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# THE GUIDED CATHETERIZATION AND RADIOGRAPHY OF THE ABDOMINAL VESSELS*

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CANNULATION of blood vessels and heart cavities is an old procedure in physiology and an historian's competence would be required to indicate who used this method first. As with many other methods old in experimental surgery (for instance, cannulation of the trachea for anæsthesia), it took some time before catheterization of blood vessels became a clinical procedure. In the field of cardiovascular investigation and surgical therapy the self-experiment of the young surgeon, Werner Forssmann[1] can be considered as a milestone. In 1929 he introduced through his left antecubital vein a ureteral catheter into the right cavity of his heart and walked to the Department of Radiology to obtain a picture of the shadow-giving catheter *in situ*. This courageous act at a time when anticoagulants were barely used abolished the clinicians' fears of similar intravascular procedures. Since that time many thousands of heart catheterizations have been carried out. From the beginning it became a radiological tool by which angiocardiograms were obtained. Its value in differential diagnosis of pulmonary neoplasms was emphasized two years ago by H. Neuhof and associates.[2] However, the catheterization of the heart and blood vessels was mainly used for preoperative investigation in congenital heart diseases where it gives valuable information. For this purpose Cournand and associates, devised a special catheter. Occasionally the catheter was observed to pass the right auricle and to slip into the inferior vena cava and enter a hepatic vein. Later on, in 1945, Bradley, Ingelfinger, Bradley and Curry[3a] used the transcardiac way for introduction of a Cournand catheter into the right hepatic vein from which they drew blood samples in order to estimate the blood flow through the liver.

In 1934 I devised a system of two radio-opaque catheters, one sliding inside the other (Fig. 1). The inner catheter (B) slid on a slanted plane of a metal rod obstructing the lumen of the outer catheter (A) distal to a lateral opening one inch below the tip of the catheter from which it emerged with a lateral

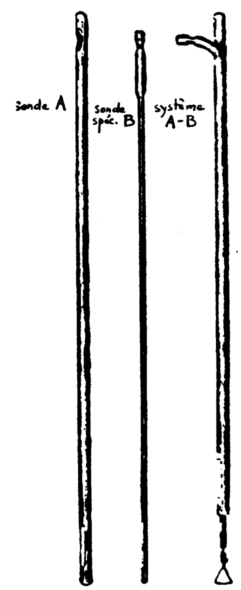


Fig. 1.—System of two radio-opaque catheters, one sliding inside the other. (A) Outer catheter; (B) inner catheter; (A-B) the inner catheter emerging from the outer catheter with a lateral curve.

curve (A-B). Thus the catheterization of branches of a vessel admitting both catheters was made possible. Together with Dr. Ravina and Dr. Cottenot several experiments catheterizing side branches of the pulmonary vessels were carried out in Paris. However, I left France and that prevented further work.

A year ago we used this two-catheter system for cannulation of the hepatic veins via the femoral vein under the screen in normal dog

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livers and livers rendered ischæmic experimentally. With these catheters it was as easy to draw blood samples from the right as from the left hepatic vein. However, radio-opaque catheters are not smooth enough to avoid fibrin precipitation inside their lumen and the sliding of the inner catheter is hampered by a certain stickiness. Finally I found that a transflex tubing with an inner metallic leader (Fig. 2A and B), the end of which can be curved by turning the nut of its handle, is not only suitable for catheterization of the right and left hepatic veins but also for catheterization of other branches of the inferior vena cava.

It is evident that the branches of the abdominal aorta also can be catheterized by the same method.

