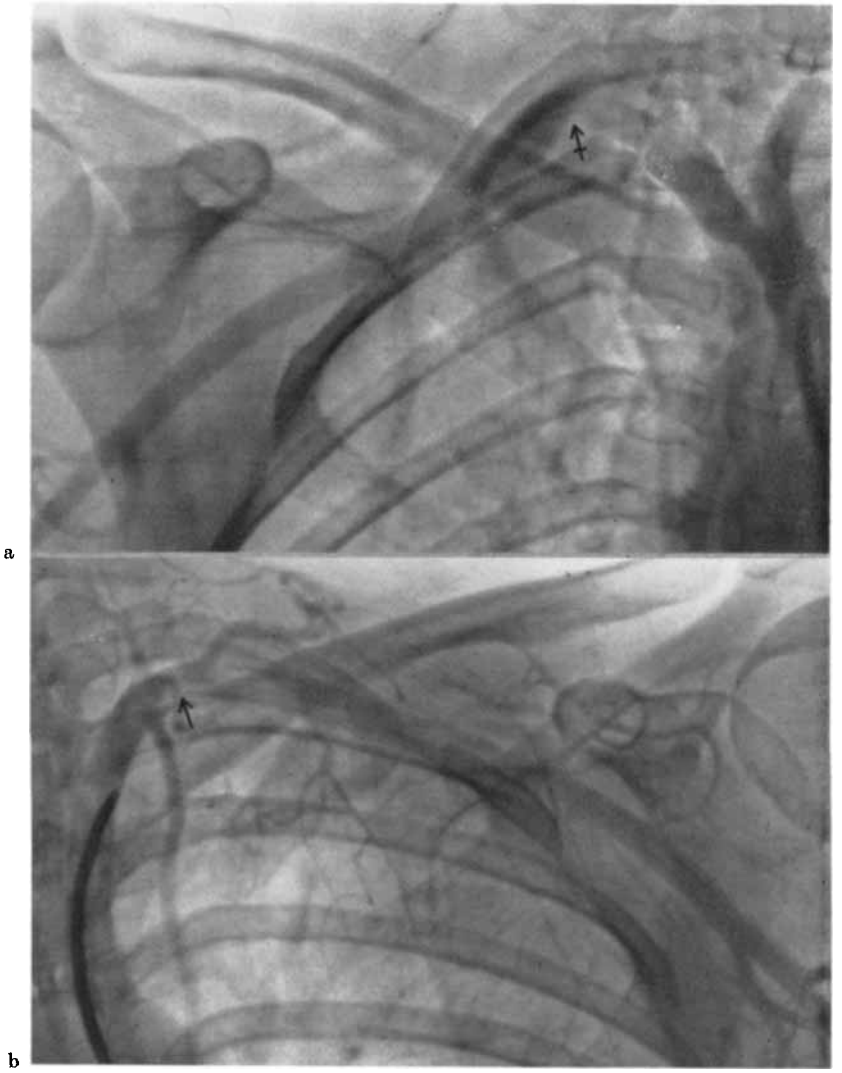


Fig. 2. Scalenus anticus syndrome with cervical ribs verified at operation. a. Catheterization of innominate artery after percutaneous introduction of catheter via left femoral artery. Visualization of innominate artery with branches after injection of 18 ml Triurol 25 %. At ↔, compression of right subclavian artery by right scalenus anticus muscle. b. Tip of catheter placed in left subclavian artery under fluoroscopic control; injection of 15 ml Triurol 25 %. At →, compression of left subclavian artery by left scalenus anticus muscle.

