Selective abdominal angiography

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EDITORIAL SYNOPSIS This paper illustrates the value of carefully siting the tip of the intra-aortic catheter adjacent to the artery supplying the organ about which more information is required. Cancers in the liver were consistently identified correctly, and useful information has been obtained contributing to the diagnosis of pancreatic tumours, chronic pancreatitis, cirrhosis of the liver, cancer of the colon, and visceral vascular disease.

Angiography of the abdominal viscera can give diagnostic information in selected patients and the value of percutaneous splenoportography has been well established (Steiner, Sherlock, and Turner, 1957). The diagnostic usefulness of hepatic venography is currently being evaluated at this institution. This procedure has been shown to define diagnostic abnormalities in the presence of cirrhosis or tumour in the human liver (Schlant, Galambos, Shuford, Rawls, Winter, and Edwards, 1963). The hepatic artery has been visualized both by direct needle puncture during laparotomy and also by retrograde catheterization (Farinas, 1946). Ödman (1958, 1959) has shown that selective catheterization of the coeliac artery allowed the visualization not only of the hepatic arterial system but also that of the spleen, stomach, and of the pancreas.

Selective abdominal angiography recently became the subject of studies in several institutions (Boijesen, Ekman, and Olin, 1963; Acker, Galambos, and Weens, 1964; and Glenn, Evans, Halpern, and Thorbjarnarson, 1964). A preliminary report from this institution was based on 19 patients and it described six types of cases in which selective coeliac arteriography was of diagnostic value (Acker *et al.*, 1964). Selective abdominal angiography in the study of vascular diseases of the abdominal viscera was recently reviewed (Galambos, 1965). The present report describes the diagnostic value and the dangers of selective abdominal angiography in 44 studies, and 25 patients not previously described are reported.

TECHNIQUE

The patients were premedicated with hydroxyzine pamoate (Vistaril), 50 mg. intramuscularly, and meperi-

dine (Demerol), 75 mg. intravenously, just before the procedure. Local anaesthesia was used after routine skin preparation over the femoral artery. A flexible spring wire was inserted through a Cournand needle into the femoral artery, and it was passed under television image amplification control into the abdominal aorta. The Cournand needle was removed and a flexible Ödman-Ledin radiopaque polyethylene catheter with a pre-moulded tip was passed over the flexible spring guide wire. Great care was taken not to stretch the distal curvature on the catheter as it was placed on the guide wire and as it was passed through the skin into the arterial lumen. The catheter was advanced to the appropriate level in the aorta depending upon the artery which was to be catheterized. For the coeliac artery, for example, the catheter was advanced to the twelfth thoracic vertebra. The guide wire was gradually withdrawn, the tip of the catheter was rotated anteriorly and turned slightly to the left side and moved down until the tip entered the coeliac artery. On the anterior-posterior view, the orifice of the coeliac artery was usually between the twelfth thoracic and first lumbar vertebrae, the extremes ranging between the bodies of the twelfth thoracic and first lumbar vertebrae. Usually the catheter could not be passed more than 5 cm. into the arterial lumen. The movement of the radiopaque catheter during respiration was greater in the superior mesenteric artery than in the coeliac artery. During the manoeuvring of the catheter and between test injections, the catheter was frequently flushed with heparinized saline to prevent clotting. In order to ascertain the location of the catheter, test injections of 2 ml. diatrizoate sodium and methylglucamide (Renovist) were made repeatedly. Because of these injections a renal pyelogram was usually obtained before angiography.

