Diagnostic Value of Translumbar Aortography

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A historical review of aortography is made that substantiates its present status as a diagnostic tool, particularly in angiology and urology. The technic, premedication, and anesthesia are discussed in detail. The hazards of the procedure and their prevention are reviewed. The reactions to contrast media are enumerated. Aortography plays a selected but important role in the evaluation of aortic aneurysms, arterial occlusion, and stenosis of major vessels. Its value in the diagnosis of abdominal abnormalities is less encouraging. Numerous urologic disorders are discussed in their relationship to angiographic study.

AORTOGRAPHY was introduced in 1929 by Dos Santos,1,2 who, inspired by the work of Egas Moniz on cerebral angiography, reported a series of 300 cases in which the abdominal aorta was visualized by translumbar puncture. The diagnostic advantages of the method and its physiologic implications have been conclusively demonstrated. Balestra,3 Osorio,4 and others5,6 confirmed these findings and stressed the harmlessness of the method. In spite of these favorable statements the procedure did not find its way into clinical practice. The difficulties were probably caused by lack of a proper contrast medium. Early examiners used sodium iodide, which was difficult to handle and proved to be toxic in animal experiments.7 Thorotrust was an unsatisfactory medium because of severe damage due to its radioactivity and storage in the reticuloendothelial system.8 The situation improved with the introduction of water-soluble contrast media that diminished the hazards of the procedure and opened the way to new trials. Saito and Kamikawa9 as well as Castellanos and Pereiras10 obtained aortograms by countercurrent injection; later, a catheter was introduced high into the aorta.11,12 Nelson13 and Doss14 revived interest in the translumbar method as they demonstrated that the procedure is reasonably safe, easily performed, and accurate.

Several authors described large series of cases outlining its importance for angiology and urology.15-25 Complications were very few. Up to the year 1947 Dos Santos16 performed 3,000 aortographies without an immediate fatality. Smith22 reported 1,500 consecutive translumbar renal arteriographies without any serious accident.

Technic

The performance of translumbar aortography generally follows the technic of Smith22 as described subsequently. The importance of teamwork consisting of operator, roentgenologist, and anesthetist must be stressed. Each member should have adequate knowledge of the anatomy and topography of the area involved in translumbar aortic puncture.

Preparation and Premedication

The patient is prepared with a cleansing enema on the preceding evening and given a laxative to empty the colon. The following day food is withheld until the examination is performed. In the morning 100 mg. of cortisone is given orally to prevent anaphylactic reactions to dye.28 A quickly acting barbiturate is administered 2 hours before the procedure and meperidine (Demerol) and atropine are given 1 hour preoperatively. When spinal or general anesthesia is used, sedatives may be discarded. Atropine should be used regularly to prevent occasional arterial spasms after the injection of contrast medium.

A test for sensitivity to the contrast media is performed prior to the procedure. The intradermal injection, often recommended in the literature,29 is impractical, since the highly concentrated media cause skin irritation and sometimes necrosis. A better method is the intradermal test with dye diluted in the patient's serum with readings after 8 and 24 hours.30 The intraocular route of testing30 may also be used although irritation of the eyes

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occurs without any other evidence of hypersensitivity. Intravenous injection of 2 ml. of dye should be performed in the operating room and the patient observed closely for about half an hour. In case of hypersensitivity aortography should be abandoned as the reactions to dye are unpredictable.

Anesthesia

In the early era of aortography general or spinal anesthesia had been used exclusively because the dye injection was very painful. At present this is necessary only when the patient cannot cooperate, i.e., in children, or neurotic, or very senile persons. In these cases intravenous anesthesia with 2.5 per cent sodium pentothal supplemented by gas may be given. However, general anesthesia in the prone position is always dangerous and regularly requires intubation. The dye injection necessitates relatively deep anesthesia followed by a period of nonstimulation, which may lead to longer and deeper postoperative depression.

Local anesthesia can be recommended for routine use. It causes only little distress. The patient can be informed about each step so as to lessen his anxiety and enlist his cooperation.

The patient is placed in the prone position, his back being cleansed and surgically draped. An intradermal procaine wheal is made at a point below the twelfth rib about 10 to 12 cm. to the left of the spinal processes. The subcutaneous tissues and deep muscle layers are infiltrated with a 3-inch, 21-gage needle, which is directed superiorly, ventrally, and medially toward and around the spine. The vertebral body has to be anesthetized carefully to avoid pain. The para-aortic tissues should be infiltrated since “splanchnic anesthesia” markedly diminishes the incidence of untoward reactions during dye injection. Goodwin and Walter injected procaine into the aorta for the same purpose.

The routine use of local anesthesia is not in accord with the opinion of many roentgenologists. Dotter and Steinberg in their comprehensive account of angiography seemed to favor the use of general anesthesia.