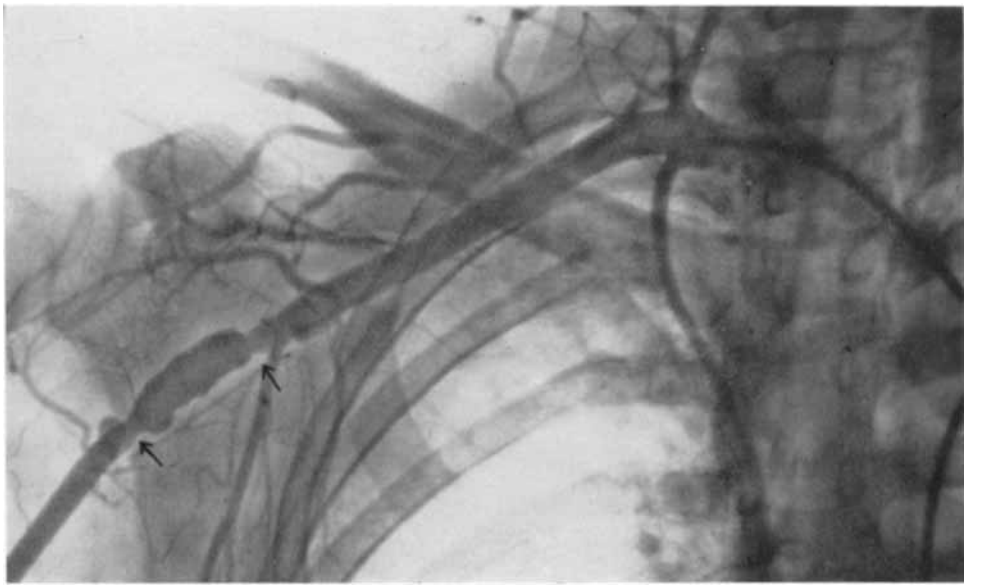


Fig. 3. Postoperative examination of traumatic aneurysm of right axillary artery (resection and transplantation of long saphenous vein). Catheter introduced percutaneously via right femoral artery; tip placed in right subclavian artery under fluoroscopic control; injection of 35 ml Rheopak 40 %. (Venous graft ↑.)

the tip. These recoil-reducing measures considerably diminish the displacement of the catheter on the injection of contrast medium (ÖDMAN).

The catheter is inserted percutaneously via the femoral artery into the arterial system using SELDINGER's technique. The ordinary distal bore of the polythene tubing exactly fits SELDINGER's instrumentarium, size PE 160. The catheter is passed up the aorta until the tip lies approximately at the level of the arterial branch concerned when it may be manoeuvred in the desired direction in the aorta. It is directed so that it points towards the direction in which the artery runs from its origin. The tip is then slowly brought past the region where the artery is thought to arise. When the tip reaches the orifice of the artery it will, because of the elasticity of the catheter, make its way into the lumen of the vessel. In many instances the catheter may also be passed further out into aortic branches of the second order. The whole procedure of catheterization is carried out under fluoroscopic control. Thus, the movements of the catheter may be closely watched and it is possible to determine when the extremity is situated in the aorta or in one of its branches. After the catheter has been manoeuvred into a suitable position the contrast medium is injected, manually or by aid of a pressure ap-

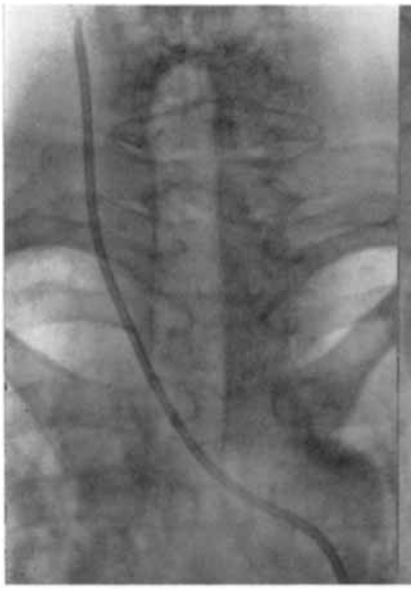


Fig. 4. Catheter introduced percutaneously via left femoral artery; tip manoeuvred up the right common carotid artery under fluoroscopic control.

