RENAL AORTOGRAPHY AND SELECTIVE RENAL ARTERIOGRAPHY

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During the last decade aortography has, in this and other countries, become increasingly popular and has been considered a reasonably safe procedure, particularly for the radiological examination of the renal arterial blood supply.

The methods of renal angiography may be grouped under two main headings: renal aortography, in which the renal arteries are delineated by contrast medium from an opacified aorta; and selective renal arteriography in which the opaque medium is injected through a catheter passed into the renal artery. These two methods may be further sub-divided under their appropriate sub-headings.

Renal Aortography

(a) Percutaneous trans-lumbar needle puncture of the aorta as introduced by Dos Santos, Lamas and Pereira Caldas (1929).

(b) 'Cut down' or modified 'cut down' transfemoral arterial catheterization of the aorta as advocated by Farinas (1946) and Lindgren (1953).

(c) Percutaneous transfemoral retrograde aortography as introduced by Seldinger (1953).

Selective Renal Arteriography

(a) Selective renal artery catheterization, followed by injection, using a special metallic-ended catheter directed by a magnetic field, after a peripheral artery 'cut down' technique introduced by Tillander (1951, 1956).

(b) Percutaneous transfemoral selective catheterization of a renal artery practised by Edholm and Seldinger (1956) and Ödman (1956) and adopted by Gregg, Allcock and Berridge (1957).

It must be conceded that 'cut-down' methods no longer play any real part in arteriography and are only of historical interest; they are now rarely used. This paper, therefore, only deals with the current methods of renal arteriography in common use and endeavours to show briefly the advantages and disadvantages of each, stressing the importance of the percutaneous selective method of renal arteriography as the method of choice.

Translumbar Aortography

The well-established translumbar needle puncture method of aortography, introduced by Dos Santos *et al.* (1929), has enjoyed international popularity, but more recent reports have shown that there are many disadvantages and complications in using this method, thus nullifying any claim that it is a quick and reasonably safe method for the examination of the renal arterial blood supply. The main disadvantages are that the patient usually requires a general anaesthetic, thus turning a minor procedure into a major one, resulting even in such complications as laryngospasm, as reported by McAfee and Willson (1956); as the patient lies prone, the kidneys are further from the X-ray film than if he is supine, a factor which influences radiological detail; the prone position also promotes unwanted filling of the ventral aortic branches, particularly the smaller divisions of the coeliac and mesenteric arteries, which often masks a detailed study of kidney vasculature, as demonstrated by Gregg *et al.* (1957). Para-aortic injection of contrast medium, haematoma formation, mal-direction of a large volume of medium into a renal artery, renal failure, aortic dissecting aneurysms, and paraplegia are some of the complications of translumbar aortography which have been fully reported by Miller, Wylie and Hinman (1954), Alwall, Johnsson, Tornberg and Werkö (1955), Boyarski (1954), Gaylis and Laws (1956), Hare (1957), Roy (1957), and Edling and Helander (1957); and even haemothoraces have occurred following the dictum that the aortic puncture site must be a high one in order to avoid direct injection of contrast medium into the renal or other arteries. It should be appreciated, however, that many of the recorded complications appear to have been due to errors of technique, particularly the use of pressure injection aids combined with the use of too large a volume and too high a concentration of contrast medium. Repeated injection and repeated needle puncture of the aorta have been responsible for some of the reported accidents by Miller *et al.* (1954) and

Alwall *et al.* (1955). The patient also often receives a large dose of X-radiation to a large area.

Transfemoral Retrograde Renal Aortography

To overcome some of the disadvantages of the translumbar method, the retrograde method of aortography, as devised by Seldinger (1953), has become popular. By this method, basal narcosis and local anaesthesia at the femoral artery puncture site is all that is required and the patient is supine and cooperative. The catheter tip is positioned in relation to the renal arteries by means of a small test injection; any bleeding from the femoral puncture site after removal of the catheter is easily controlled by manual compression. By this method, however, mal-position of the catheter tip may still lead to unwanted over-filling of the ventral aortic branches, and the renal vessels may be partially obscured by these and also lumbar artery opacification, as demonstrated by Gregg *et al.* (1957). Also, in a tortuous aorta the catheter tip may point directly into the mouth of a renal artery, or the tip may 'whip' and move under the influence of the main injection, thereby causing a large volume of contrast medium to be inadvertently injected into a renal artery, as described by Gregg *et al.* (1957) and quoted by Gregg (1957).