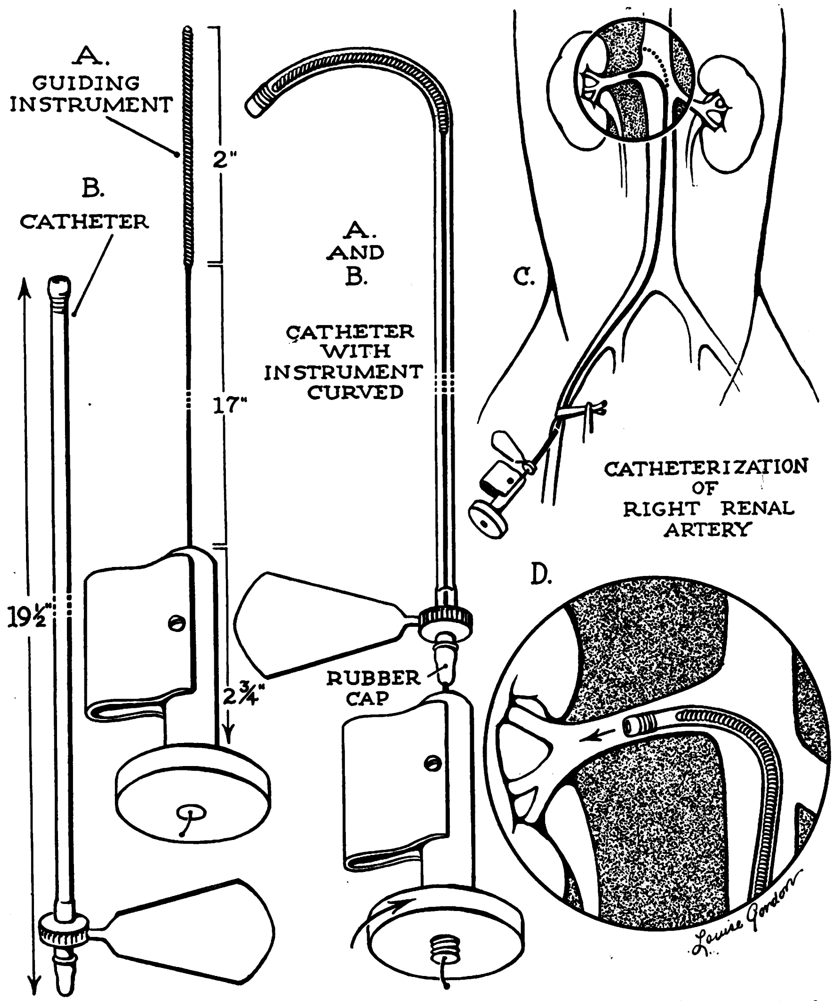


Fig. 2.—Instrument for guided catheterization. (A) Guiding instrument, the end of which can be curved by turning the nut on its handle. (B) Transflex tubing having a metal cap at its tip. (A-B) Guiding instrument and catheter in curved position. (C) Guided catheterization of the right renal artery via the right femoral artery. (D) Inset illustrating the phase during which the tip of the catheter slides over the curved instrument and penetrates deeper into the catheterized vessel.

## METHOD

The animal is anæsthetized with nembutal and its saphenous vein or femoral artery is located. Before introducing the catheter the animal is heparinized with 1 to 2 c.c. of a 1:1,000 solution. The peripheral end of the dissected vein or artery is ligated and a Penrose tubing is passed around the central end. The vessel is incised and the catheter containing the leader introduced into the lumen. The Penrose tubing is stretched and clamped with a bulldog clamp, close to the wall of the vessel. The elastic tubing tightens the wall around the catheter and prevents leakage of blood.

The animal is placed under the screen and covered with lead sheets except for the abdominal region and a small field in the triangle of Scarpa where the catheter was introduced. It is handled with lead gloves. Close attention should be given to the protection of the operator from the effects of radiation. Under the screen the catheter is found lying in the lower part of the aorta or the inferior vena cava. It is easily recognized by the heavy shadow of the metal leader. The catheter is moved upwards until it reaches the diaphragm. Here the tip of the leader is curved by turning the nut. Catheter and leader now look similar to the seasonal sugar-cane lying in the lumen of the aorta or inferior vena cava. By moving the "cane" downwards the walls of the vessels are slightly stretched. As soon as the tip of the curved catheter meets an opening of a side vessel it will slip into it, evading the force of elasticity of the stretched wall. When the tip of the catheter hooks into a side vessel, its slight bouncing movement can be seen readily under the screen. The transflex catheter is now slid over the leader which is maintained in position. The shadow of the metal cap at the tip of the transflex tubing detaches itself from the shadow of the leader and migrates horizontally and laterally, penetrating as deep as the width of the catheterized branch of the large vessel allows (Fig. 2C and D). The transflex catheter is now maintained in position and the leader is removed while its curve is gently released by turning the nut, in an anticlockwise direction. Blood samples can be taken now for different laboratory determinations (function tests, excretion tests, etc.), blood pressure can be measured and the organ can also be flooded directly with drugs for therapeutic purposes or with a radio-opaque substance in order to obtain a venogram or arteriogram.