After the test injections had confirmed the proper location of the catheter, the patient was placed in a supine position on a rapid film changer. Forty ml. of contrast material was injected in three seconds. Transient periumbilical pain was experienced by the patients during the few seconds of rapid injection, but no other side effects were attributable to the rapid injection. (Multiple side perforations in addition to the usual opening at the

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TABLE

SUMMARY OF 25 CASES IN PRESENT SERIES

Patient and Number	Age	Sex	Clinical History	Diagnosis	Angiographic Findings	Complications	Other Findings
1 H.J., C11137	77	M	Chronic alcoholic; weakness; anorexia; jaundice; large, hard, tender liver	Hepatoma	Abnormal vascular pattern of liver; tumour staining	None	H.Ph.S ¹ cold nodule in centre of liver
2 C.J., C50493	67	G	Asymptomatic; abdominal mass	Bile duct hamartoma (cyst)	Unsuccessful ^a	Haematoma	H.Ph.S. cold mass in liver
3 J.K., C163206	64	M	Weakness; anorexia; weight loss	Metastatic cancer to liver	Unsuccessful	None	Liver biopsy; metastatic adenocarcinoma
4 R.M., C64841	76	M	Loss of appetite; abdominal pain for three weeks; hepatomegaly	Bronchogenic carcinoma with liver metastasis	Tumour staining in liver; distortion of branches of hepatic arteries	None	Biopsy: metastatic carcinoma; H.Ph.S. normal
5 R.A., C125689	32	M	Abdominal pain; diarrhoea; diabetes and malabsorption	Chronic pancreatitis; malnutrition	Hepatic artery originates from the superior mesenteric artery; normal visualization of pancreas	None	Pancreatic calcification
6 J.S., C111934	64	M	Weakness; anorexia; hepatomegaly	Colonic carcinoma with metastasis to liver	Unsuccessful	None	Biopsy; metastatic adenocarcinoma
7 G.B., C159941	63	M	Vomiting; abdominal pain; hepatomegaly	Colonic carcinoma with metastasis to liver	Distortion and irregularities of finer branches of hepatic artery	None	Liver biopsy; adenocarcinoma
8 W.G., W77723	58	M	Chronic alcoholism; portal hypertension with bleeding oesophageal varices; hepatic coma	Cirrhosis	Distortion of third order branches of hepatic artery; opacification of portal vein	None	Liver biopsy; cirrhosis
9 M.E., C106201	75	F	Vague epigastric discomfort; weight loss; hepatomegaly	Adenocarcinoma of colon with liver metastasis	Displacement of coeliac axis and distortion of finer branches of hepatic artery	None	Liver biopsy; metastatic adenocarcinoma; H.Ph.S.; cold nodules
10 J.M., C133904	63	M	Increasing weakness; weight loss; anorexia; generalized abdominal pain	Gastric carcinoma	Normal coeliac angiogram	None	Biopsy: normal liver gastric cytology; papillary adenocarcinoma; laparotomy
11 A.G., C5556	37	F	Chronic alcoholic; abdominal pain; subtotal gastrectomy; pancreatic pseudocyst; cholecystectomy	Chronic relapsing pancreatitis	Abnormal arterial pattern	Arteriospasm of femoral artery	Pancreatic insufficiency by secretin test
12 J.B., W23223	46	M	Chronic alcoholic; epigastric pain	Subacute hepatic necrosis with post-necrotic cirrhosis	Mechanical failure of x-ray equipment	None	Liver biopsy; subacute hepatic necrosis with early cirrhosis

¹H.Ph.S. = Hepatic photoscan following Au¹⁹⁸ colloidal gold.^aUnsuccessful = Could not catheterize the coeliac artery.

tip of the catheter were essential to prevent the catheter from sliding out of the artery into the aorta during the rapid, forceful injection of the contrast material.) The frequency and duration of the exposures varied depending on the purpose of the study. When visualization of only the arterial system was required, 13 seconds total exposure time was adequate. On the other hand, exposures of up to 37 seconds have been used for the visualization of the portal circulation. In general, the exposures were two per second for three seconds, one per second for three additional seconds, and one every other second thereafter. The catheter was retained in its position until the films were developed and repeated injection either in the same artery or in another vessel was made when indicated.