Intra-aortic Dye Injection

During or before anesthesia, a scout film of the lower chest, abdomen, and pelvis is made. In this way the position of the spine, the bowel shadows, and the roentgen exposure can be checked. A lead marker at the site selected for skin puncture helps to estimate the direction of the needle and the approximate length of the puncture. It is important to insert the needle rather high in the aorta at the level of the twelfth thoracic vertebra to avoid close contact with the big abdominal vessels. In order to outline the renal arteries some investigators advise insertion of the needle at the level of the first lumbar vertebra to prevent a large portion of the dye passing into the upper abdominal vessels. This procedure is associated with some hazard as the needle enters the “dangerous zone” of Dos Santos near the orifices of the renal and superior mesenteric arteries. Direct forceful injection of contrast medium into 1 of these arteries may lead to severe complications.

If visualization of the lower aorta or arteries of the extremities is desired, puncture at the level of the third lumbar vertebra may be planned. A stronger opacification of the arteries of the lower extremities will be obtained, but it may be difficult to reach the aorta, which at this point is freely movable and more anterior.

A 6-inch, 18-gage needle fitted with a stylet is satisfactory for the purpose of aortography, but the thin-walled, 17-gage needle with the Huber point is more suitable. The large bore of the needle permits rapid injection. The Huber point promotes better dispersion of the dye in the aorta as the jet of fluid leaves the needle at an angle. The needle is directed always superiorly, ventrally, and medially from the chosen point on the skin toward the body of the vertebra. After the bone is encountered, the needle is withdrawn slightly and reinserted more ventrally until it passes around the spine. At this point the stylet is removed and the needle advanced 1/2 to 1 cm. until a pulsating blood flow indicates puncture of the aortic wall. This moment is easily recognized as a sense of decreased resistance, similar to puncture of the dura during lumbar puncture. Some caution is necessary at this time as the aortic wall may offer increased resistance and undue pressure can cause the needle to pass through the aorta, enter the abdominal cavity, and injure a viscous.

After the aorta has been entered, tubing and syringe previously filled with contrast medium are attached with Luer-Lok connections to the needle. The tubing prevents direct traction or pressure during the injection, which may cause dislocation of the needle and para-aortic deposition of dye. Polyethylene tubing is transparent and inelastic and can be sterilized by immersion in Zephran hydrochloride solution for 12 hours. Polyvinyl tubing can be sterilized by autoclaving, but becomes stiff and cloudy.

To increase the concentration of the contrast medium some modifications of this standard technic have been proposed. Large 14-gage needles have been used and contrast medium has been injected simultaneously through 2 needles in the aorta. The benefit from these variations, however, is not enough to justify the increased danger of hemorrhage. The rapidity of the injection seems more important than the quantity of the medium.

The injection of 10 to 30 ml. of contrast medium should be performed in 1 to 3 seconds. Several devices have been developed to speed the injection, but renal complications are more likely to occur with mechanical injectors.
recommended that the injection be done by hand, so that changes in resistance can be detected. However, the concentration of dye with hand injection may be poor and several other "physiologic" mechanical devices have been proposed.

We use a simple wooden stand that holds a 20 and a 50-ml Luer-Lok syringe in a stable vertical position. Sufficient force may be exerted on the syringe barrel to deliver the dye within a few seconds. If the injection is started when the aortic blood reaches the syringe, one can feel sure that the needle is in the aorta and air injection is excluded. The syringe should be flushed with warm saline to promote easy motion of the barrel during injection and dye solution should be warmed to body temperature before use to prevent formation of crystals.

The application of elastic tourniquets around the thighs recommended by Dos Santos does not improve concentration of dye in the intraabdominal sector. However, application of blood pressure cuffs inflated above the systolic pressure seems to improve the filling of the renal arteries and the outline of the kidneys. The head-down position, recommended by Dos Santos and Maluf and McCoy, is not useful. Pneumoretroperitoneography aids the outline of the organs and their blood supply and may be justifiable in selected cases when retroperitoneal changes are expected. The combination of aortogram with simultaneous retrograde pyelogram is superfluous.

Contrast Media

Dos Santos and his followers used almost exclusively 80 to 100 per cent solution of sodium iodide for radiographic purposes. This medium gives excellent contrast, but produces many untoward reactions. It has a high viscosity and causes painful sensations in the abdomen and extremities. Organic radiopaque dyes have superseded its use, since they give equally good roentgen contrast and few reactions. Organic iodine compounds such as 75 per cent sodium iomethamate, 70 per cent iopromate, and 70 per cent sodium acetrizoate are now used routinely.