## ABDOMINAL VENOGRAPHY

Venography was introduced by Sgalitzer,[4] Wohlleben[5] and others. Abdominal venography was first described by Dos Santos[6] and applied by P. Farinas,[7] B. J. O'Loughlin[8] and others. In this the radio-opaque substance is injected "in current" through the saphenous vein and serial pictures of the large abdominal veins are taken. The femoral and iliac veins, as well as the inferior vena cava, become visible, and sometimes the site where the hepatic veins branch off is marked. Portal venography as reported by Moore and Bridenbaugh[9] and by Leger and associates[10] is a procedure that can be used only

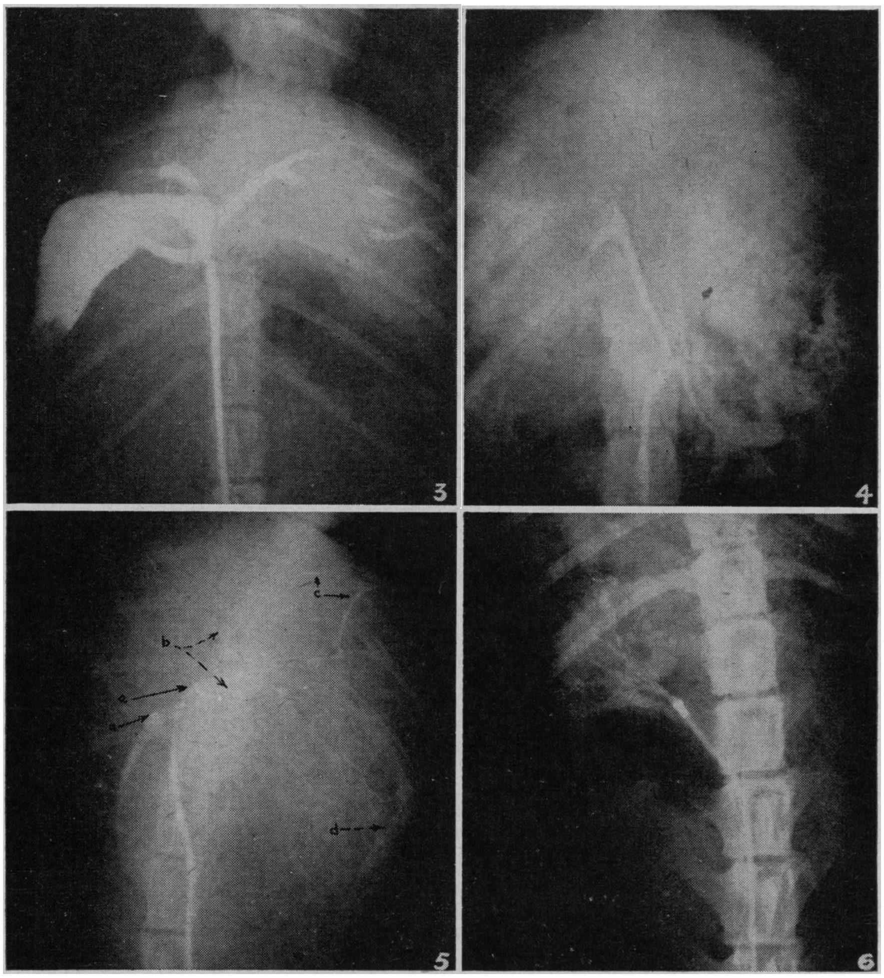


**Fig. 3.**—Following retrograde injection of 75% diodrast (20 c.c.) into a right hepatic vein the entire vascular pattern of the right and left hepatic veins has become visible. **Fig. 4.**—Normal arteriogram of the cœliac axis in the dog obtained by guided catheterization of the vessel. The splenic shadow is mottled due to the accumulation of diodrast in the venous sinuses of the splenic pulp. **Fig. 5.**—Arteriogram of the cœliac axis in a dog which had had its hepatic artery ligated and its spleen removed: (a a) sites of ligation; (b) tortuous collateral artery anastomosing with the left gastric artery (c); (d) vascular tangle in the inflammatory process around the foreign body. **Fig. 6.**—Normal arteriogram after catheterization and injection of 3 c.c. of 35% diodrast into the right renal artery.

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during laparotomy. It gives an outline of the portal vessels in the liver parenchyma.

Catheterization of the hepatic veins with a catheter arranged after the Foley principle allows us to inject these veins with a radio-opaque substance in a retrograde way and to obtain a venogram.[11] Fig. 3 shows the venogram of a normal dog's liver obtained by our technique of catheterization. In a similar way the other main branches of the vena cava can be catheterized and injected with radio-opaque substance.

