AORTOGRAPHY

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Abdominal aortography is an investigation which consists of rendering opaque the blood flow through the aorta and its larger branches to permit a radiological study of the vascular pattern in the organs of the abdomen. The renal artery, unlike vessels to the abdominal viscera, divides regularly with minor variations and arborizes into a fine delicate but typical pattern in the renal parenchyma.

Reynaldo Des Santos and his colleagues Lamas and Caldas (1929) working at the Santa Maria Hospital, Lisbon, first introduced translumbar aortic puncture for the purpose of aortography, and in their publication of 300 cases were convinced of its importance in renal investigation. It encountered much criticism because of the serious reaction which occurred from the injection of 100 per cent. solution of sodium iodide. Henline and Moore (1936) using the same contrast medium for aortography in experimental dogs, reported a high mortality which further prejudiced the use of this procedure in human beings.

Nelson and Doss (1942) and other American investigators working independently, re-introduced aortography as a safe and valuable procedure and published series involving many thousands of cases without there being a fatality.

The slow acceptance of aortography in this country as an adjunct to other more familiar diagnostic procedures was due to the misapprehension that the technique was difficult and dangerous, and that the indications for its use were not precise.

The increasing demand in recent years for arteriography in the field of renal as well as vascular surgery has inspired ingenious devices for the rapid automatic change of film cassettes and the injection of contrast medium with great speed by a mechanically-driven syringe. A simple technique such as described below gives adequate information and has fewer complications.

Routes

The contrast medium—30 ml. of 70 per cent. diodone—is introduced into the vascular system by translumbar aortic puncture or by retrograde femoral artery catheterization. The latter route was first described by Pierce (1951) and consists of percutaneous puncture of the femoral artery and introduction of polythene tube via the cannula into the external and common iliac arteries and up to the aorta to the level of the renal vessels. The lumbar route is easier to master, quicker to perform and more suitable for routine use in an otherwise busy radiological department.

Technique

Equipment

The equipment for trans lumbar injection is now provided as a set—Middlesex Hospital Pattern, produced by Warner Bros. It has three needles of different length and calibre, the largest being 15 cm. 16 S.W.G. for adults, 12 cm. 18 S.W.G. for small adults and 9 cm. 20 S.W.G. for use in children. It also contains a 30 ml. syringe with a metal case to envelop it for protection against bursting during manual injection, and a length of reinforced pressure tubing with adaptor to connect the needle to the syringe.

Contrast Medium

Sodium iodide is the most radiologically dense of all intravascular contrast mediums but toxicity is its great disadvantage. Since 1950 it has been replaced by an organic iodide solution—70 per cent. diodone—which has the merit of causing fewer and less severe reactions with small sacrifice of contrast and definition. An iodide sensitivity test must always be carried out if an I.V.P. has not already been obtained.

Anaesthesia

The procedure can be performed under general or local anaesthesia but, unless one has had much experience with the technique, the advantages of having a conscious patient to co-operate in holding the breath during the performance are far outweighed by having the patient relaxed under general anaesthesia. Under the latter circumstances there is less tension at both ends of the needle.

The patient lies in a prone position on a wooden tunnel through which cassettes can be passed. A metal marker is applied at the level of the body of the twelfth dorsal vertebra—the level at which
the aortic puncture is proposed. A trial film will verify this, as well as confirm the accuracy of sitting and exposure. A syringe of saline is connected up to the needle by the pressure tubing and the system filled with saline. The skin is punctured below the last rib on the left, four-finger breadths away from the spinous processes—two-finger breadths in children—and the needle is advanced to the side of the body of the last dorsal vertebra. Having found this landmark, the needle is then directed more vertically, slipping past the vertebral body to penetrate the aorta with a sensation of puncturing the theca. Pulsating puffs of blood gently pushing the syringe plunger back will indicate a successful puncture.

A trial film whilst injecting 5 ml. of diodone is always advisable to confirm the position of the needle.

The 30 ml. syringe is now charged with 70 per cent. diodone and connected to the system. The injection is then made and completed in four to five seconds, sending a column of diodone upwards into the thoracic aorta. During this time the respirations are stopped by the anaesthetist and four loaded cassettes are passed through the tunnel beneath the patient and exposed at two-second intervals. Co-ordination is essential and a preliminary practice by the team is worthwhile.

Interpretation of the Normal Arteriogram

Using this simple technique a series of four films is obtained. The first taken half way through the injection shows a column of diodone in the thoracic aorta; the second represents the arterial phase when the column of contrast material descends to the abdominal aorta and fills its main branches. In this phase the coeliac axis and its divisions are usually well filled and may obscure some branches of the renal arteries. It is possible to obtain stereoscopic pictures by a second injection of diodone when the origin and course of the vessels can then be traced easily. Experience has taught that such a refinement is rarely indicated. The third film may demonstrate a transient venous phase when the renal veins may be seen coincident with the small arterial branches. The fourth film of the series is the nephrogram phase when the kidneys are silhouetted by increased density.