PATIENTS

Nineteen patients were reported earlier (Acker *et al.*, 1964). Twenty-five additional patients are briefly described in Table I. Five of these patients had metastatic cancer to the liver, two had primary hepatoma with cirrhosis, four had cirrhosis of the liver, four had chronic pancreatitis with pancreatic insufficiency (one of these also had cirrhosis of the liver), one had pancreatic carcinoma and one had a retroperitoneal mass in the region of the pancreas, two had gastrointestinal bleeding, the source of which in one of these patients was undetermined, one had colonic cancer, one had a small gastric cancer, one had ulcerative colitis, one had a bile duct haematoma, and one had Cruveilhier-Baumgarten

TABLE continued
SUMMARY OF 25 CASES IN PRESENT SERIES

Patient and Number	Age	Sex	Clinical History	Diagnosis	Angiographic Findings	Complications	Other Findings
13 B.B., W22902	72	M	Epigastric pain; weight loss; reflux oesophagitis	Malabsorption due to chronic pancreatitis	Tortuosity of splenic artery; abnormal vascularization of pancreas	None	Normal liver biopsy; normal oesophagoscopy; abnormal fat absorption
14 G.W., C138371	34	M	Haematemesis; melaena	Gastrointestinal bleeding of undetermined cause	Normal coeliac arteriogram	None	Necropsy not permitted; uraemia
15 J.G., W55200	43	M	Chronic alcoholism; jaundice; epigastric pain	Upper gastrointestinal bleeding; gastric ulcer	Normal coeliac arteriogram	None	Liver biopsy; mild, non-specific changes
16 J.F., C12632	42	F	Chronic alcoholism; ascites; loss of weight; steatorrhoea	Cirrhosis; chronic pancreatitis; malabsorption	Normal coeliac arteriogram	Haematoma	Liver biopsy; septal cirrhosis
17 E.H., C10080	54	F	Epigastric pain; jaundice	Carcinoma of pancreas	Occlusion of hepatic artery and portal vein	None	Laparotomy and biopsy
18 V.P., W231239	54	F	Portal hypertension; splenectomy; spleno-renal shunt; ascites; hepatic coma; 'cirrhotic' nephropathy and morphologically normal liver. Large, patent umbilical vein	Portal hypertension of unknown aetiology	Distortion and tortuosity of branches of hepatic artery, normal portal vein; normal hepatic vein	None	Biopsy (3 occasions): normal liver; necropsy normal small liver, portal vein—umbilical vein anastomosis
19 J.T., C30717	59	M	Right flank pain; weight loss; massive hepatomegaly with systolic bruit	Hepatoma	Displacement of hepatic vessels by tumour	None	H.Ph.S.: cold nodules in right lobe of liver, biopsy: hepatoma
20 P.F., C55505	69	F	Pneumonia; hepatomegaly; anaemia; peri-umbilical mass	Carcinoma of colon (hepatic flexure)	Superior mesenteric angiogram; tumour staining	None	Biopsy; normal liver, H.Ph.S.: normal
21 J.B., W60317	50	M	Ten mth. history of diarrhoea; chronic ulcerative colitis	Active ulcerative colitis	Distortion of small vascular pattern of colon	Thrombosis of femoral artery	Ulcerative colitis (granulomatous) by biopsy
22 A.M., W63070	70	M	Cirrhosis with portal hypertension; hepatic coma precipitated by bleeding varices	Cirrhosis	Abnormally tortuous small hepatic arteries; increased capillary opacity at cholecystectomy site	Haematoma	Biopsy; cirrhosis
23 E.M., W16459	76	F	Postprandial abdominal pain, malabsorption, weight loss	Suspected abdominal angina	Dissecting aneurysm	?	
24 W.H., W32716		M	Periumbilical attacks of postprandial pain	Suspected mesenteric artery obstruction	Normal superior mesenteric angiogram	None	Large atheroma at orifice of superior mesenteric artery
25 C.D., C61266	64	M	Weight loss; abdominal pain; hepatomegaly; epigastric mass	Disseminated lympho-glandular tuberculosis	Displacement of pancreaticoduodenal artery	None	Laparotomy retroperitoneal mass of of caseating lymph nodes

disease. In two patients primary vascular disease was suspected before the study. One of these had thrombosis of a branch of the inferior mesenteric artery and one patient was suspected of having abdominal angina due to mesenteric artery occlusion.

