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HEPATIC ARTERY CATHETERIZATION FOR LOCAL ORGAN PERFUSION IN MALIGNANT DISEASE

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In 1941, Farinas described a technique for the arteriographic examination of the abdominal aorta and its branches using a urethral catheter inserted into the femoral artery at Scarpa's triangle. His aim was to use the arterial system in the treatment of cancer of the abdominal organs. Dos Santos introduced abdominal aortography more than a decade before, using a blind aortic puncture technique that was then considered to be dangerous. In 1951, Bierman reported the use of intra-arterial catheterization of the abdominal viscera with a Courand catheter for the purposes of roentgenographic visualization, administration of chemotherapeutic agents in high concentration to specific organ neoplasms, and for pharmacological and physiological studies. He found the retrograde approach unsatisfactory because of the obtuse angle and distal lip such vessels have at the point of branching. In 1961, Byron reported his experience with left brachial artery catheterization for chemotherapy in abdominal neoplasms. He also used the catheter to administer whole blood and plasma, electrolytes, analgesics and nutritional adjuvants. He studied histamine and adrenalin effects on neoplastic arterial supply. A year later, Clarkson reported selective hepatic artery catheterization for chemotherapy of primary and secondary liver neoplasms. In 1963, Reed and Kuipers discussed disseminated carcinoid tumors and, in the same paper, related their experience with hepatic artery catheterization. Their cases are included in this report. In 1964, Sullivan reported a surgical approach, deeming it essential to ligate all associated vessels supplying extrahepatic tissue and desiring direct and fluorescent visualization of the metastatic process.

It is not the purpose of this paper to discuss the treatment of malignant disease, but rather to present our experience with hepatic artery placement utilizing the resources of the cardiac physiology laboratory and the skills of the cardiac catheterization team.

Cardiac Physiology Laboratory, Division of Cardiovascular Disease.
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MATERIALS

Sixty-eight patients were selected by our Oncology Division as suitable candidates for hepatic artery catheterization. Ages ranged from 13 to 75 with an average of 57 years. The sexes were equally distributed. In the majority of patients, the primary lesion was found in the gastrointestinal tract wall. Other primary lesions included carcinoma of the gall bladder, pancreas and adrenal gland, melanoma of the choroid, osteogenic sarcoma of the tibia and primary hepatoma. In one case the primary was not discovered. The physical status varied considerably, but generally, apart from their neoplastic disease, patients were felt to have a stable cardiovascular status.

METHOD

A new Number 7 or 8 Cournand catheter was used in all cases but one, the lone exception requiring a Bing catheter. It was filled with heparin solution and attached to a 10 cc. syringe by way of a stopcock. The catheter was introduced into the arterial system by cutdown, usually of the left brachial artery, three or four centimeters proximal to the antecubital crease. This site was chosen because the artery is easily available and because the collateral circulation is rich; also, it permits full flexibility at the elbow joint. Occasionally, the right brachial artery was used for re-insertion of a second or third catheter or for placement of the first if the left brachial had been sacrificed in earlier procedures.

The catheter was advanced up the brachial and the axillary arteries and then into the arch and descending aorta. In order to improve the maneuverability of the catheter and facilitate its manipulation into the descending aorta and into the celiac axis, the catheter was sterilized in a special mold to give it a temporary exaggerated distal curve. The distal ten centimeters of the catheter were fitted into a lucite mold as shown in Figure 1. After gas sterilization, the wrapped catheter was stored at atmospheric pressure for 24 hours before use to reduce chances of any toxic reaction. The catheter stiffened slightly during sterilization, taking on the shape of the mold. Occasionally, an additional terminal hook aided placement of the catheter tip in the appropriate branch of the celiac axis. Using this method, we were able to minimize catheter pressure on the arterial walls since the catheter became soft and pliable again as it warmed to body temperature.

Selective celiac catheterization was achieved by rotating the tip anteriorly, and, commencing at the level of the diaphragm, manipulating up and down within the abdominal aorta. External rotation changed the angle of the tip with each probe. It was usually not difficult to place the tip in a branch such as a renal artery, and this position was then identified by the injection of small puffs of contrast material. Using this method, the lower boundary of search could be easily established. Often, the tip would be placed in the celiac axis on the first try. Earlier placements were preceded by aortic arteriograms using a hand injection of contrast material through a National Institutes of Health catheter (Figure 2). As the operators gained experience, it was found that the specially curved catheter could be inserted directly using hand injections of contrast material to correctly identify vessels, and to selectively place the catheter. A fluoroscope with nine-inch image intensifier provided excellent visualization.