Renal failure following this method of renal aortography has been reported by Dormandy, Joecks and Sutton (1957). It may be accepted, however, that this method for renal arteriography has many advantages over the translumbar needle puncture method and subscribes less to complications. A smaller field of radiation is used and a reduction in the amount of injected medium is possible.

It is, in this country at least, becoming more the custom to use lower percentage strengths and smaller volumes of less toxic contrast medium for either of the aforementioned methods of renal aortography. This concurs with the recommendation of Olsson (1955) that an injection of 20 ml. of a 60 per cent. Diodone compound and 20 ml. of a 50 per cent. triiodone compound should never be exceeded. This is also particularly important if it is known that impaired renal function exists, as stressed by Josselson and Kaplan (1954), Roy (1957), Darmondy *et al.* (1957) and Gregg (1957).

Edling and Helander (1957) discuss the importance of adequate renal tests prior to aortography to prevent renal damage, they also deprecate the use of repeated injections of contrast medium.

Selective Renal Arteriography

In order to overcome some of the disadvantages

FIG. 1a.—Male 56. Two episodes of haematuria in 12 months. I.V.P. showed no excretion in upper group of calyces and filling defect in upper part of kidney pelvis. Retrograde pyelogram confirmed no filling of upper calyces. 'Renal pelvic tumour probable'.

FIG. 1b.—Left selective renal arteriogram—nephrogram phase. A few small pathological vessels are present in the central and upper third regions. Nephrogram strong inferiorly but poor above. Renal veins visualized well into later part of examination and on delayed films suggesting venous compression in kidney hilar region.

Pathology.—Papillary pleomorphic transitional cell carcinoma of renal pelvis.

FIG. 2.—Male 46. Three episodes of haematuria. I.V.P. showed enlargement of upper pole of right kidney with compression and displacement of calyces. 'Grawitz tumour probable'.

Selective arteriogram showing typical malignant tumour vessels with pooling of contrast medium. Note free vascular anastomosis between tumour, capsular and lumbar vessels. A renal vein is also shown.

Pathology confirmed renal carcinoma.

and complications already mentioned, and in particular to protect the kidneys from damage by the injection of an uncontrolled amount of contrast medium into the renal arteries, techniques of selective renal artery catheterization have been developed. By these techniques only a small volume of contrast medium—usually not more than 6 ml. of a 30 per cent. solution—is injected directly into a renal artery. This method obviates the use of a high injection pressure; there is no masking of the renal vessels by unnecessary opacification of other vessels; it is often only necessary to subject one kidney to insult; a test injection for catheter-tip localization is usually not necessary, so that the calyces and pelvis of the kidney are not already opacified when the main injection is made (Fig. 1b and Fig. 2).

Edholm and Seldinger (1956), employing the percutaneous transfemoral route, used a non-opaque polythene catheter—opacified by the aid of a guide wire—with a preformed curve at one end, which they manipulated into the renal artery following the preliminary method of aortic introduction as described by Seldinger (1953). For details of their technique the reader is referred to their original paper.

Ödman (1956) introduced the use of a special opaque lead-polythene catheter which, being malleable, can be made into any suitable shape for selective catheterization of the main aortic branches, and it is with this method that the present author has had experience, Gregg *et al.*

(1957). By either of these selective catheterization methods it is possible to pass the tip of the catheter under X-ray screen control into a renal artery thus, besides protecting the other kidney, smaller films are used and better detail is secured. Also of great importance is the use of a smaller beam of X-rays thereby cutting down the radiation received by the patient.

METHOD

Following basal narcotic premedication and a surgical skin preparation of the thighs and pubic regions, the patient is brought to the X-ray department and placed supine on a rapid film or cassette changer.

Under strict aseptic technique, and following local anaesthetic infiltration, a femoral artery is punctured by means of a wide-bore needle and a flexible guide wire is passed up through the needle to the iliac level. The puncture needle is then removed from the guide wire which remains in the artery. The opaque catheter, with its preformed curves, is then threaded over the guide wire and passed through the cutaneous tissues into the femoral artery and up into the aorta. The curved end of the catheter should be threaded over the guide wire with its tip pointing towards the side to be examined, and this direction should be maintained while the catheter is being manipulated into the aorta. The guide wire is then removed, a saline syringe is attached to the catheter which is passed up into the aorta and the preformed tip is manipulated into the required renal artery under screen control; this normally only takes a few minutes. The use of an image intensifier greatly facilitates the manipulation of the catheter tip into the renal artery.