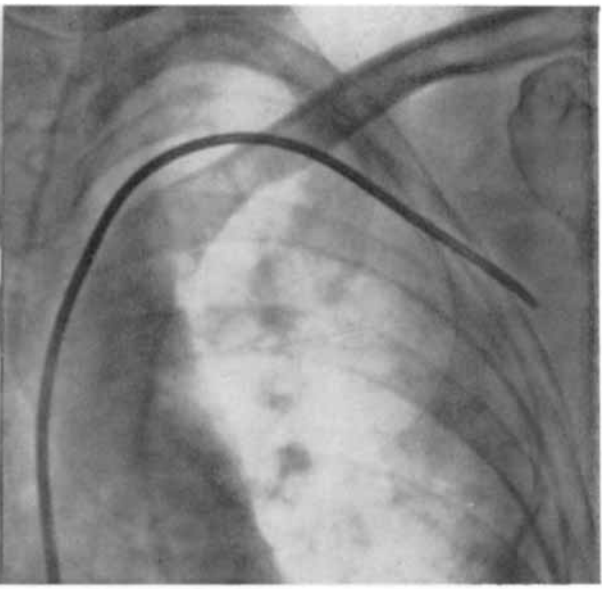


Fig. 5. Catheter introduced percutaneously via left femoral artery; tip of catheter guided into left brachial artery under fluoroscopic control.

paratus. The dose and concentration of the medium may be adjusted so that only the vascular area concerned is clearly visualized.

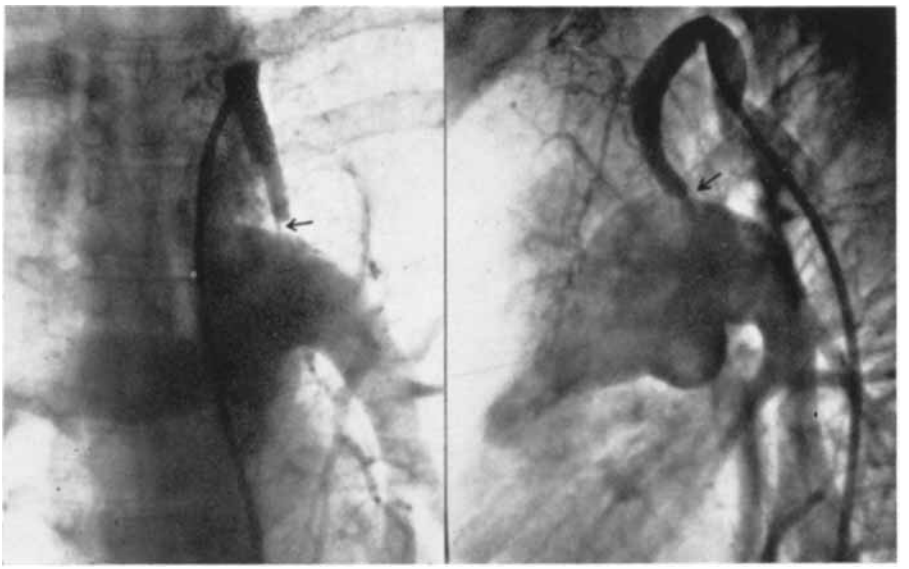
Up to the present some 20 angiographic examinations by this selective technique have been carried out. Experiences have shown that each arterial branch requires its special shaped catheter and modification of the technique. The different arterial branches have been examined as follows.

1. Angiographic examinations of the innominate artery:

The catheter near its extremity is modelled as an S (Fig. 1, Type 1). It is placed so that the tip points forwards and upwards in the upper part of the ascending aorta. The catheter is then slowly retracted under control to ensure that the initial direction of the tip is maintained. At the point of origin of the innominate artery the tip will make its way into the lumen of the artery. The contrast medium may at this stage be injected if so desired in the particular case (Fig. 2 a). If not, the catheter may be advanced further into the branches of the innominate artery (Figs. 3 and 4), so that contrast medium may be introduced only into the right subclavian artery, or into the right common carotid artery alone.

2. Angiographic examinations of the left subclavian artery:

For this purpose a catheter that is slightly bent distally is used (Fig. 1, Type 2). After it has been passed into the upper part of the descending aorta the tip may be



a b

Fig. 6. Postoperative examination of Fallot's tetrad (anastomosis according to Blalock between left subclavian artery and pulmonary artery); tip of catheter lies in left subclavian artery; injection of 35 ml Rheopak 40 %. Visualization of left subclavian artery, pulmonary artery, and junction between these vessels, which is very narrow (→). Collateral circulation between systemic arteries and pulmonary circulation in upper part of anterior mediastinum outlined. a. A.p. b. Lateral.

manoeuvred into the left subclavian artery by pushing the catheter cranially (Figs. 2 b and 6). It may also be brought further out into the arterial trunks of the arm (Fig. 5). The contrast medium is injected into a suitable region according to the requirements of the particular case (Figs. 2 b and 6).