It is obvious that in cases where a portal-caval anastomosis is present, the catheterization of the portal vein and the retrograde injection of its branches can be carried out. Similarly the catheterization and retrograde injection of a radio-opaque substance into the internal iliac veins might give some information about pathological changes in the pelvic organs which could not be diagnosed by simpler means.

Summarizing the principle of the venography of organs, we must state that the catheterization of the large venous vessels is carried out in the direction of the blood flow; the catheterization and injection of their side branches, however, is effected in a retrograde way. An inverse direction is followed in the catheterization and radiography of the abdominal arteries. Here the large vascular channel is catheterized in a retrograde way, but its side branches are catheterized and injected in current. This will allow us to reduce markedly the amount of the injected radio-opaque substance.

### ABDOMINAL AORTOGRAPHY

Abdominal aortography by direct translumbar puncture of this vessel and injection of radio-opaque substance into it was introduced in 1929 by Dos Santos and associates. In 1932 Makoto Saito and Kaminkawa[12] described a new method of retrograde arteriography, the injection "in refluence". The same principle was used by Farinas in 1945[13] for the radiography of the aorta and the iliac arteries. Already in 1940 this author reported[14] his method of aortography by retrograde catheterization of the aorta through the femoral artery. He introduced a catheter Nr. 7-8 Porges into the femoral artery in the triangle of Scarpa and moved it along the iliac artery into the aorta up to the level of the organ to be investigated. Diodrast (70% 20 to 30 c.c.) was injected and an 8 to 10% concentration of the shadow-giving substance in the aorta was obtained. By placing the end of the catheter close to the mouth of the aortic branch of the organ to be examined a good radio-opaque filling of its vessels is effected.

The method of retrograde catheterization and aortography was adopted by many authors. Different arteries were used as a way of approach to the aorta.

In 1948 in the *Acta Radiologica* Radner[15] described a method of aortography by retrograde catheterization through the radial artery. In the same issue Brodén, Hansen and Karnell[16] and Brodén, Jönsson and Karnell[17] reported thoracic aortographies carried out with the method suggested by Radner. In 1949 Freeman and associates[18] and Burford and associates[19] reported independently thoracic aortographies obtained by retrograde catheterization of the common carotid artery. The latter also gave a report of a personal communication of Crawfoord who used the radial artery to insert a cannula for retrograde aortic catheterization. E. C. Peirce[20] used the femoral artery, while Pearl, Gray and Friedman[21] used the radial or the femoral artery as a way of retrograde catheterization of the aorta. In 1950 Goodwin, Scardino and Scott[22] recommended the preparation and "cut down" of the lateral circumflex branch of the profound femoral artery for insertion of a catheter to be introduced into the aorta.

In February, 1951, Dr. W. G. Bigelow presented at the Surgical Staff Meeting of the Toronto General Hospital a case of aneurysm of the thoracic aorta visualized by retrograde aortography through the lateral circumflex femoral artery and discussed the advantages and inconveniences of this method.

Recently, Howard R. Biermann and associates[23] described their technique of intra-arterial catheterization through the common carotid, brachial or femoral arteries. Using a Cournand catheter they were able to catheterize the abdominal arteries mostly via the right common carotid artery.

In our experiments on anæsthetized dogs we used the femoral artery for insertion of the leader-containing catheter, and prevented the hæmorrhage around the catheter by snugging a Penrose tubing around the central end of the incised artery while the peripheral end of the vessel was ligated. Under the screen, and taking care to be protected from the effects of radiation, we introduced the catheter up to the diaphragm. For catheterization of the cœliac axis we preferred the lateral position of the dog. Thus the orifice of the cœliac artery is situated laterally to the aortic axis. By curving leader and catheter and sliding them along the anterior (now lateral) wall of the aorta the orifice of the cœliac axis is picked up and the catheter introduced into its lumen.

Fig. 4 shows the normal arteriogram of the branches of the cœliac artery injected with 20 c.c. of 75% diodrast; the hepatic and splenic arteries are distinctly seen. The shadow of the liver is homogeneous, while that of the spleen is mottled. The mottling is produced by flooding the venous sinuses of the splenic pulp with diodrast. A picture was taken 15 minutes later with the catheter left *in situ;* the liver and the spleen still cast a distinct shadow. When 4 c.c. of 75% diodrast were used, only the splenic vessels and a finer mottling of the splenic parenchyma were visible, while the liver shadow remained homogeneous.