Indications

Congenital abnormalities

Absent kidney. An aortogram carried out after an I.V.P. has indicated an apparently non-functioning kidney occasionally discloses a complete absence of kidney. In such a case the renal artery is completely absent and a nephrogram does not appear.

Ectopic kidney. On the other hand a nephrogram may prove the kidney, absent from its normal position, to be an ectopic or a crossed ectopic one, and in the arterial phase the aberrant vascular supply to the kidney may be clearly seen. This information is of considerable value if for any reason surgical exploration is proposed.

Hypoplastic or atrophic kidney. In the arteriogram the renal artery is of slender calibre and the nephrogram shows a faint shadow of a very small kidney.

Horse-shoe kidney. The disposition of the aberrant vascular supply can be demonstrated prior to sectioning the isthmus should this be contemplated. Engel and Poutasse (1955) record an autopsy finding of a single renal artery supplying an entire horse shoe kidney.

Polycystic kidney. This condition is more usually demonstrated and proved by intravenous or retrograde pyelography but there are occasions when neither of these investigations can be of any assistance. Aortography may then demonstrate a typical picture of long narrow kidneys with a poor blood supply. The long slender vessels are deviated around the cysts and the nephrogram, which is not as dense as in the normal, is blotchy giving a cotton wool effect.

Swellings of the Kidney

It is in the differential diagnosis between cysts and solid tumours of the kidney that aortography finds its greatest application for by this means a cyst accurately diagnosed can prevent an unnecessary surgical undertaking, and a parenchymal tumour can be unequivocally demonstrated.
In a solitary cyst the vessels are displaced by a well defined rather translucent avascular soft tissue shadow, and in the nephrogram it is usually well demonstrated by contrast with the dense parenchyma around it (Fig. 1). Further confirmation of presence of a cyst may be obtained by percutaneous needling and aspiration of the contents for cytological examination.

A parenchymal tumour, on the other hand, is demonstrated characteristically by a stippling or mottling by contrast material pooling in the vascular spaces of the tumour (Figs. 2 and 2a).

Aortography serves no useful purpose in the investigation of tumours of the renal pelvis for they show no typical picture. Their diagnosis rests entirely on clinical and pyelographic findings. Nevertheless it is important for the surgeon to make a pre-operative distinction between a parenchymal adenoma and a tumour of the renal pelvis, for in the latter case the whole ureter as well as the kidney must be removed.

**Assessment of Renal Function**

**Hydronephrosis.** Aortography is particularly helpful in cases of hydronephrosis in determining the cause and in deciding the type of operation for its correction. In some cases it will reveal the presence of an aberrant artery to the lower pole of the kidney apparently obstructing the pelviureteric junction. It is most debatable to place the whole guilt of obstruction on this accessory artery for, in reviewing a long series of aortographies, it is surprising how frequently trouble-free aberrant vessels are seen. However, a pre-operative study of the calibre of the vessel and an estimate of the amount of the lower pole supplied by it is helpful if its ligature and section is proposed.

The degree of renal function is the most important pre-operative information in the condition of pelvi-ureteric obstruction for upon this rests the decision to retain or remove the kidney.

Cortical atrophy is associated with a reduction in vascular supply and is indicated in the arteriogram by diminished calibre of the main artery and its branches. Many of these vessels are further attenuated by deviation over a voluminous renal pelvis. The nephrogram is reduced in density and if seen with a coincident pyelogram the thickness of functioning cortex is well delineated.

**Hypertension.** An important place for renal arteriography is in the investigation of unexplained hypertension and particularly if it is of recent onset. Early recognition of hypertension due to renal artery or pyelonephritic changes is essential if improvement by nephrectomy is to be expected, for delay in such treatment may allow irreversible changes to take place in the normal kidney. An arteriogram in such patients may demonstrate:

(i) An aneurysm of the renal artery.
(ii) An obstruction due to arterial thrombosis.
(iii) A small contracted pyelonephritic kidney showing only a faint nephrogram and a poor blood supply.

Aneurysms are rare but thromboses of the renal artery are more commonly found. Obstruction may occur in a branch of the renal artery when it is possible to recognize in the arteriogram an avascular infarcted area in the renal cortex.

Chronic pyelonephritis causing hypertension may be a unilateral condition with improvement following nephrectomy, or bilateral when the outlook is hopeless and beyond surgical influence. This important detail can be determined by aortography.

**Haematuria of unexplained origin.** A renal cause of haematuria can in some cases escape detection by pyelography when aortography may demon-
strate an adenocarcinoma of the renal cortex which has not become large enough to disclose itself by deviation of a calyx.