3. Angiographic examinations of the coeliac artery:

Catheterization of this artery requires a catheter the whole length of which is bent in an S-shape with a distinct accentuation close to the extremity (Fig. 1, Type 3). The patient is examined in the supine position, the lumbar curvature of the spine being straightened out as far as possible. This facilitates the manoeuvring of the catheter in the abdominal aorta. Screening is carried out mainly in the lateral view. The catheter is passed up the abdominal aorta to the level of the diaphragm. In this position it is placed so that its tip points in a ventral direction. The catheter is then gently pulled caudally under close control to ascertain that the extremity retains its initial direction. When it reaches the point of origin of the coeliac artery it slips into the lumen of this vessel (Fig. 7 a). This may generally be readily seen on screening. Occasionally, however, it is difficult to localize the tip of the catheter in relation to the various vessels. This is especially the case when the coeliac artery deviates laterally towards either side (Figs. 8 and 9). Under such circumstances the position may be judged by test exposures during the injection of relatively small amounts of contrast solution (20 ml of Umbradil 35 %; Fig. 8). After it has been ascertained that the tip of the catheter lies in the coeliac artery, angiographic examination is carried out by injection of 30 to

a

b

Fig. 7. Hodgkin's disease. a. Lateral. Catheter inserted percutaneously via right femoral artery. Distal part of catheter, introduced into coeliac artery, points ventrally. b. A.p. Enlargement of spleen. 35 ml Umbradil 50 % injected. Venous phase exposed about 10 seconds after injection started. Splenic vein and portal vein with their branches clearly visualized. Concentration of contrast medium in parenchyma of spleen and liver.

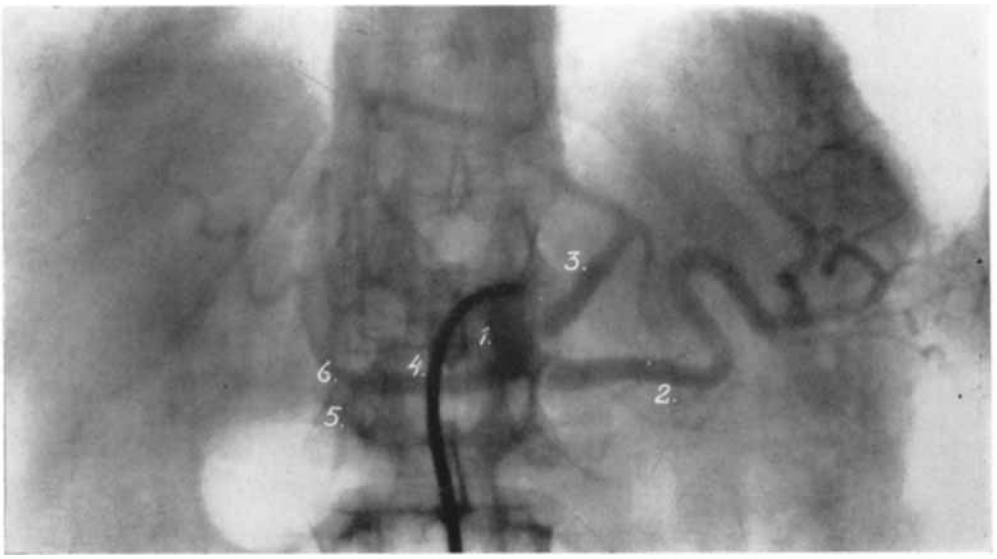
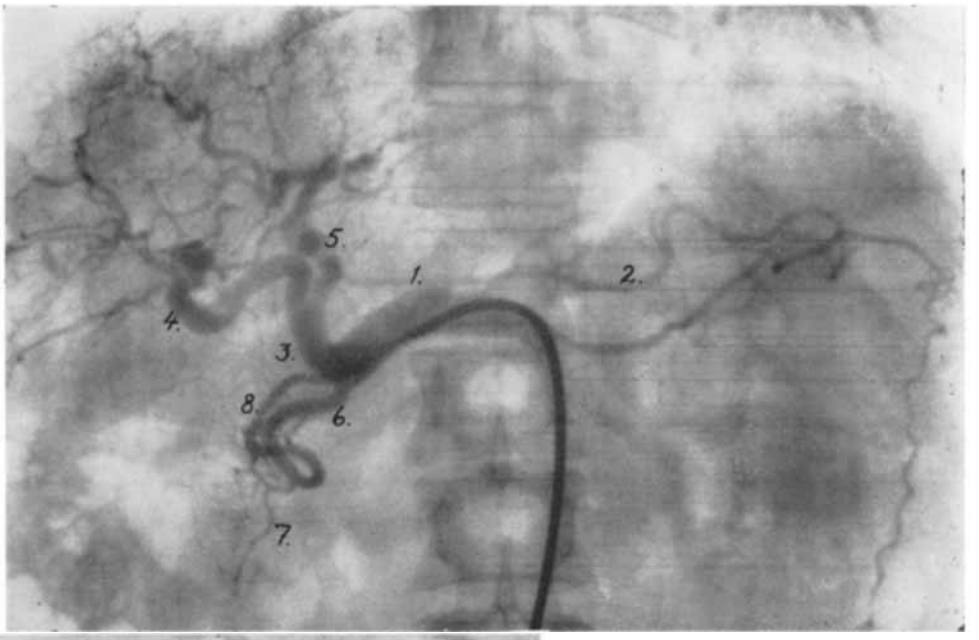