When the catheter tip enters the renal artery it is seen to move outwards and, on the left side, will usually pass outside the shadow of the vertebral bodies (Figs. 1b and 3). On the right side the tip will usually pass just to the right of a line through the spinous processes (Fig. 2). These appearances, of course, will be subject to any displacement of the aorta. As the catheter tip engages into a renal artery, the up and down pulsation or 'aortic' movement changes into a side-to-side movement and a click is often transmitted down the catheter to the operator. The catheter may momentarily become arrested in the mouth of a lumbar artery when it is noticed that it does not pass laterally, the operator does not get a good back-flow of blood and the injection of a few ml. of saline sometimes causes a burning flank pain, segmental in distribution. During manipulation the catheter is kept patent by the occasional injection of saline or heparin saline solution.

When the catheter has been correctly positioned

FIG. 3a.—Female 54. Non-functioning left kidney on I.V.P. Selective arteriogram showing thinned hypoplastic renal arteries stretched around cyst-like spaces. Appearances typical of those described by Idbohrn (1956) in obstructive uropathy. Note filling of lumbar vessels caused by back-flow of medium into lumbar artery.

FIG. 3b.—Nephrogram showing contracted hydronephrotic kidney with only a thin rind of cortical tissue remaining. Note fine capsular and pelvic anastomosis.

Pathology confirmed ureteric obstruction due to carcinoma of the ureter.

a 'trial' injection of 5 to 10 ml. of saline is made and, if no discomfort is reported, the angiographic examination is undertaken: 6 ml. of a 30 per cent. solution of one of the less toxic contrast media (Urografin is very suitable) is injected steadily but fairly slowly (taking about $1\frac{1}{2}$ sec.), and six films are exposed as rapidly as possible; these will demonstrate the arterial pattern of the kidney, the nephrogram, and often the main venous drainage.

Aberrant or accessory renal vessels, as demonstrated by an area of non-opacification in the nephrogram, may be independently catheterized and if it is necessary to examine the contra-lateral kidney the catheter is rotated and made to engage into the opposite renal artery.

It has been demonstrated by Gregg *et al.* (1957) that the opaque catheter size PE 160 does not block the renal artery (Fig. 2), neither does it appear to cause any narrowing of the artery by spasm, as reported by Wickbom and Bartley (1957) and Lindbom (1957), which occurs in the case of medium-sized arteries during catheterization for peripheral arteriography. The 'streamling' appearances in the main renal artery suggest that, during injection, there is probably free mixing of medium and blood by the time the smaller renal branches are filled (Fig. 2). It has been the present author's experience that renal function tests, combined with microscopic examination of the urine before and after selective renal arteriography, have

failed to show any changes suggestive of renal damage due to the examination. This concurs with the experimental work of Idbohrn (1956).

Bleeding from the femoral artery puncture site after removal of the catheter is easily controlled by manual compression even in older people with less muscular arteries and, contrary to popular belief, the selective method for renal arteriography is often no more time consuming than other methods.

The selective method may be combined with retrograde renal aortography for estimation of the main renal artery size if aorto-renal grafting is to be considered. Such a successful graft operation has been described by Poutasse, Humphries, McCormack and Corcoran (1956).

Selective renal vein catheterization and venography is also a practical proposition using the Seldinger method of retrograde manipulation via the femoral vein.

Improvements in cineradiological techniques will undoubtedly widen the application of selective renal angiography and offer a more detailed anatomical and functional assessment of the kidney, besides lowering the X-ray dosage received by the patient, as shown by Gregg *et al.* (1957).

Indications for Renal Arteriography in General

Arteriography has been employed for the demonstration of almost every kidney lesion. Its use, however, is sometimes thought to be of

limited value and assistance, and to affect the management of only a small number of cases. The more common indications may be summarized thus:—

(1) Cases in which the pyelographic findings may be equivocal in the differential diagnoses of renal carcinoma, cyst or other space-filling lesion (Fig. 1b and Fig. 2).

(2) Cases of unexplained haematuria with negative clinical and pyelographic findings in which an early renal carcinoma may be found.

(3) To demonstrate the amount of functioning renal tissue in relation to the kidneys' blood supply in cases of obstructive uropathy; (Fig. 3a and Fig. 3b) as shown in the experimental work of Idbohn (1956).