Radiography

X-ray technic plays an extremely important role in aortography. The degree of radiopacity differs with the size of the patient, the level of injection, and the expected pathology. For anteroposterior views 25-30 milliamperes at 85-90 kilovolts, and an exposure of 1/50 of a second are sufficient as a rule. The film should be exposed during injection of the last few centimeters of the dye. The timing is important as the dye is propelled quickly and the maximal concentration may be easily missed. A syringe wired for automatic x-ray exposure was proposed for this purpose. For visualization of the aorta and its branches, a single film is sufficient. This may be accomplished on an ordinary radiographic table with a Potter-Bucky diaphragm and a 36-inch target-film distance. A long cassette, 14 by 34 inches, in conjunction with a long stationary grid may be used to visualize the abdominal aorta simultaneously with the arteries of the legs. Dos Santos recommended stereoscopic films, since superimposition of aortic branches often makes identification difficult. The pictures can be taken simultaneously with a special device, or 2 injections with different position of the tube may be used.

For visualization of the abdominal organs and especially the renal parenchymal vessels, multiple film exposure is necessary. The flow of the dye is better followed and details are visualized that otherwise escape observation. Dos Santos early recognized the necessity of multiple exposures during the course of the injection and others used the method routinely. It was found that the aorta remains outlined for 3 to 4 seconds after the injection. Usually 1 film gives a better picture than the others, depending on the force of the injection. Visualization of the peripheral branches is variable and may precede or follow the optimum filling of the aorta. At least 8 pictures, should be taken, 4 of them at 2-second intervals and the rest 1 to 4 minutes after the injection. The exposure is 1/5 second with 200 milliamperes at 90-95 kilovolts. In this way the aorta and its main branches will be visualized and the opacification of the abdominal organs, or the pooling of dye in some abnormal structures seen.

In the presence of renal pathology additional films should be exposed 5, 15, and 30 minutes after dye injection. Excretion of contrast substance in the kidney with filling of renal pelvis, ureters, and bladder will be demonstrated.

After-Care

After the dye has been injected, the needle is instantly removed and a sterile dressing applied. An infusion of saline or liberal oral intake of fluid will aid excretion of the dye. When general anesthesia is used, the usual precautions are taken until recovery from anesthesia. In patients examined under local anesthesia the blood pressure and pulse are taken every 30 minutes, but they may be elevated after 4 hours. Medication for pain will be necessary only in cases of extravasation of dye or inadvertent direct injection into renal or mesenteric arteries.

Results

The primary objective of aortography is the demonstration of the aorta and its branches. The degree of vascularity allows conclusions relative to the condition of the abdominal and pelvic organs, especially the kidneys. The artery will be larger than normal with hypertrophy or acute inflammatory lesion of an
involved organ. A decrease in the caliber indicates fibrosis and atrophy of the organ.23

Abnormalities of the Aorta and its Branches

Congenital Anomalies. Aortography presents an excellent tool for diagnosis of congenital vascular lesions such as aberrant vessels, arteriovenous fistulas, and aneurysms. Aberrant vessels of the aorta are seldom of clinical significance, but near the kidney they can lead to hydronephrosis through obstruction of the ureteropelvic junction.14 Congenital coarctation of the abdominal aorta is extremely rare; only 16 cases have been recorded in the last 100 years.16 In some cases it may lead to heart failure and can be corrected surgically.46 Arteriovenous fistulas are usually diagnosed clinically. However, in congenital abnormalities arteriography is necessary to delineate the vessels involved and the size and number of communications.16 Visualization of post-traumatic fistulas will also be of considerable help in repair.

Congenital aneurysms of the abdominal aorta are extremely rare. Their detection is hampered by the difficulty of aortography in childhood.31 Several instances of aneurysm of hepatic, splenic, celiac, and renal arteries have been described.47, 48 They usually contain calcium and can be recognized without arteriography except for cases with uncertain localization.15 These aneurysms are of clinical interest, as they may rupture. Now they can be resected without sacrificing the organ involved.48

Aortic Aneurysm. The loss of elasticity in a circumscribed area leads to the formation of an aneurysm. Abdominal aortic aneurysms occur mostly below the level of the renal arteries and are usually arteriosclerotic in origin. They may be recognized clinically as expansively pulsating masses in the abdomen. Sometimes it is impossible to differentiate between the pulsation due to aneurysm and that due to a tumor over the aorta. In the absence of typical roentgenologic signs such as calcification or bone erosion, aortography should be done.49

Recognition of aortic aneurysm has become more important, since the condition can be surgically repaired.50 Aortography will facilitate selection, since extreme dilatation of the aorta and multiple aneurysms are not suitable for surgery. Operative correction is urgent if there is pain because the untreated cases do not survive longer than 3 years.51