RESULTS

To date we have performed 44 selective coeliac, superior or inferior mesenteric arteriographies. Nineteen of these coeliac angiograms were reported previously (Acker *et al.*, 1964). Twenty-five additional cases are described in this report. In four patients we have been unable to catheterize the artery of choice. In one case the examination was unsatis-

factory because of mechanical failure of the equipment. This compares with about 20% failures noted by Ödman (1958) who performed 61 examinations on 58 patients and was unable to enter the coeliac artery in 12 of these examinations.

Normal coeliac angiograms are illustrated in Figures 1, 2, and 3. During the arterial phase (Fig. 1), the splenic, the left gastric, and the common hepatic arteries were well outlined as they usually originated from the coeliac axis. The gastroduodenal and the right gastric arteries usually originated from the common hepatic artery. The left gastroepiploic artery usually came from the splenic artery, and it anastomosed with the right gastroepiploic artery which was a branch of the gastroduodenal artery.

FIG. 1a.

FIG. 1b.

FIG. 1. Normal coeliac angiogram; L. Hep = left hepatic artery; R. Hep = right hepatic artery; Hep. = hepatic artery; C.A. = coeliac axis; L.G. = left gastric artery; Cyst. = cystic artery; P.-D. = pancreatico-duodenal; R.G.-E. = right gastroepiploic; L.G.-E. = left gastroepiploic; Sp. = splenic.

The cystic artery or arteries came from the right hepatic or the superior pancreatico-duodenal artery, a branch of the gastroduodenal artery.

Variations of the origin of the major branches of these arteries were commonly seen. Often the hepatic artery originated from the superior mesentery

rather than from the coeliac axis. Anastomoses between the branches of the coeliac axis and the superior mesenteric artery were often prominent.

During the capillary phase (Fig. 2), the opacification of the mucosa of the stomach, gall bladder, duodenum, or intestine was readily apparent in

FIG. 2.

FIG. 2. Capillary phase of Figure 1. The rugal folds of the gastric mucosa are outlined in the area of the gastric air bubble. The fundus is densely opacified. The gall bladder is well defined and its uniformly thin normal wall is readily seen. The draining veins begin to opacify at this stage.

FIG. 3.

FIG. 3. The venous phase of Figure 1. The mucosal opacification has faded at this stage though the gastric fundus is still dense. The draining veins are filled now with contrast material. The splenic vein (↓) crosses behind the stomach and it is partially obscured by it. The portal vein (↓) is well outlined as it emerges in front of and to the right of the first lumbar vertebra. Its intrahepatic branches can be seen though they are obscured by the diffuse opacification of the liver. The gastroepiploic veins (→) are well outlined.

FIG. 4. Late venous phase in a normal superior mesenteric angiogram. The catheter is in the aorta with its curved distal 5 cm. in the superior mesenteric artery. The superior mesenteric and the portal veins are sharply outlined. The right lobe of the liver is densely opacified and the smooth, sharp and delicately wavy edge can be seen clearly. Below the liver the right kidney is faintly opacified.

some but not all cases. The appearance of the viscera at this stage resembled a very fine barium coating of its mucosa.

During the venous phase, the draining veins were opacified. At this stage the portal vein was well defined together with the splenic (Fig. 3) or the superior mesenteric vein (Fig. 4) during selective coeliac or superior mesenteric angiography, respectively. The portal vein usually was better opacified after selective superior mesenteric than coeliac angiography. The inferior mesenteric veins were well visualized after inferior selective mesenteric angiography.