Fig. 8. A. p. Coeliac artery deviates to the left. Injection of 20 ml Umbradil 35 %. Early arterial phase. 1. Coeliac artery. 2. Splenic artery. 3. Left gastric artery. 4. Common hepatic artery. 5. Gastro-duodenal artery. 6. Main hepatic artery.



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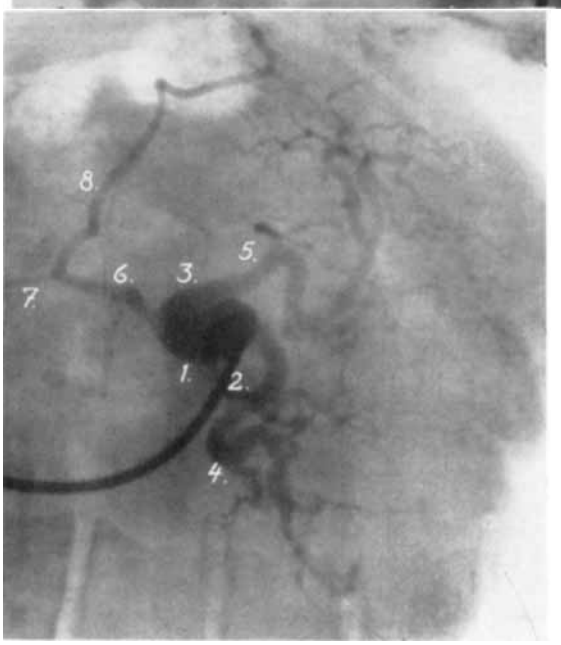
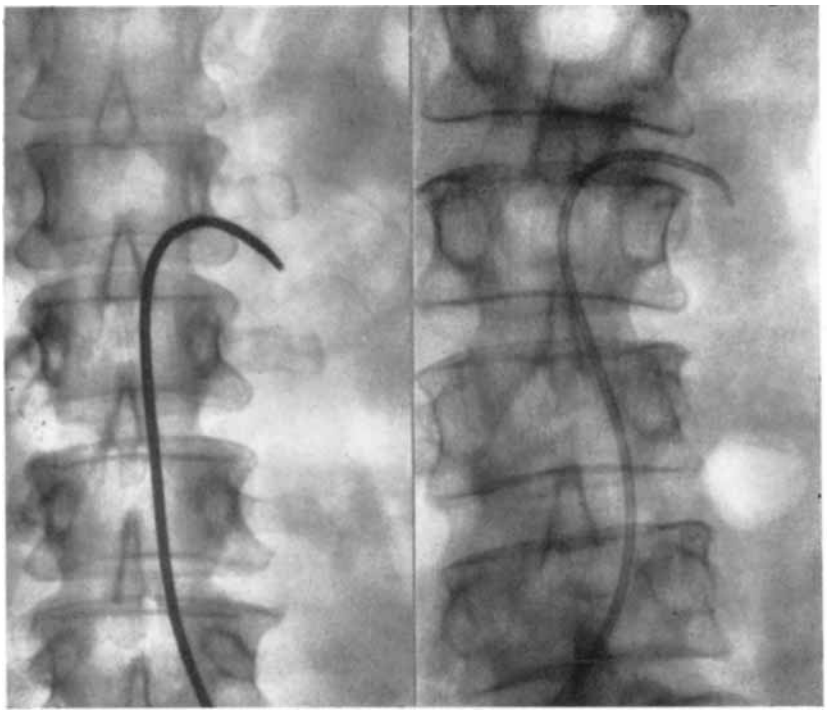