(4) For the demonstration of the size and site of ectopic kidneys and to show their functioning capacity in relation to their blood supply. In the case of a 'horseshoe' kidney, to estimate the amount of renal tissue (by the nephrogram) and the blood supply of the isthmus, if surgery is contemplated for unilateral disease, thereby demonstrating the correct surgical approach.

(5) For the investigation of the renal aspects of hypertension, particularly hypertension due to occlusive disease of the main renal arteries as described by Poutasse *et al.* (1956) and Hodson (1957).

Applications of Selective Renal Arteriography in Particular

These include all the accepted general indications for renal arteriography; but bearing in mind the improved radiographic detail and safety afforded by the selective method, some further possible indications might be considered under:—

(1) For detailed assessment of the kidney's blood supply in relation to small lesions, especially localized tuberculosis now that partial nephrectomy has become more popular. It may also be possible, by assessing the vascularity of the kidney in the region of the lesion, that some opinion might be given as to the likely effectiveness of chemotherapy, as suggested by Gregg *et al.* (1957).

(2) For detailed assessment of the smaller branches of the renal vasculature pattern in hypertension, particularly that arising in pyelonephritis as described by Hodson (1957) though, as he points out, renal biopsy is at present of more value.

(3) For the examination of one kidney only, thus sparing possible damage to the other when it is known that a lesion is unilateral, and, conversely, for arterial and functional assessment of the sound kidney before removal of the diseased one.

(4) For detailed study and visualization of aberrant renal vessels, suprarenal, capsular and lumbar anastomoses (Fig. 2 and Fig. 3b). Such

anastomoses are known to exist and have been described by Boyd.

(5) As a method of examination for an exact biochemical assay and study of human kidney function under varying conditions by simultaneous arterial and venous renal catheterization combined, perhaps, with ureteric catheterization.

And finally, as already stressed, as a method to reduce not only the area of X-radiation received by the patient, but also the controlled amount of contrast medium injected into the kidney under examination, as advocated by Gregg *et al.* (1957), and also to protect the contralateral kidney from any possible 'chemotoxic' effects of injection which may occur in other methods of renal arteriography.

Contra Indications

In the presence of impaired renal function, renal aortography should not be undertaken by the translumbar or retrograde catheter methods unless strict caution is observed with regard to both the amount and concentration of the contrast medium used, as already mentioned by Sutton (1957) and Gregg (1957). It would probably also be prudent to have adequate renal function tests as advocated by Edling and Helander (1957) before embarking on the examination by these methods. However, using small volumes and concentrations of less toxic media (Urografin 30 per cent.) by the selective catheterization method, even in the presence of impaired renal function, a cautiously conducted examination may be undertaken.

Experience has shown that reactions to present-day contrast media are almost non-existent, so that preliminary sensitivity tests are usually omitted.

Tortuous iliac arteries in older people may cause difficulty during the retrograde manipulation of a catheter but this hardly constitutes a direct contra-indication for the examination of renal arteriography.

Conclusions

The method of percutaneous selective renal artery catheterization has been shown, on theoretical and practical grounds, and for reasons of safety to the patient, to be the best approach to renal arteriography.

Summary

1. The methods of renal arteriography are briefly summarized.

2. The more popular and conventional translumbar and catheter replacement methods are discussed (excluding technical details) with special reference to the limitations, disadvantages and possible dangers of each method.

3. The method of selective renal arteriography

by catheterization is briefly described and mention is made of its advantages over the more conventional methods.

4. Indications for renal arteriography in general are discussed.

5. Indications and possible applications of selective renal arteriography in particular are discussed.

6. Contra-indications and conclusions are discussed.

7. Three examples of selective renal arteriography are illustrated.

Addendum

A modification of the selective method of arterial catheterization has recently been described by Gollmann (1957). The ordinary flexible guide wire normally has a spiral wire wrapped around a stiff straight centre or core. Gollmann, however, uses a removable central core. The guide wire is passed into the aorta by the ordinary method and the straight core is removed. A bent core is then passed up the spiral wire, the tip of which is directed into the renal artery. The polythene catheter is then threaded over the guide wire and passed directly into the vessel under examination; the guide wire is then removed. Not only is it possible to move the whole guide wire in the catheter, but the core

is also movable in the spiral. By this method the catheter need not have a preformed curve at its tip and may be of a non-opaque variety.

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