ILLUSTRATIVE EXAMPLES

CASE 9 M.E., a 75-year-old coloured woman, was admitted to hospital because of weight loss, malaise, and increasing anorexia. She had nausea but no vomiting. About one year before admission her bowel habits changed and she developed severe constipation progressively. The liver was enlarged. A rounded, ill-defined mass was palpated in the right lobe of the liver. There was a systolic bruit over this area. The spleen was not palpable.

FIG. 5. Coeliac angiogram, demonstrating the displacement of the coeliac axis (↓) to the left and also displacement of the branches of the right hepatic artery. Hepatic arteries are attenuated. Tumour staining, that is, opacification of scattered areas, is seen (→). This apparently is because of the accumulation of contrast material in the numerous distorted small vessels which perfuse the tumour nodules.

No other abdominal masses were felt. A moderate amount of ascites was present. Barium enema demonstrated a suspicious lesion in the caecum. Coeliac angiography demonstrated the features of metastatic tumour in the liver (Fig. 5). A hepatic photoscan showed a large 'cold' nodule in the right lobe of the liver, and needle aspiration biopsy of the liver confirmed the presence of metastatic adenocarcinoma.

The characteristic features of vascular abnormalities caused by metastatic carcinoma in the liver were the distortion and displacement of small hepatic vessels, and 'tumour staining' due to opacification of the large number of tortuous small vessels in the tumour nodules.

CASE 2 A.G., a 37-year-old coloured woman, was a heavy consumer of various spirits. She had previously been admitted to hospital on several occasions because of chronic relapsing pancreatitis; for cholecystectomy and sphincterotomy; because of a pseudocyst of the pancreas which was drained into the stomach; and because of a bleeding gastric ulcer which was treated by subtotal gastrectomy. She was admitted on this occasion because of chronic pancreatitis and pancreatic insufficiency.

Physical examination revealed a malnourished woman with no additional significant physical abnormalities other than several healed operative incisions on her abdomen. Selective coeliac angiography was performed to study the vascular pattern of the pancreas in a patient with well-documented episodes of pancreatitis and previous gastric and biliary surgery (Figs. 6a and b).

FIG. 6a

FIG. 6b.

FIGS. 6a and b. *Superior mesenteric angiogram. The catheter is in the aorta with its tip in the superior mesenteric artery. The contrast material opacifies the branches of this artery without reflux into the aorta. The first major branch of the superior mesenteric artery is the hepatic artery which communicates via a large anastomotic vessel with the coeliac axis. This anastomotic vessel comes off the hepatic artery and follows the course of the gastroduodenal artery. Behind the hepatic artery this vessel joins a tortuous artery which follows the course of the pancreaticoduodenal artery and runs caudad along the right side of the vertebral column and divides into an abnormal arterial network. The normal pancreatic vessels are not seen. The coeliac axis and its two branches, the splenic artery and the ligated left gastric artery, are well visualized.*

This case illustrates an abnormal arterial grouping in the region of the head of the pancreas and non-visualization of the normal pancreatic vessels in a patient with recurrent pancreatitis. It also demonstrates the simultaneous opacification of the superior mesenteric and coeliac arterial branches through the large anastomotic gastroduodenal artery.

FIG. 7.

FIG. 7. *Coeliac angiogram. The coeliac axis is pushed to the left and the course of the gastroduodenal artery (←) is distorted, the hepatic artery is tortuous and is occluded (↑). There are several large anastomotic arteries from the splenic and left gastric to the hepatic artery and to some of its branches beyond the point of occlusion. (Subsequent exposures also demonstrated the occlusion of the portal vein without prominent collateral veins.)*

CASE 17 H.E., a 54-year-old coloured woman, was admitted to hospital because of vomiting, epigastric pain, weight loss, malaise, and jaundice. She had an enlarged, firm liver, but neither the gall bladder nor the spleen were enlarged. Serum bilirubin was 21 mg.% per 100 ml., and the alkaline phosphatase 40 Bodansky units, thymol turbidity 8.2 units. The serum albumin was 3.5 g. and total globulin 2.8 g. per 100 ml. Selective coeliac angiography was performed to identify the suspected carcinoma in the head of the pancreas (Fig. 7).