In rupture of an abdominal aneurysm the life expectancy is extremely short. With aortography it may be possible to demonstrate the condition before death. In a few instances surgical repair may be accomplished.50

Atherosclerosis. According to statistical observations the abdominal aorta is most frequently and extensively involved in generalized arteriosclerosis.23 The changes can be recognized by aortic dilatation and tortuosity. The major branches are large and often show calcifications. Their course is irregular and tortuous because of elongation and loss of elasticity. A decrease in caliber indicates secondary changes in the wall due to fibrosis or thrombosis.52

Arteriosclerotic constriction is usually caused by encroachment of an arteriosclerotic plaque and may culminate in obstructive thrombosis or rupture. With an arteriogram the obstructed area and the collateral circulation may be seen. Sometimes even the length of the obstructed segment may be estimated if the distal artery is filled through collateral vessels.44

In cases of peripheral arterial disease translumbar arteriography is preferable as the aorta is easily accessible and the damaged femoral vessels are not further traumatized. The danger of arteriospasm is lessened and the collateral vessels may be better visualized. Aortography is imperative when the femoral pulses are absent, as the block must be located in the iliac arteries or higher. Stenosis of the major arteries is more frequent than previously suspected and may simulate the symptoms of peripheral arterial obstruction.25

Arterial stenosis or thrombosis may appear in young people and differentiation from arteritis and especially from thrombangiitis obliterans is often necessary. In arteriosclerosis the arteries are wide and show an irregular course and contour. In arteritis the narrowing of the lumen is concentric and the vessels are small. They always have a curved course without angulation.18

Aortography is just as helpful in cases of embolism as it is in the diagnosis of arterial
thrombosis. It gives the exact position of the embolus.\textsuperscript{53}

\textit{Leriche's Syndrome.} Thrombosis of the bifurcation of the abdominal aorta was recognized by Leriche\textsuperscript{54} as a distinct clinical pathologic entity. It manifests itself gradually and is characterized by fatigue in the legs, intermittent hip claudication, loss of firm erection, absent femoral pulses, symmetrical moderate atrophy of the legs, and signs of impaired circulation without trophic changes of the skin or toenails. The obliteration usually originates in 1 of the common iliac arteries, but the thrombus soon extends proximally, reaching the terminal aorta. The aorta may be blocked completely or partially. The thrombosis may spread upward toward the origin of the mesenteric and renal arteries. The condition is more frequent than is generally realized, the autopsy incidence being 0.1 per cent.\textsuperscript{55} Aortography is of great value in diagnosis and is evaluating the extent of involvement and of the collateral circulation. With the block at the aortic bifurcation, enlarged intercostal and lumbar arteries and anastomoses of the inferior mesenteric artery with branches of the hypogastric arteries may be seen. If the thrombosis reaches the inferior mesenteric artery, the collateral vessels between the middle and left colic artery dilate. If the block is higher, the collateral circulation will be between the internal mammary and inferior epigastric arteries.\textsuperscript{18}

Progressive thrombosis of the lower abdominal aorta may be compensated for many years by collateral circulation. Sooner or later it leads to grave ischemic phenomena in the lower extremities due to secondary peripheral changes. Death usually occurs from gangrene and infection of the extremities, or from coronary heart disease. In cases with thrombosis of the renal arteries, hypertension and renal insufficiency are the outcome.\textsuperscript{41}

Early recognition of aortic thrombosis is very important, since resection of the aortic bifurcation is technically possible and the circulation to the extremities may be restored with a homologous graft or synthetic prosthesis.\textsuperscript{56}

Chronic thrombotic occlusion should be differentiated from acute embolism involving the aortic bifurcation. In the latter case the onset is always acute and associated with severe shock and violent pain. Because of inadequate collateral circulation, paraplegia and ascending gangrene are likely. Translumbar aortography will outline the so-called saddle embolus and facilitate embolectomy.\textsuperscript{51}

\textit{Diagnosis of Abdominal Abnormalities}

Disease of the abdominal organs may be recognized from the status of the arteries supplying them.\textsuperscript{27} Abnormal dilatation, stenosis, or obstruction of an artery indicates pathologic change. The course of the arteries from the celiac axis may give information about the liver, spleen, and the mesenteric arteries. Physiologic variations are so numerous, and our experience so meager, however, that exact diagnosis is often difficult.

In aortic serigraphy the abdominal diagnosis is facilitated by the outline of the spleen and liver, due to retention of the dye in the sinusoids. Parenchymal opacification is very pronounced in the kidney and the spleen, and distinctly less in the liver.\textsuperscript{47}

Splenic enlargement, rupture of the spleen, and accessory spleens may be diagnosed by means of the splenogram.\textsuperscript{18} Epigastric tumors may be visualized if they are large enough to dislocate vessels. However, undoubtedly positive results are rare. Enlargement of the liver may be substantiated by the hepatogram.