Fig. 5 shows the arteriogram of the cœliac axis in a dog, the hepatic artery of which was ligated several months previously. After the injection of 5 c.c. of 75% diodrast no shadow is cast in the right hypochondrium. The arteries of the liver are obstructed at certain points. Dense dots indicate the stagnation of the contrast medium in the cul-de-sacs of the ligated arteries. A tortuous collateral artery anastomoses with the left gastric artery. A splenectomy was performed on the same dog and the splenic artery ligated accidentally with a heavy linen thread which produced suppuration and fistulization. The increased vascularity of this process is shown by sharply outlined arteries which course towards the foreign body and surround it with a dense vascular tangle. The autopsy report given by Dr. W. S. Hartroft confirms the greater vascularity of the fibrous tissue around the ligature. Similarly the other abdominal branches of the aorta can also be catheterized.

## RENAL ARTERIOGRAPHY

The interest in the radiography of the renal arteries arose shortly after Dos Santos published his method of direct aortography by translumbar puncture. Although the radiology of the kidneys was already a thoroughly investigated field, still urologists felt a need for new methods of visualization of the kidney. They were therefore among those who used aortography frequently. Quoting a report of 80 aortographies by Grady Waterson Reagan, Jr. and Grayson Carroll,[24] the value of abdominal arteriography from the urologists' viewpoint consists in making the differential diagnosis of renal masses possible: Hypernephroma, polycystic disease, solitary renal cysts, retroperitoneal tumours not arising from the kidney, ectopic kidney, anomalies and aneurysms of renal vessels can be discovered.

However, these and other authors (Smith, Rush and Evans;[25] Melick and associates[26]) mention the following hazards of aortography: too great quantities of a toxic contrast medium must be used; accidental puncture and injection of all the substance into the superior mesenteric artery

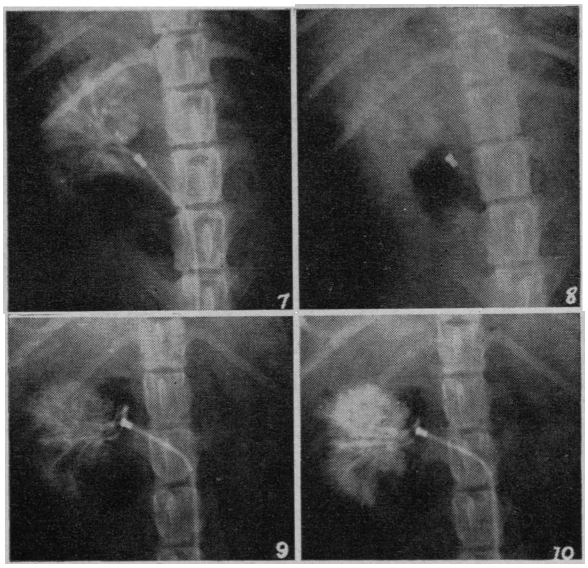


**Fig. 7.**—Normal arteriogram after catheterization and injection of 6 c.c. of 35% diodrast into the right renal artery. **Fig. 8.**—Radiography of the same kidney 10 minutes later. The metal cap in the renal artery proves that the catheter is still *in situ*. **Fig. 9.**—Renal arteriography of a kidney wrapped in cellophane 4 months previously (3 c.c. of 35% diodrast). **Fig. 10.**—Same kidney as in Fig. 9 after the injection of 6 c.c. of 35% diodrast.

producing thrombosis of the vessel and necrosis of the gut; translumbar aortography being a blind procedure, aortic intramural injection, perforation of an intraperitoneal viscus, pneumothorax, etc., may occur. The direct catheterization of the renal artery avoids these complications.

After the injection of 3 c.c. of 35% diodrast the ventral and dorsal set of arterial branches in the hilus of the kidney and the interlobar arteries delimiting the pyramids of the kidney show clearly (Fig. 6). After injection of 6 c.c. of 35% diodrast the arterial pattern becomes more distinct (Fig. 7). The shadowed cortical substance is now segmented by lighter areas of the medullary rays of Ferrein which contain less radio-opaque substance because they have a smaller vascular supply. The entire vascular pattern of the kidney is shown in all its details in these radiograms. Of interest is also a radiogram taken 10 minutes after the injection, the catheter being left *in situ* in the renal artery. Most of the radio-opaque substance was carried away, but there is still a good outline of the kidney as a whole and a vague picture of its vascular pattern has persisted (Fig. 8).

That the method of direct catheterization of the renal artery may reveal fine changes in the vascular architecture of the kidney is proved by the following radiograms. They show the renal arteriography of a kidney wrapped in cellophane after the method of Page, 4 months previously. After the injection of 3 c.c. of 35% diodrast the hilar branches of the renal artery especially the loops of their ventral and dorsal set are very conspicuous. Some of the interlobar arteries are already visible too (Fig. 9).