b

Fig. 9. Splenectomy. Catheter introduced percutaneously into arterial system via right femoral artery; tip guided into coeliac artery under fluoroscopic control. (The vessel deviates to the right.) Injection of 35 ml Umbradil 50 %.

Visualization of coeliac artery and branches. 1. Common hepatic artery (dilated). 2. Left gastric artery. 3. Main hepatic artery. 4. Right hepatic artery. 5. Left hepatic artery. 6. Gastro-duodenal artery. 7. Superior pancreatico-duodenal artery. 8. Right gastro-epiploic artery.

a. Frontal. (Note concentration of contrast medium in liver parenchyma.) b. Lateral.



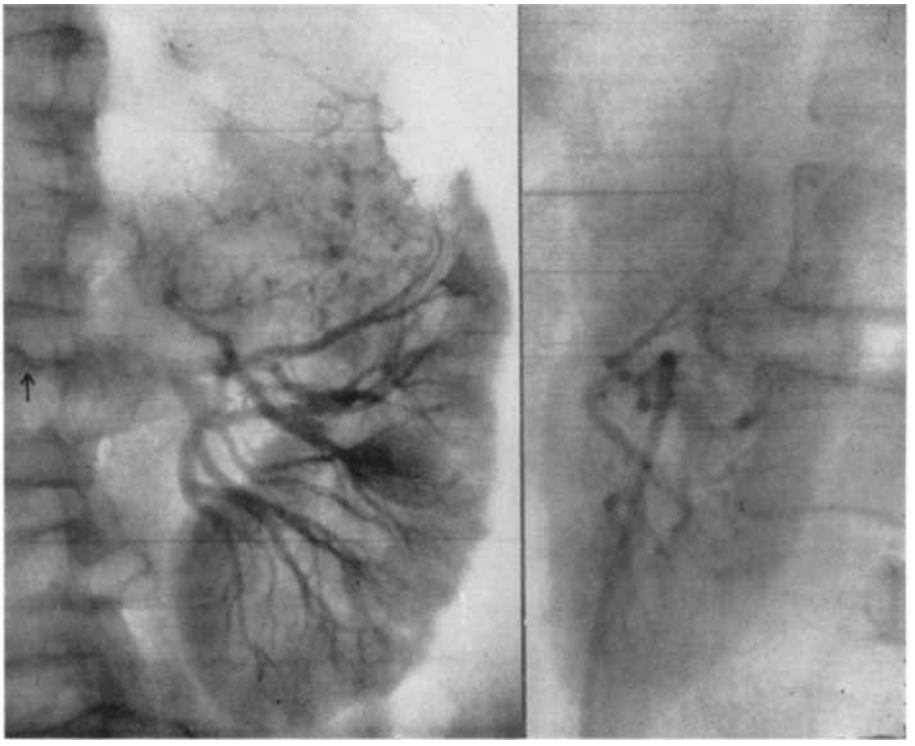
a b

Fig. 10. a. Catheter introduced percutaneously into arterial system, via left femoral artery; tip guided into *ipsolateral* renal artery under fluoroscopic control. b. Percutaneous insertion of catheter via right femoral artery. Catheterization of *contralateral* renal artery. Compare shape of catheter in a and b.