Primary or secondary tumors of the liver may be seen if they displace branches of the hepatic artery or if they cause defects in the homogeneous hepatic opacification.\textsuperscript{58} Advanced cirrhosis of the liver gives only a faint contour. The association of cirrhotic liver with enlarged mesenteric vessels observed by Nelson\textsuperscript{13} has not been substantiated in subsequent series.\textsuperscript{34}

Disease of the mesentery and intestine can be inferred from angiograms of the superior and inferior mesenteric arteries. The displacement of major arteries and filling defects in some parts of the ansiform loops permit recognition of tumors of the mesentery. However, the mesenteric angiogram is difficult to interpret as the ansiform loops overlap frequently. Sometimes pooling of contrast medium in abnormal vessels of a malignant tumor makes the diag-
agnosis possible.\textsuperscript{24} The positive results are too rare to warrant using translumbar aortography as a diagnostic tool in recognition of intestinal tumors.

Exploration of the upper retroperitoneum with aortography is rather disappointing. The filling of hepatic and splenic arteries and the resulting splenograms and heptograms obscure the details in this part of the abdomen and limit the conclusions that can be drawn. Several attempts to visualize pancreatic tumors failed in our series.\textsuperscript{31} Attempts to demonstrate the site of bleeding in upper gastrointestinal hemorrhage with aortography proved futile.\textsuperscript{59} Tumors of the adrenal glands may be recognized by observation of the size and distribution of the suprarenal arteries or by displacement of adjacent blood vessels.\textsuperscript{60} Adrenal carcinoma may also cause downward displacement and flattening of the kidney. In some cases pooling of contrast medium in a suprarenal tumor may be seen.\textsuperscript{13} Aortography is decidedly inferior to retroperitoneal air insufflation, which renders good outlines of the kidney and glands.\textsuperscript{61}

Masses in the lower retroperitoneum have been diagnosed by displacement of the aorta and kidneys.\textsuperscript{41} Abnormalities of the lumen and pressure defects are rare due to the elasticity of the aortic wall, but the abdominal aorta is movable and readily gives way to external pressure. Deformation and displacement of the renal shadow may be of diagnostic aid.

Demonstration of pelvic disease by means of aortography is seldom indicated because the diagnosis can be made by simpler methods. The conclusions concerning the course of the hypogastric arteries and branches are invalid, since these vessels show many physiologic variations that cannot be differentiated from pathologic changes. Only tumors with increased vascularity will be clearly demonstrated.\textsuperscript{6} In cases of large uterine myoma "a hairpin bend" of the uterine artery and an increase in its width were reported.\textsuperscript{62}

Differentiation between ovarian tumors and growths arising from the uterine wall by means of a different blood supply, has not been satisfactory.\textsuperscript{62, 63} When a fibroma is associated with an ovarian tumor, the correct diagnosis is impossible.

The maternal circulation of the placenta has been studied by means of translumbar aortography.\textsuperscript{6} The blood sinuses give a characteristic mottling in the x-rays and allow determination of the point of attachment. Hartnett\textsuperscript{62} was able to establish the correct diagnosis of placenta previa in 2 cases. The method may be of diagnostic value in establishing extraterine gravidity but its use is limited, since aortography may induce labor in women near term.

In summation it can be said that the use of aortography for abdominal diagnosis is limited. With the exception of tumors in the lower retroperitoneum, the aortogram fails to add additional information to the physical examination, routine x-ray studies, or retroperitoneal pneumography.

\textbf{Aortography in Urologic Diseases}

In contrast to the rather disappointing results of aortography in general abdominal pathology, experiences in the diseases of the kidney are encouraging. Rapid cassette devices opened an entirely new field in urologic investigation.\textsuperscript{21} Information includes the status of renal arteries, the condition of the kidney parenchyma, and its excretory function.

Visualization of the renal vessels is of value in demonstrating aneurysms, arteriovenous fistulas, and vascular obstruction due to embolism and thrombosis.\textsuperscript{64} Accessory renal arteries from the left side of the aorta, from the proximal portion of the renal artery, and from neighboring vessels will be noted.\textsuperscript{64} They usually do not enter the hilus, but pierce the outer surface of the kidney.

The diagnosis of renal abnormalities is aided by the characteristic opacification of the parenchyma with the dye. The phenomenon of nephrography was observed by Hellmer\textsuperscript{65} in ordinary pyelography after he used highly concentrated contrast media intravenously. In abdominal aortography, it occurs regularly and helps to analyze the size and the form of the kidney. The opacification of both kidneys occurs usually within 2 to 5 seconds after the major renal vessels are visualized. It is caused by a large concentration of dye within the parenchymal vessels and also by the increased
dye secretion into the tubules. Great density signifies good function and lack of kidney visualization indicates severe renal damage.\textsuperscript{14, 34} Coincident with the nephrogram opacification of the renal vein may be observed. The phenomenon occurs infrequently and its diagnostic implications are still uncertain.