At exploratory laparotomy, a tumour mass was found in the head of the pancreas, and a transduodenal needle biopsy confirmed the diagnosis of adenocarcinoma. Vascular invasion was confirmed. A palliative cholecystojejunostomy was performed.

Displacement of the gastroduodenal artery is indicative of an enlargement of or a mass in the region of the head of the pancreas. Arterial and venous invasion of a pancreatic carcinoma can be demonstrated by this method. There was no evidence for any ischaemic liver injury despite the occlusion of both the hepatic artery and portal vein. Arterial blood perfused the liver, however. This was indicated by the delayed opacification of the branches of the right and left hepatic arteries. The absence of prominent venous collaterals suggests that the portal vein only recently was occluded.

CASE 25 D.C., a 64-year-old coloured man, was admitted because of epigastric pain, weight loss, and night sweats

FIG. 8. Coeliac angiogram. The catheter is in the aorta with its tip in the coeliac axis which divides into the splenic and hepatic arteries. The first major branch of the hepatic artery is the gastroduodenal artery which runs caudad to the right of the eleventh and twelfth thoracic vertebrae and divides into several branches just above the first lumbar vertebra (L1). One of these branches, the anterior pancreaticoduodenal artery (↖) is displaced to the right by a mass in the region of the head of the pancreas.

for four months. The anorexia and weight loss were marked. He complained of constant mid-abdominal pain. In the left supraclavicular fossa, a 3×3 cm. firm lymph node (Virchow's node) was found, and he also had a firm, fixed, painless epigastric mass. The haematocrit was 33%, serum albumin 2 g., and globulin 5.3 g. per 100 ml. The serum bilirubin was normal; bromsulphalein retention was 40% in 45 minutes, and alkaline phosphatase was 9.6 Bodansky units. The VDRL was positive. Gastrointestinal radiographs showed a mass which stretched the duodenum and displaced the stomach anteriorly. The coeliac angiogram indicated a mass in the region of the pancreas (Fig. 8). Biopsy of a supraclavicular node and of the liver revealed caseating granuloma with acid fast bacilli.

At laparotomy the 'pancreatic' mass proved to be a matted group of caseating retroperitoneal lymph nodes.

Displacement of the anterior pancreaticoduodenal artery is usually associated with pancreatic tumours, but also can be due to retroperitoneal lymphadenopathy.

CASE 20 P.F., a 69-year-old coloured woman, was admitted to hospital because of acute pneumonia. During routine physical examination the liver was palpated 3 cm.

FIG. 9. Superior mesenteric angiogram. The catheter is in the aorta and its distal 5 cm. is in the superior mesenteric artery. The first branch of this artery is the hepatic artery. The branches to the small intestine are coming off on the left crossing the radio-opaque catheter. The second major branch on the right is the right coeliac artery which supplies the hepatic flexure of the colon and gives off a large branch which anastomosed with the ileocolic artery (←→). The carcinoma of the colon overlies the lower pole of the right kidney. During the arterial phase the marked distortion of the arcuate branches is prominent near the cancer (↙).

FIG. 10. Closer view of Figure 9 during the late capillary phase demonstrating the intense tumour staining of the colonic cancer. (Dotted line describes the lower pole of the right kidney.) The draining veins begin to opacify (↘). Tumour staining in the area of regional lymph nodes is not observed. The renal pelvis and ureter are well outlined.

below the costal margin and a periumbilical mass was thought to be present. Her haematocrit was 36% and stool guaiacs were 4+. A barium enema showed a constricting lesion in the transverse colon close to the hepatic flexure. A mesenteric angiogram showed the vascular pattern of a colonic cancer (Figs. 9 and 10). Liver biopsy was not remarkable.