50 ml of Umbradil 50 % at a rate of 10 to 12 ml of solution per second. Exposures may be made in two planes at right angles (Fig. 9), which also facilitates the identification of various contrast-filled vessels and the interpretation of pathologically changed structures. In this type of examination visualization is obtained not only of the branches of the coeliac artery but also of the venous return-flow, especially in the splenic and the portal vein (Fig. 7 b). More or less distinct concentration of contrast medium in the tributary parenchymatous organs may also be obtained (Figs. 7 b and 9). The series of exposures in these examinations should therefore comprise a minimum of 30 seconds, so that there will be time for different phases of the contrast circulation to be recorded.

4. Angiographic examinations of the renal arteries (selective renal angiography):

For catheterization of the renal arteries the whole length of the catheter should be slightly curved with a distinct accentuation close to the extremity (Fig. 1, Type 4). With this type of catheter the renal artery to be catheterized is best reached via the femoral artery on the *same* side. This procedure is the most suitable for contrast visualization of the vessels of the kidney. If this method of catheterization cannot be carried out, the femoral artery on the other side has to be used. In that case the whole length of the catheter should be modelled to an S-shape with an extra-marked curve close to the



a b

Fig. 11. Hypernephroma of left kidney. (Same case as Fig. 10 b.) Percutaneous left-sided selective renal angiography, 15 ml Triurol 25 % injected. Arterial phase. Pathologic vascular structures in upper half of kidney, characteristic of hypernephroma. a. True a. p. of kidney. (Tip of catheter ↑). b. True lateral.

extremity (Fig. 1, Type 5). In catheterization of the renal arteries the catheter is placed in the aorta above or below the region where the renal artery is believed to branch off, the tip of the catheter pointing towards the side concerned. The catheter is then passed gently caudally or cranially, as desired, under control to ensure that the tip retains its initial direction. At the point of origin of the renal artery the tip will make its way into the lumen of the vessel, which may be noted fluoroscopically without difficulty (Fig. 10 a and b). The contrast medium, up to a maximum dose of 15 ml of Umbradil 35 % or Triurol 25 % is injected manually or by aid of a pressure apparatus; at a rate of 8 to 10 ml per second. The injection of the solution should be performed with the tip of the catheter reaching only a short distance inside the renal artery in order that all its branches be visualized and the contrast medium distributed over the whole vascular bed of the kidney. If the tip of the catheter lies too near the periphery the result may be that only one or a few of the arterial branches will be visualized, with an unnecessary high concentration of contrast medium in the corresponding vascular area. In the presence of anomalies of the renal arteries (aberrant renal arteries) it is best to try to catheterize each vessel separately.

Selective renal angiography has been performed in two planes at right angles. The