X-rays taken 5 to 30 minutes after the dye injection show an excretory urogram that is helpful in diagnosis of diseases of the pelvis, ureters, and bladder.\textsuperscript{25} The pyelogram may be seen even if no significant nephrogram is present. This phenomenon speaks for endogenous kidney disease and has been noted in malignant hypertension, chronic glomerulonephritis, and terminal stages of pyelonephritis.\textsuperscript{21} The failure of a pyelogram, together with an absent nephrogram, indicates that the kidneys are non-functioning and the pathologic changes irreversible.\textsuperscript{34}

Developmental Anomalies of the Kidney. Aortography is of particular value in those cases of renal pathology in which intravenous and retrograde pyelograms do not show the kidney. Agenesis of the kidney can be recognized easily because no renal arteries and no nephrogram is seen.\textsuperscript{40} In hypoplasia of the kidney the artery is small and has only a few branches; the nephrogram shows a small and faintly outlined kidney.\textsuperscript{46} The pelvis and ureter are small in the resulting urogram. Horse-shoe kidney and ectopic kidney are easily detected by means of a nephrogram. In these cases as well as in crossed renal ectopia there are a number of anomalous vessels. In duplication of the kidney 2 separate vascular networks and double pelvis are seen.\textsuperscript{54}

Polycystic Kidney. The main value of aortography in polycystic kidney is the determination of potential renal function with resulting information about the prognosis. Failure to visualize the kidney in serial examination is a sign of renal insufficiency and bad prognosis.\textsuperscript{21}

Differentiation between Renal Cyst and Tumor. The differential diagnosis between benign solitary cysts and malignant kidney tumors has always been a difficult problem in urology, as both may produce identical deformity of the pelvicalyceal system. In the nephrogram a solitary cyst appears as a relatively avascular structure with widely divergent large vessels in the periphery.\textsuperscript{17} The excretory urogram will reveal transformation of the pelvis according to the size and position of the cyst. The picture may demonstrate not only large cysts near the hilus, but small cysts near the periphery of the kidney.\textsuperscript{18}

In contrast to these findings, hypernephroma if not necrotic shows an increased opacification characterized by "puddling of the dye," due to retardation of blood flow in the highly vascularized tumor.\textsuperscript{13, 14} Even a small tumor may be detected if enough medium is retained in the newly formed sinusoidal vessels.\textsuperscript{2} Only positive results are conclusive as malignant renal tumors are often associated with necrosis and may contain poorly vascularized zones.\textsuperscript{66}

Metastatic cancer may also be seen in nephograms,\textsuperscript{21} but the diagnosis can often be missed. Papillary adenocarcinoma and squamous-cell carcinoma of the renal pelvis will show displacement of the vessels and an abnormal pyelogram may help to identify them.\textsuperscript{25}

Hydronephrosis. The etiology of hydronephrosis can be clarified by routine urologic examination. Aortography will be necessary when intravenous pyelography gives poor visualization of the affected kidney and the retrograde pyelogram is unsuccessful. It is also indicated in cases where urinary infection makes retrograde pyelography undesirable. It will help to localize the course and number of the anomalous vessels and to determine how much they contribute to the circulation of the kidney.\textsuperscript{14} The function of the kidney may be also ascertained. When the parenchymal changes have advanced so far that they interfere with the blood supply, the kidney should be removed, since it probably will never regain its function.\textsuperscript{18} If the vascularity of the kidney is good and a nephrographic effect is obtained, every effort should be made to save the kidney even though the renal cortex is markedly thin.\textsuperscript{21}

Chronic Kidney Infections. Aortography is seldom necessary in bladder disease, renal calculi, calculous or tuberculosis pyonephrosis, and pyelonephritis but it may be useful from the functional aspect, since a good nephrogram
proves good excretory function and indicates good prognosis.

Chronic infection causes a decreased arterial supply to the renal parenchyma and a poor nephrogram.52 The vessels are spread apart and decreased in number. They may be stretched, displaced, or bent and often show abrupt terminations. The differentiation between actually decreased circulation and incomplete filling is not easy and can be accomplished only by routine use of a rapid cassette changer permitting adequate study of the aorta, the renal arteries, and their terminal branches.54

Recently aortography has gained attention in connection with tuberculosis of the kidney. The necrotic areas of the renal parenchyma show decreased vascularity and more or less circumscribed dark areas in the contrast-laden kidney. Changes in the renal pelvis may be recognized in later studies. Weyde21 believed that local or segmental resection of the kidney may be possible if the extent of the lesion and its relationship to the pelvis is known.