Another picture was taken after 6 c.c. were injected. The entire vascular pattern looks irregular. There is a vague outline of the renal pyramids by interlobar branches and only few and short interlobular branches appear. The vascularization of the renal cortex is poor and most of the radio-opaque substance is present in the juxta-medullary part of the kidney (Fig. 10). It looks as if the blood flow has shifted from the cortex to the medulla. A radiogram taken 1½ minutes after the start of the injection, shows a similar picture. The fine image of the hilar branches has disappeared but the radio-opaque substance is still present in the same parts of the kidney as described above.

## DISCUSSION

The radiography of the large abdominal veins is limited to visualization of the course and contours of these vessels, their eventual anomalies and displacements. This visualization was obtained by injection of a radio-opaque substance in current and by serial photography. The radiography of the hepatic veins we described enlarges the field of venography. It allows us to make visible the vascular pattern of an *abdominal parenchymatous organ* by guided catheterization of a side branch of the inferior vena cava and by injection of the contrast medium in refluence which will shadow and sharply outline the contours of the organ.

Theoretically it should be possible to obtain venograms of all organs that drain their blood into the inferior or superior vena cava (*e.g.*, the heart through the coronary sinus). At present we are experimenting on renal venography via the femoral or right external jugular vein and results will be given later.

In cases where a portal caval anastomosis is established, the portal vein has in fact become a side branch of the inferior vena cava and can be catheterized and injected via the saphenous vein.

No untoward effects on the catheterized veins were observed and this method does not present any greater risks than other methods of vascular catheterization do.

The radiography of the abdominal arteries has become a frequent procedure. Various methods were used to obtain good arterial radiograms. While on this continent a number of authors (Nelson,[27] Wagner and Price,[28] Goodwin and associates,[22] Melick and associates,[26] Smith and associates[25]) advocated abdominal aortography by direct translumbar puncture, a recent editorial[29] deals with the dangers of this procedure, which are manifold: danger of hæmorrhage from the aorta, especially in hypertensive cases or in those with pathological changes in the aortic wall.

Injection of a high dosage of the contrast medium is necessary to obtain its sufficient concentration in the aortic blood. Rapid injection of a toxic substance may produce apnœa, convulsions or death. Broman, Forssman and Olsson[30] in their experimental work have shown that brain damage may occur with cerebral angiography. Death after aortography where large doses of highly concentrated radio-opaque substance were rapidly injected may be explained by a similar mechanism, even when injection is carried out at a great distance from the brain.

The main hazard of translumbar aortography is the blindness of the procedure, which may lead to the puncture of an intra-abdominal viscus. Mesenteric thrombosis by injection of the contrast medium under pressure into the superior mesenteric artery may happen and be followed by necrosis of the gut. In dogs the translumbar aortic puncture is a disastrous procedure, as was demonstrated by Henline and Moore.[31] Out of 19 dogs, 5 dogs died from traumatic hæmorrhage and 3 from the toxicity of the drug.

The retrograde catheterization of the aorta and injection of a radio-opaque substance, introduced by P. L. Farinas in 1941,[14] tends to obviate these difficulties and to give to the radiologist, not familiar with the special translumbar technique, the benefit of aortography. However, in spite of many modifications reported by Radner,[15] Brodén et al.,[16, 17] Burford et al.,[19] Freeman et al.,[18] Converse Peirce,[20] Goodwin et al.,[22] Pearl et al.,[21] the retrograde technique has still its shortcomings. Many of these authors use vital arteries as a way of approach (as for instance, the carotid, which should not be touched) and have to face the complications following thrombosis of these vessels.

The amount of radio-opaque substance used cannot be effectively reduced in the retrograde method. The tip of the catheter can be seen under the screen with difficulty and therefore its position in relation to the aortic branch to be injected is only approximated. Thus not all the injected material will flow into the desired opening and some of it will still be carried away by the aortic flow. A high concentration of skiagraphic material is therefore necessary and it may produce toxic or cerebral phenomena. To avoid this massive flux of radio-opaque substance into the cerebral vessels or into another undesired organ, a "pilot injection" and "scout film" are considered necessary before injecting the total dose of contrast medium. In spite of these precautions, the pounding wave of the aortic pulse may kink, fold, coil or deviate the catheter into an undesired direction and make the procedure ineffective.