Normal anatomic variation in the hepatic artery origin was frequent, but by a system of trial and x-ray, the appropriate branch was catheterized. Hepatic malignancies and prior abdominal surgery also altered the regional vascular anatomy. The most difficult maneuver of the procedure was the manipulation of the catheter along the celiac artery and selectively into the main hepatic trunk. This sometimes involved moving the catheter through an arc of 180° or around a right-angled corner. This could be done with greater ease if the catheter were in use only a few minutes and still relatively stiff and maintaining the curve well. Once the catheter became soft and straightened, its maneuverability was considerably diminished. On one occasion, the above mentioned method was not successful, but with a Number 7 Bing catheter and Bing-Gadd deflector, the desired placement was obtained. The catheter designed for use with the Bing-Gadd deflector was not generally satisfactory for this use, because without the deflector it lacked sufficient body for manipulation, and with the deflector contrast material could not be injected with sufficient rapidity.

Patient assistance with various respiratory maneuvers, sniffing, and positional changes was of some help. When the location was felt to be acceptable as seen on fluoroscopy, it was rechecked with antero-posterior and lateral roentgenograms using injections of 5 to 10 cc. of contrast material and timing the exposure approximately two-thirds of the way through.
Figure 2
Anteroposterior and lateral views of abdominal aorta and its major branches.
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the injection. Generally, good position was felt to permit perfusion of the whole liver
without perfusing arterial branches to the bowel or pancreas; however, this was not always
possible and sometimes not desirable.

After catheter placement, the artery was ligated with 3-0 surgical silk just distal to the
arteriotomy and the catheter was anchored in place with silk through the skin edge and
around both catheter and vessel. The skin was closed about the catheter. During the
procedure, the catheter was flushed with heparin solution, 0.1 mgm./cc., at frequent and
regular intervals to prevent clotting. Upon completion of the procedure, the catheter was
attached to a Barron's constant-flow pump infusing the same solution. About 20 feet of
tubing between the patient and the pump permitted considerable mobility of the patient in
his room. On completion of a course of therapy, the patient was discharged with the catheter
in place and instructed to inject 50 mgm. heparin in 5 cc. saline every second day in order
to maintain catheter lumen patency. Catheters have been kept in place for periods varying
from one week to six months.

It was our hope to keep the procedure as simple and as brief as possible. Happily,
the shortest case required only 30 minutes from scrub to bandage, though the longest case
lasted several hours.

RESULTS

Sixty of the sixty-eight patients selected were successfully catheterized. Sixteen
had a second catheter inserted, seven a third and four a fourth, for a total of 87
successful placements. The usual indication for replacement was either a blocked
catheter or a displaced tip that could not be manipulated back into position. In six
instances, the catheter was repositioned by slightly advancing or withdrawing the
tube according to the need. These were minor adjustments and relatively simple
to perform.

Of the eight failures, five were attempted only once; three others were attempted
from both arms. In two of these, atherosclerotic changes in the subclavians prevented
advancement of the catheter into the arch. In a third, an obstruction was encountered
in the brachial artery. In three other cases, the celiac axis could not be found or
entered. One of these failures was possibly due to a chronic dissecting aortic aneurysm.
In another patient, the catheter was inserted into the celiac artery but, on advancing
it further, the tip moved into the gastroduodenal artery and could not be selectively
advanced into the common hepatic artery alone, beyond the origin of the gastro-
duodenal. At that time, this was felt to be unacceptable. The Bing-Gadd deflector
was used here without success. Finally, in one patient, the common hepatic artery
took its origin from the celiac trunk at such an acute angle that it was impossible
to advance the catheter tip into it, even using the Bing-Gadd deflector.

COMPLICATIONS

Complications were reported in 10 of the first 35 cases catheterized. Patient
23 complained of coolness of the left arm and mild mottling of the skin. As
the patient was relatively intolerant to the catheter, it was removed after one week.
He made no further complaints about the arm, although the brachial artery was
ligated. Patient 26 complained of one episode of coolness and numbness of the
involved arm after prolonged elevation of the extremity. He thereafter avoided
this position and the catheter remained in place for three months. Patient 4 developed
cyanosis of the left third and fourth fingers one month following catheter insertion.

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Figure 3
Hepatolienogastric trunk type with catheter in celiac axis beyond splenic artery origin.

Figure 4
Right and middle hepatic arteries arising from the superior mesenteric artery.
A stellate block was performed and anticoagulants and nicotinic acid administered. No further progression was reported. Case 16 developed severe arm pain two months after catheterization and was also treated with a stellate block. The left hand became cyanotic, most marked in the fifth digit and distal third of the fourth digit. During the following three weeks, obvious dry gangrene developed, involving the tips of the second, third, fourth and fifth fingers. The patient died of his neoplastic disease five weeks after the onset of arm pain. The gangrene was felt to be due to subclavian or axillary artery thrombosis. Case 19 developed a fever and chills and was treated at home with tetracycline. Though this was possibly a septicemia due to the catheter, which had been in place for 2½ months, it was more likely due to a left lower lobe pneumonia. Patient 24 developed cellulitis around the catheter entry site three weeks after catheterization. This developed into an abscess of penicillin-resistant Staphylococcus aureus and required treatment with Vancomycin.