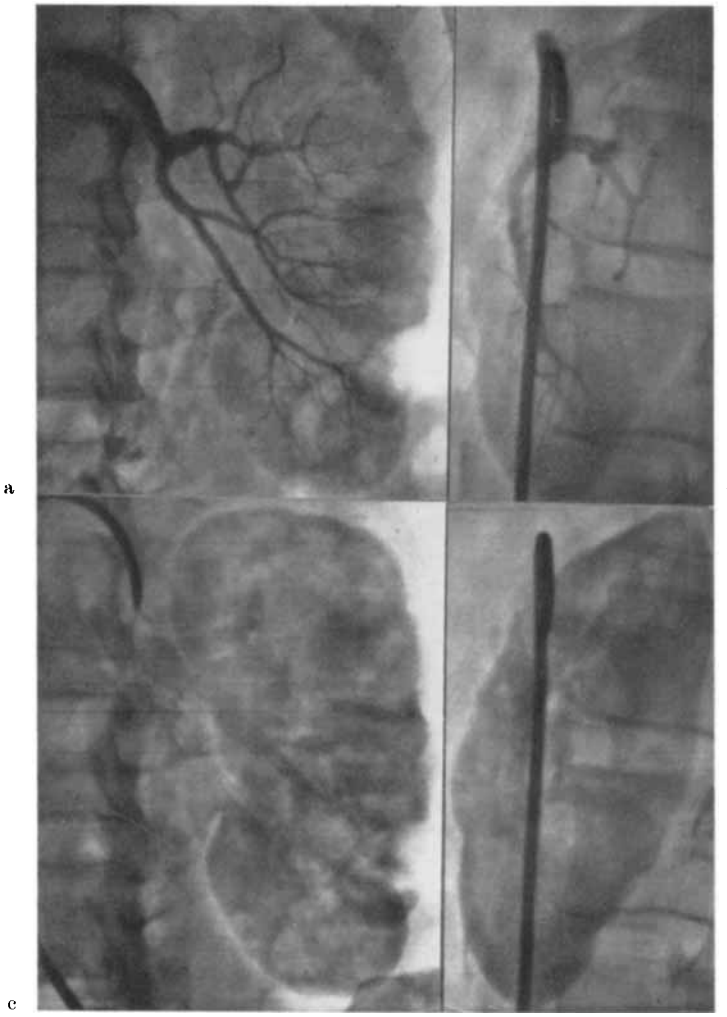


Fig. 12. Chronic pyelonephritis. Percutaneous left-sided selective renal angiography, 15 ml Triurol 25 % injected. a. Arterial phase. (True a. p. of kidney.) b. Arterial phase. (True lateral.) c. Venous phase with concentration of contrast medium in parenchyma. (True a.p. of kidney.) d. Venous phase with concentration of contrast medium in parenchyma. (True lateral.)

patient should be placed so that the kidney is exposed in its true antero-posterior and lateral projection, respectively (Figs. 11 and 12). The different phases of the passage of the contrast medium through the renal vascular bed should be followed (Fig. 12).

The selective angiographic examinations described have been carried out without complications and have throughout been strikingly easy to perform. To some extent, the technique can probably be rendered

more selective. There are, for instance, obvious possibilities of examining certain branches of the subclavian artery individually by the angiographic technique. Contrast filling of the branches of the coeliac artery one by one, could probably also be obtained.

Apart from the above-mentioned branches of the aorta, other branches have also been catheterized, although without an attendant angiographic examination; these include the superior mesenteric artery. Furthermore, when the catheter is inserted via the femoral artery on one side it may be passed through the bifurcation of the abdominal aorta into the common iliac artery on the other side.

Conclusions

It is felt that the chief advantages of the technique described are as follows:

A radiopaque catheter may be introduced percutaneously into the arterial system, manoeuvred under fluoroscopic control, and advanced into the major branches of the aorta.

The contrast medium may be injected in an adequate dose and concentration, and consequently adjusted to the special conditions of the examination.

Visualization of irrelevant vascular areas, which is undesirable, is avoided.

The risk of deleterious effects due to the toxicity of the contrast medium is greatly reduced in comparison to earlier current methods. This is of particular importance in contrast filling of the renal vessels. In ordinary renal angiography, both kidneys have to be subjected to a more or less arbitrary dose of contrast medium. In selective renal angiography the medium is introduced into one kidney only, and the dosage can also be regulated with respect to such factors, on the one hand, as the degree of opacity required and, on the other, the risk of injury to the renal parenchyma.

SUMMARY

A preliminary report is given of percutaneous selective angiography of the main branches of the aorta. A new type of radiopaque polythene catheter is introduced percutaneously. Moulded in such a way that its shape is adjusted to the aortic branch to be examined, the tip of the catheter is advanced under fluoroscopic control into one of the branches of the aorta, where the contrast medium is injected.

ZUSAMMENFASSUNG

Ein vorläufiger Bericht über die perkutane selektive Angiographie der Hauptzweige der Aorta wird abgegeben. Ein neuer Typus eines röntgendichten Polythenkatheters

wird perkutan eingeführt. Die Spitze des Katheters, die so geformt ist, dass ihr Aussehen der zu untersuchenden Aortaabzweigung angepasst ist, wird unter Durchleuchtungskontrolle in einen der Äste der Aorta eingeführt; hier wird das Kontrastmittel injiziert.

RÉSUMÉ

L'auteur présente une note préliminaire sur l'angiographie sélective percutanée des principales branches de l'aorte. Un cathéter radio-opaque en polyéthylène d'un nouveau type est introduit par voie percutanée. Modelée de façon que sa forme s'adapte à la branche aortique à examiner, l'extrémité du cathéter est poussée sous contrôle radioscopique dans une des branches de l'aorte, où l'on injecte le produit de contraste.

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