The retrograde catheterization of the aorta may be considered as a step to the ideal method which is the direct catheterization and injection of the artery to be investigated. Biermann, Miller and associates[23] have reported on this problem recently. However, the use of a Cournand catheter for the catheterization of an abdominal artery via the radial artery is a procedure that demands special skill and good luck. The catheterization of the abdominal artery through the right common carotid artery is easier but the danger of subsequent hemiplegia is too great (3 out of 23 cases) to accept it as a routine procedure. The catheterization of the abdominal arteries with a Cournand catheter through the femoral artery is, as stated by the same authors, hardly possible, "because of the obtuse angle and the distal lip such vessels have at the point of branching."

The guided catheterization of the abdominal arteries avoids most of the above difficulties. The heavy shadow cast by the metallic leader in the transflex tubing can be easily followed under the screen even with the red light on, which facilitates the manipulation of the catheter. The metal cap at the tip of the catheter gives a good view of how and when the catheter is sliding into an aortic side branch. As stated, its shadow detaches itself from that of the metal leader, migrates laterally and shares the respiratory rhythmical displacement of the intra-abdominal organ. It usually stays in the artery. When the catheter has slipped out (due to its insufficient introduction), the beating of the metal cap synchronously with the aortic pulse wave is observed. Having had only old x-ray equipment available for our experiments, our animals had to be transported after catheterization from the radioscopic to the radiographic table and still the catheter remained *in situ*. The latter table has neither a "rapidograph" nor a Potter-Bucky diaphragm. Nevertheless our arterial radiograms show a good detail of the entire vascular pattern of the organ although most of them have been obtained with a very small amount of radio-opaque substance (4 to 10 c.c. of 35% diodrast solution). The retrograde venography of the hepatic veins, however, requires a concentration of 70% diodrast.

SUMMARY

1. A method of guided catheterization of abdominal vessels is described.

2. The catheterization is carried out with a plastic catheter having inside it a metallic guide of which the end can be curved in various degrees and directions. The heavy shadow of this instrument allows a good orientation under the screen.

3. In dogs the femoral vein or artery mainly was used as a way of approach to the side branches of the inferior vena cava or abdominal aorta.

4. Good visualization of normal and abnormal vascular patterns in liver, spleen and kidney was obtained with small amounts of skiagraphic material.

5. The catheterization of both the arteries and the veins of abdominal organs can be used for physiological and pathophysiological studies of the function of these organs. It may also allow a direct therapeutic action by drugs, antibiotics, radioisotopes, etc., on the diseased organs.

It is a pleasure for me to express my sincere thanks to Dr. Best for his continued encouragement and interest. He has also provided the facilities for this work.

Many thanks to Mr. Walter Cowan of the Department of Surgery for his technical assistance in the radiographical work.