**Inconclusive pyelograms.** Aortography can also help to confirm the presence or reassure one of the absence of a tumour of the renal cortex when pyelographic investigation has raised a suspicion.

**Retroperitoneal tumours.** Particularly in conjunction with retroperitoneal oxygen insufflation is aortography useful to distinguish renal tumours from other retroperitoneal swellings. It does occasionally show the vessels to a suprarenal tumour quite clearly, but this is more by good fortune than good technique and is not a reliable form of investigation in this condition.

**Partial Nephrectomy.** A study of the arterial phase of an aortogram carried out in the course of investigating a renal condition is of particular value if partial nephrectomy is contemplated. Graves (1954) has shown that the renal artery divides into branches which have been named and though the pattern of division is irregular, their number and distribution are constant (Fig. 3).

**Contra Indications**

Transient renal damage from rapid injection of iodine contrast material undoubtedly occurs and recovery is quick and complete unless some impairment of renal function is already present. For this reason it is inadvisable to perform aortography if the level of non-protein nitrogen of the blood is raised unless the circumstances are exceptional. Neither is it advisable to perform any major surgery without an interval of some days following aortography in order to allow complete recovery of renal function.

Iodine sensitivity naturally precludes aortography.

**Complications**

The complications associated with the performance of aortography in this country are few and rarely serious. No fatality has occurred in a long series carried out by the writer in collaboration with Dr. C. G. Whiteside at the Middlesex Hospital since 1950. In only one case has anuria occurred and may have been due to hypersensitivity from summation of effect following a second injection of 30 ml. diodone. The patient made a satisfactory recovery.

**Intramural Injection**

Intramural injection can be the most serious of accidents occurring in the performance of aorto-
Intramural injection: 20 to 30 ml. of contrast medium may be forcibly introduced into the media of the vessel causing a dissection of the wall. This process in which the intima is raised may involve the orifice of a major branch or may extend into the branch to cause occlusion, ischaemia and thrombosis with necrosis of the organ it supplies. To avoid such an accident Whiteside (1959) emphasizes the importance of directing the needle obliquely upwards into the aorta at the level of Dorsal XII. Should intramural injection occur dissection is more likely to extend upwards and will involve only the intercostal branches.

This accident occurred in one case of the Middlesex Hospital series when the terminal few ml. of contrast medium was introduced into the media in spite of a preliminary test to determine the site of the needle. There were no sequelae (Fig. 4).

Extravasation of Blood

Extravasation of blood following the withdrawal of the needle or by transfixion of the aorta does occur, particularly in hypersensitive cases, but it has never been a serious matter.

Periaortic Injection of Diodone

This is a common incident particularly in obese patients but the contrast medium is quickly absorbed and usually causes only a short period of lumbar backache.

Conclusion

In conclusion aortography is a safe procedure when using a simple technique but requires the practised co-operation and co-ordination of a team for the best results to be attained. It should be used selectively and where the more familiar methods of urological investigation have proved inadequate and inconclusive.

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Bibliography continued on page 639.
thiazide is in the range of 100-200 mg. When prolonged therapy is required, supplementation of potassium intake will be required and the supplements are best given on non-diuretic days (Poznanski and Cromie, 1959).

Hydroflumethiazide ('Hydromex')—chemically 3 : 4 - dihydro - 7 - sulphamyl - 6 - trifluoromethyl - 1 : 2 : 4 - benzothiadiazine - 1 : 1 - dioxide, has been introduced more recently and is undergoing investigation (Hobolth et al., 1958; Sele, 1958; Kobinger and Lund, 1959). It has approximately the same potency as hydrochlorothiazide and the dosage range is similar.

Despite its frequency and in spite of much experimental study, the mechanisms responsible for hyponatraemia in chronic cardiac failure are still far from clear. There is no question, however, that some patients with intractable cardiac oedema benefit from steroid therapy (Gutner et al., 1957; Heidorn et al., 1955; Reimer, 1956; Dresdale et al., 1958). Mickerson and Swale (1959) have recently described a series of 13 patients who showed the following features in common: all had obstinate cardiac failure and had become resistant to treatment with digitalis, low-sodium diet and diuretics; they complained of excessive tiredness and increased pigmentation both of the skin and buccal mucosa was present; all showed hyponatraemia with a normal or elevated serum potassium and a raised blood urea with one exception. All exhibited a great increase in urinary output due to a predominant water diuresis with disappearance of oedema following the addition of prednisolone, in a dose of 5 mg. t.d.s. for 24-48 hours followed by a maintenance dosage of 2.5 mg. twice or thrice daily, to existing therapy with digitalis and diuretics and the substitution of the low-sodium intake by a normal diet.

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Aortography

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