**Hypertension.** The visualization of the kidney vessels is of great value in clarification of some cases of hypertension. Since the experimental work of Goldblatt,67 it is known that occlusive lesions of 1 or both renal arteries may be related to sustained hypertension. The proof in the majority of cases exists on circumstantial evidence with verification only after death.68 Recently such cases have been recognized by means of aortography.41 The procedure should be contemplated in patients with an acute onset of hypertension that is associated with an episode of abdominal pain or trauma.66 It will demonstrate the unilaterality or bilaterality of the disease, the changes in the caliber and the walls of the renal arteries, and the degree of renal ischemia.

In renal infarction an abrupt termination of arterial branches is seen with an avascular distal segment of parenchyma.52 In older infarctions a depression of the renal cortex may be perceived in the serigraph. Multiple renal infarctions may lead to hypertension as the zone of diminished viability around the necrotic tissue may liberate substances of hypertensinogen-like action.68

Hypertension may also be the result of unilateral kidney disease that causes atrophy of the parenchyma and vessels. The recognition of these cases is extremely important as operation can eliminate the pathogenic mechanism and relieve the hypertension.67

In selected cases of essential hypertension aortography may give prognostic clues through the study of arterial supply and the degree of kidney opacification.66 An absent nephrogram indicates a poor prognosis, especially if the hypertension is of short duration.

**Contraindications and Complications of Aortography**

For many years translumbar aortography was regarded as a difficult and dangerous procedure and the indications for its use were ill defined. These same obstacles embarrassed pyelography in its early stages before frequent use over many years established it as an essential diagnostic tool.

A distinct warning against the method was issued by Henline and Moore7 following an experimental study of 19 dogs in which the aorta was punctured through the posterior approach. Five animals died from traumatic hemorrhage shortly after the aortic injection, and 3 apparently from toxicity of sodium iodide. Dos Santos26 pointed out repeatedly that the risk of hematomas in dogs is greater than in human beings. Extravasation of blood does occur in human beings but the valvular effect of the oblique passage ensures rapid closure following withdrawal of the needle.2 Inadequate anesthesia during injection may permit movement of the patient and lead to a tear in the aorta and extravasation of the dye. Hemorrhage is probably responsible for the occasional lower left chest pain and left shoulder pain. Injection of the medium intramurally or outside of the aortic wall results in a painful sensation in the back or in the epigastrium, but the expected tissue necrosis and damage to the aortic wall have proved to be rare.16 Deterling69 described a severe and prolonged chemical neuritis of the lumbar nerves.

Because of possible rupture, aneurysm or extensive calcification of a normal-sized aorta has been considered a contraindication to
aortography, but growing experience has not substantiated increased danger of bleeding in these cases.19

In their anatomic studies Wagner and co-worker25 pointed out that injury to neighboring viscera by the advancing needle is most unlikely. Wagner and Price20 reported entrance of the needle into the azygos system of veins. Maluf and McCoy25 observed complete severance of the thoracic lymph duct at the level of the seventh to eleventh thoracic vertebrae with resulting chylothorax. A few instances of pleurisy as well as of pneumothorax have been observed.32 Perforations of an intraperitoneal hollow viscus may also occur.16 Shapiro25 described injury of the splenic artery that necessitated splenectomy.

Wagner and Price20 reported a fatality from mesenteric thrombosis with gangrene of the intestine. The needle was inserted into the orifice of the superior mesenteric artery and the entire amount of 80 per cent sodium iodide injected into its branches. There was no autopsy in this case. Melick and Vitt16 observed a similar event with death in 48 hours due to gangrene of the bowel, but the autopsy revealed generalized intestinal carcinomatosis. Several instances of injections into the splenic, hepatic, and renal arteries have been reported in the literature with only minor reactions.32

Systemic reactions to dye may occur immediately as hypersensitivity reactions, or may be delayed due to toxic effects upon the parenchymatous organs, particularly the liver and kidneys. Toxic and allergic reactions consist of nausea, vomiting, transient cyanosis or dyspnea, fall in blood pressure, feeling of heat, and sudden death. Premedication does not prevent these symptoms. Drugs do not seem to help in relieving them. However, our recent experience indicates that premedication with cortisone successfully diminishes the frequency and the intensity of these reactions.28

Courand and co-workers71 found 26 sudden deaths in a group of 6,224 patients who had angiocardiographic examinations. The type of death was usually ascribed to respiratory arrest, during or immediately following injection. To our knowledge only 1 instance of sudden death due to anaphylactic shock following translumbar aortography has so far been reported.28 The cardiac arrest was preceded by severe dyspnea and urticaria. Facilities for immediate administration of oxygen, epinephrine, and cardiac resuscitation should be available during aortography.