Selective catheterization of the superior mesenteric artery allowed the visualization of the distorted vascular pattern of cancer of the colon. At operation an adenocarcinoma of the colon was found in this region of the hepatic flexure. No metastasis was detectable. A curative resection of the tumour was performed.

CASE 23 E.M., a 76-year-old white woman, was studied because abdominal angina was suspected. Arteriography was attempted and the catheter was introduced into the abdominal aorta from both femoral arteries. Contrast material appeared each time in the aortic wall, demonstrating a dissecting aneurysm. Whether this lesion existed before the examination or was caused by the examination could not be determined with certainty.

DISCUSSION

The clinical use of selective abdominal angiography for the diagnosis of visceral diseases is still in its infancy, but selective catheterization of the major intra-abdominal branches of the aorta can be performed with safety and dispatch. The availability of new and non-irritating iodinated compounds permits the injection of large amounts of contrast material in the catheterized arteries with sufficient speed to visualize their branches and opacify the capillaries of the viscera which they supply as well as their venous drainage systems. Other than transient pain, no untoward reaction was observed after the repeated injections of sodium and methylglucamine (Renovist) totalling 100 ml. during a single examination.

The splenic artery is usually tortuous in patients with portal hypertension. However, we have found marked tortuosity of the splenic artery in patients with chronic pancreatitis in whom the spleen was not enlarged and liver function tests and liver biopsy showed no evidence of liver disease.

In the cirrhotic human liver post-mortem injection of contrast material in the portal or in the hepatic veins demonstrated abnormalities of hepatic venous pattern without significant abnormalities in the portal venous pattern (Galambos and Schlant, 1962), confirming previously reported observations that vascular abnormalities in the cirrhotic liver are confined primarily to the tributaries of the hepatic

vein (Schlant *et al.*, 1963). In this study the intrahepatic branches of the hepatic arterial system did not show a uniform pattern in the patients who had cirrhosis without hepatoma. Tortuosity and attenuation of the intrahepatic branches of the hepatic artery have been seen in some of these patients. The number of examinations of cirrhotic patients is not sufficient to give a reliable percentage figure. Tortuosity and attenuation of the intrahepatic branches of the hepatic artery were marked in one other patient with Cruveilhier-Baumgarten disease who had no morphological abnormality of the liver on three liver biopsies and at necropsy but had portal hypertension.

The visualization of the portal venous system in patients with portal hypertension may be of great clinical value. Many of the patients who would be candidates for percutaneous splenoportography cannot be examined either because of an increased bleeding tendency as a result of their liver disease, or because of previous splenectomy. In such patients it is possible to obtain delayed films after the injection of contrast material in the superior mesenteric artery or the coeliac axis in order to visualize the portal venous system. Selective splenic arteriography was recently shown to opacify adequately the portal vein (Pollard and Nebesar, 1964). The visualization of the portal vein through the splenic and superior mesenteric veins following the coeliac and superior mesenteric arteriography respectively is illustrated in Figures 3 and 4. In the latter case (Fig. 4), previous splenectomy and splenorenal anastomosis would have precluded percutaneous splenoportography.

Intrahepatic cancer has an arterial blood supply (Breedis and Young, 1949). Primary or metastatic carcinomas of the liver were consistently associated with distortion and tortuosity of the small hepatic arteries and showed increased vascularity in areas presumably containing tumour nodules. During the late capillary phase, the contrast material remained visible in small nodular areas giving rise to the descriptive term of 'tumour staining', which was not seen in the absence of intrahepatic cancer. Displacement of larger hepatic arterial branches was also associated with intrahepatic cancer.