Patient 29 pulled her catheter out at home and presented in the Emergency Room with uncontrolled hemorrhage. This was readily controlled with a small pressure dressing.

Figure 5

The gastroduodenal artery arises from the left hepatic which, in turn, arises from the celiac artery.
Figure 6
Spontaneous advance of a catheter left under moderate tension.
Patient 25 diaphoresed freely but did not complain of chest pain during two unsuccessful attempts at catheterization. The day following the second attempt she developed a fever of 104°F Fahrenheit, and became semicomatose. She expired on the third day. This patient was elderly, had inoperable disease and was undoubtedly a poor risk for catheterization. Cause of death was acute myocardial infarction, which may or may not have been related to the catheterization procedure.

Two months after catheter placement, thrombosis of the right hepatic artery was reported in Case 1. It was also noted that the contrast material injected pooled within the liver parenchyma suggesting erosion of the hepatic artery wall. A Bing-Gadd deflector was used in Case 28 to advance the catheter tip into the common hepatic artery. Pooling of contrast material here suggested a subintimal tear, although the catheter was repositioned and left in place without trouble.

**DISCUSSION**

We have selected a group of x-rays that point up the scope of this technique. Figure 2 demonstrates well the abdominal aorta using a hand-injected bolus of dye through a National Institutes of Health catheter. It shows the close proximity of the origins of the celiac, superior mesenteric and renal vessels. We had hoped to be able to group the anatomical variations according to Michel's classification, but as the technique became more refined we found it unnecessary to opacify so extensively, and so this endeavor was discarded. Most patients seemed, however, to fall into the hepatolienogastric trunk type as seen in Figure 3. In four patients, the right and middle hepatic arteries took their origin from the superior mesenteric, while the left hepatic arose from the celiac trunk. Figure 4 demonstrates the right and middle hepatic vessels arising from a common hepatic, which in turn arises from the superior mesenteric immediately distal to its origin. The companion film, Figure 5, shows the left hepatic originating from the celiac artery. Also of note in this film is the gastroduodenal artery, taking its origin from the left hepatic.

In one case the catheter could not be advanced within the common hepatic beyond the left gastric. By leaving it under increased tension for a period of 24 hours, it spontaneously advanced into the desired position. In Figure 6, the catheter tip lies in the common hepatic just proximal to the gastroduodenal artery. The catheter could not be advanced further and so it was left in this position under moderate tension. In the film taken the following day, it is readily seen that the catheter has spontaneously advanced into an excellent position for hepatic perfusion.

The vascular structures were frequently found to be displaced or otherwise distorted from the norm by the malignant process. Figure 7 demonstrates the displacement of the right hepatic artery inferiorly and the middle hepatic supermedially by a large tumor mass. We might also point out a very nicely shown gastro-epiploic in this film. The catheter was left in the common hepatic in a patient with pancreatic cancer and hepatic metastases (Figure 8), so that both the pancreas and the liver could be simultaneously perfused. It is true that some of the metabolite infused
Figure 7
A large hepatic mass displaces the normal vessels super- and infero-medially.

Figure 8
The pancreatic vessels have the beaded appearance associated with malignancy.
Figure 9

Before — Catheter in good position.
After — Catheter tip has eroded the wall of the common hepatic artery.
through this catheter perfused the duodenum. More recently, we have been less zealous of the need for completely excluding the intestinal arterial supply from perfusion. The beading of the vasculature in this film is highly suggestive of pancreatic malignancy.

Vascular trauma did occur. Two months after insertion of a catheter in our first case the catheter tip eroded the wall of the hepatic artery producing extravasation of contrast material into liver parenchyma. Figure 9 demonstrates the catheter's initial position and the extravasation of dye as seen two months later. In Figure 10 is seen a traumatic aneurysm of the left hepatic artery near its origin from the common hepatic.

As well as verifying the position of the catheters, films taken during these procedures suggested the further potentials of this procedure as a diagnostic as well as a therapeutic tool. Almost all of the major abdominal vessels are amenable to selective catheterization. We have put the catheter tip selectively in the gastroduodenal, hepatic branches, splenic, superior mesenteric, inferior mesenteric and renal arteries. It is possible to use the catheter to study arteriovascular integrity in any of these associated organs and to perfuse them using the indwelling catheter technique. The possibility of biopsy using a catheter biopsy instrument has yet to be fully pursued.

Figure 10
Traumatic aneurysm of the left hepatic artery.
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SUMMARY

A description of the technique of hepatic artery catheterization is presented. Sixty of sixty-eight patients were successfully catheterized. Complications are reviewed and other uses of the cardiac catheter briefly discussed. Some vascular variations are demonstrated.

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REFERENCES