The sensitivity reactions may be prevented by previous testing and careful selection of the patients, although Courand72 stated that they cannot be predicted on the basis of skin or eye tests. According to Leriche,18 aortography is contraindicated in obese persons, and in patients with diminished cardiac output, or impending gangrene of the legs. In these cases the reflex action of the contrast medium with resulting spasm and its direct toxic action on endothelium may lead to arterial thrombosis with fatal results. The iodine-containing dyes should not be used in the presence of severe liver damage, poor renal function, hyperthyroidism, exudative or allergic diatheses, advanced tuberculosis, and sensitivity to iodides. Aortography is strictly contraindicated in patients with renal failure. A blood urea nitrogen of 40 mg. per cent is the limit above which dye injection is not permissible.22

Baccaullini and Ballarin23 found hemorrhages in the glomeruli of the kidney and also in the liver and spleen in dogs. Larsson and Palmlov19 demonstrated in 38 patients that there is ordinarily no detectable change in the renal function after aortography. A temporary diminution of function occurred only after direct injection of iodopyracet (Diodrast) into the renal arteries. Miller and co-workers24 reported 7 instances of renal damage following aortography. These complications would probably not occur if no more than 40 ml. of dye were injected.75 A case of acute renal failure leading to death was reported by Fry,76 who used an extremely high dose of 100 ml. of 70 per cent sodium acetrizoate (Urokon) in 1 examination.

A grave complication of aortography is paraplegia, which has been reported so far 5 times.77-80 The pathogenesis of this phenomenon is not clear. Shunts that divert the contrast material into the spinal cord circulation may be responsible for this complication.79 Evans42 blamed it on improper technic with the needle passing through the intervertebral disk and spinal canal, thus enabling the dye to escape into the subarachnoid space. The neurologic
symptoms seem to occur in cases where the puncture was performed in the lower lumbar area.

Fortunately the complications of aortography are rare. Most reactions occurred because of improper technic with insertion of the needle below the level of the twelfth thoracic vertebra and injection of dye into 1 of the major branches of the aorta.

**DISCUSSION**

More than 25 years have elapsed since Dos Santos\(^1\) described the method of translumbar aortography. The accumulated experience indicates that the procedure has brought a high degree of diagnostic efficiency into clinical diagnosis. The examination is relatively simple, since it can be carried out under local anesthesia. It is relatively safe with water-soluble, organic contrast media.

Aortography is a valuable method for examination of the abdominal aorta. Many important diseases that were formerly seen only at autopsy may now be visualized. Proper interpretation depends upon knowledge of the normal aortic tree and familiarity with its variations. Congenital anomalies, arteriovenous fistulas, aneurysms, arterial thrombosis, and emboli may be recognized and treated. The examination is not a routine procedure in patients with peripheral vascular disease, but it may be of immeasurable help in estimation of the extent of the lesion and its correction.

Conclusions concerning pathologic conditions of the abdominal organs can be reached from the status of the arteries supplying them. However, the use of aortography for abdominal diagnosis is limited, as physiologic variations are wide. The aortogram may delineate tumors in the lower retroperitoneum, but it fails to give additional information about the tumors in the upper retroperitoneal space.

Technically successful aortography may reveal valuable information in complicated urologic cases, in addition to what can be demonstrated by cystoscopy and pyelography. It is actually simpler than a retrograde pyelography and is accompanied by no more reaction. Its accuracy has been markedly enhanced since serial exposures were introduced. Valuable information concerning the amount of blood supply to the kidney and its distribution may be obtained. The condition of the renal parenchyma and its excretory function can be studied. Aortography is most useful in cases where no contrast is seen during intravenous pyelography, where retrograde pyelography is unsuccessful or shows only a slight hydronephrosis, and in cases of questionable deformity of the pelvis. It can supply preoperative information about the nonfunctioning kidney. It can visualize anomalous renal arteries and help detect congenital anomalies. Often it will permit the differentiation between renal neoplasm and a solitary cyst.

In selected cases aortography offers information that cannot be obtained by any other method. This is especially true in the field of angiology and urology.

**SUMMARY**

The diagnostic value of translumbar aortography is discussed. The technic of the procedure is emphasized. Water-soluble, organic iodine media make it reasonably safe. Serial x-ray exposures during dye injection enhance its diagnostic accuracy.

The most valuable information is obtained in the fields of angiology and urology. Some diagnostic help may be gained by the examination of the lower part of the retroperitoneal area.

**Summario in Interlingua**


Le plus significative informationes es obtenite in le campos angiologic e urologic. Datos de alicun valor diagnostic poter esser obtenite per examinar le parte inferior del area retroperitoneal.

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