REFERENCES

1. FORSSMANN, W.: *Klin. Wchnschr.*, 8: 2085, 1929.
2. NEUHOF, H., SUSSMAN, M. L. AND NABATOFF, R. A.: *Surgery*, 25: 178, 1949.
3. COURNAND, R., RILEY, R. L., BREED, E. S., BALDWIN, E. DE F. AND RICHARDS, D. W. JR.: *J. Clin. Invest.*, 24: 106, 1945.
3.a BRADLEY, S. E., INGELFINGER, F. J., BRADLEY, G. P. AND CURRY, J. J.: *J. Clin. Invest.*, 24: 890, 1945.
4. SGALITZER, M., KOLLERT, V. AND DEMEL, R.: *Klin. Wchnschr.*, 10: 1659, 1931.
5. WOHLLEBEN, T.: *Klin. Wchnschr.*, 11: 1786, 1932.
6. DOS SANTOS, J. C.: *J. interm. de chir.*, 3: 625, 1938.
7. FARINAS, P. L.: *Am. J. Roentgenol.*, 58: 599, 1947.
8. O'LOUGHLIN, B. J.: *Am. J. Roentgenol.*, 58: 617, 1947.
9. MOORE, G. E. AND BRIDENBAUGH, R. B.: *Surgery*, 28: 827, 1950.
10. LEGER, L., GALLY, L., ARVAY, N., OUDOT, J. AND AUVERT, J.: *Presse méd.*, 59: 410, 1951.
11. RAPPAPORT, A. M.: *Acta Radiol.*, 36: 165, 1951.
12. SAITO, M. AND KAMIKAWA, K.: *Am. J. Surg.*, 17: 16, 1932.
13. FARINAS, P. L.: *Surgery*, 18: 244, 1945.
14. *Idem*: *Am. J. Roentgenol.*, 46: 641, 1941.
15. RADNER, S.: *Acta Radiol.*, 29: 178, 1948.
16. BRODÉN, B., HANSON, H. E. AND KARNELL, J.: *Acta Radiol.*, 29: 181, 1948.
17. BRODÉN, B., JÖNSSON, G. AND KARNELL, J.: *Acta Radiol.*, 34: 65, 1950.
18. FREEMAN, N. E. AND MILLAR, E. R.: *Ann. Int. Med.*, 30: 330, 1949.
19. BURFORD, T. H., CARSON, M. J. AND SCOTT, W. G.: *J. Thoracic Surg.*, 18: 860, 1949.
20. PEIRCE, E. C.: *Surg., Gynec. & Obst.*, 93: 56, 1951.
21. PEARL, F., GRAY, N. AND FRIEDMAN, B.: *Ann. Surg.*, 132: 959, 1950.
22. GOODWIN, W. E., SCARDINO, P. L. AND SCOTT, W. W.: *Ann. Surg.*, 132: 944, 1950.
23. BIERMANN, H. R., MILLER, E. L., BYRON, R. L. JR., DOD, K. S., KELLEY, K. H. AND BLACK, D. H.: *Am. J. Roentgenol.*, 66: 555, 1951.
24. REAGAN, G. W. JR. AND CARROLL, G.: *J. Urol.*, 66: 467, 1951.
25. SMITH, P. G., RUSH, T. W. AND EVANS, A. T.: *J. Urol.*, 65: 911, 1951.
26 MELICK, W. F., YARBROUGH, C. P. AND BOLER, T. D.: *J. Urol.*, 66: 458, 1951.
27. NELSON, O. A.: *Surg., Gynec. & Obst.*, 74: 655, 1942.
28. WAGNER, F. B. JR. AND PRICE, A. H.: *Surgery*, 27: 621, 1950.
29. Editorial: *Am. J. Roentgenol.*, 65: 280, 1951.
30. BROMAN, T., FORSSMAN, B. AND OLSSON, O.: *Acta Radiol.*, 34: 135, 1950.
31. HENLINE, R. B. AND MOORE, S. W.: *Am. J. Surg.*, 32: 222, 1936.

# THE SURGICAL TREATMENT OF CORONARY THROMBOSIS*

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IT IS DISAPPOINTING that in spite of the great amount of information provided by physicians and pathologists, the death rate from coronary thrombosis is still high and the disability from coronary sclerosis is still great. Aside from some palliative measures and symptomatic treatment, there is very little that can be done medically, except for the anticoagulant therapy suggested by the author[22] and now in fairly general use. There is no medical cure and aside from palliative measures, there is little to change the course, progress or end results of the disease. This gloomy prospect has stirred surgeons for more than a century to attempt methods of treatment to relieve the pain and disability and in more recent years, to make direct attempts at improving coronary circulation or curing the disease. It is obvious, of course, that this disease comes in the arteriosclerosis group, and the ultimate treatment will be prevention of the disease when the control of arteriosclerosis is attained.

The disease of angina pectoris and sudden death from heart disease, have been known for a great time, but the accurate correlation between the narrowing and sclerosis of the coronary arteries and the symptoms of angina pectoris or the sudden heart deaths from coronary failure, were described in 1912 by Herrick.[1] The first recorded surgical attempts to deal with the symptoms were by Francois-Franck[2] in 1899. He dissected the cervical sympathetic ganglia and thought perhaps that the symptoms of angina pectoris were relieved thereby. Jonnesco[3] went further in resection of the cervical sympathetic ganglia with improved results. At this time, however, Sir James McKenzie's[4] dictum that "it would be unfortunate if surgeons found an operation to relieve the pain of angina pectoris" delayed further attempts on heart surgery for at least a quarter of a century. This was based on his opinion that the pain was a danger signal which protected the patient from over-exerting his heart in the presence of diminished coronary flow. It has been shown subsequently that in spite of cutting off the pain tracks, the patient is left with warning signs, to which he can be educated, to accept as a safety danger signal. Mandl,[5] Swetlow[6] and White[7] blocked the stellate and second cervical ganglia, including the second, third, sometimes fourth sometimes fifth dorsal ganglia on one side and if the pain recurred, on the other side. This gave very satisfactory relief of angina pectoris but left the patient with possible anginal pain in the mandibular region, which pain could be relieved by injection of the inferior division of the trigeminal nerve. When the satisfactory desensitization in this fashion, of the heart has

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