Angiographic demonstration of an islet cell tumour and of a cystadenoma of the pancreas has been reported (Olsson, 1963; Swanson, 1963). Usually the gastroduodenal artery supplies the superior pancreaticoduodenal branch which divides into the inferior and posterior pancreaticoduodenal arteries. The corresponding inferior pancreaticoduodenal artery usually originates from the superior mesenteric artery; thus, a rich anastomosis exists between the coeliac axis and the superior mesenteric

artery in the pancreatic bed. A vascular arcade is formed between these arterial branches, and numerous interlobular arteries arise from it to form the intra-pancreatic plexus (Michels, 1955). Tumour of the pancreas is characterized by displacement of one or several of the arteries and/or veins which run close to the pancreas, and invasion of arteries or veins by tumour of the pancreas was observed in case 17 (Fig. 7). Displacement of the gastroduodenal or pancreaticoduodenal artery may be due to pancreatic tumour; however, a mass of caseating retroperitoneal lymph nodes did likewise; therefore, such displacement, however characteristic, is not pathognomonic of pancreatic cancer.

The distorted vascular pattern of a colonic cancer was documented in case 20 during superior mesenteric angiography (Figs. 9 and 10). Such a distortion of the vascular pattern has been described by Margulis and Heinbecker (1961). There was increase in the number of tortuous small vessels in the area of the tumour, branching usually at right angles instead of at the usual acute angles. There was also destruction of the normal vascular arcades in the tumour. Tumour staining was also observed in this colonic carcinoma. This term described the persistent opacification of the area of the tumour after the capillary phase faded in the normal, uninvolved colon.

In a few cases mesenteric arteriography has been performed in patients with ulcerative colitis, either just before colectomy or after the removal of the colon. Brown, Rankin, Meaney, and Turnbull (1964) found no specific vascular abnormalities in ulcerative colitis during selective mesenteric angiography. Margulis and Heinbecker (1961), on the other hand, observed tortuosity of the smaller vessels during pre-operative mesenteric angiography or on direct injection of the artery of surgical specimens. We have observed such distortion of the normal arcades supplying the rectosigmoid and sigmoid colon in a patient with chronic ulcerative colitis (case 2) on a selective inferior mesenteric angiogram.

Mesenteric arterial occlusion either by embolus or thrombosis can be demonstrated with selective angiography. However, the selective superior mesenteric angiogram appeared normal in a patient in whom a lateral aortogram demonstrated narrowing of the orifice of the superior mesenteric artery (Galambos, 1965). At surgery a large atheromatous plaque occluded partially the first 2 cm. of the lumen of the superior mesenteric artery. Selective arteriography cannot outline the most proximal portion of the artery in which the catheter is inserted but narrowing of the arterial orifice can best be documented by placing the catheter in the aorta just proximal to

the arterial orifice during the rapid injection of contrast material and making lateral exposures.

It has been claimed that selective intra-abdominal angiography is capable of localizing gastrointestinal bleeding sites (Margulis, Heinbecker, and Bernard, 1960), which have been observed by Baum, Nusbaum, Clearfield, and Tumer (1964) in patients with the Mallory-Weiss syndrome, bleeding gastric ulcer, and incomplete rupture of the spleen. In our study the bleeding site has not been identified with selective coeliac angiography in the two patients who were examined because of gastrointestinal bleeding. One of the patients had a gastric ulcer, but no demonstrable gastrointestinal pathology was found on radiological and endoscopic examinations of the other. In some patients intense mucosal opacification was seen in the gastric fundus, antrum, small intestine, and/or gall bladder. The physiological mechanism responsible for these findings in some but not in most of our patients is currently under investigation.

DANGEROUS SIDE EFFECTS OF THE PROCEDURE

The equipment must be examined carefully before it is used for selective angiography. Guides and catheters must be repeatedly autoclaved. We found it preferable to discard these after a few examinations in order to avoid their breaking in the aorta and the necessity for subsequent surgical exploration to remove fragments of guide or catheter. Such accidents did not occur during the examination of the 44 patients who are reported in this paper, but have been observed by others.

In selected patients selective intra-abdominal angiography may give valuable information. The performance of this procedure, however, must not be taken lightly as femoral artery thrombosis occurred twice in these 44 patients. Though it might be a coincidence, both of these patients had ulcerative colitis. One of these patients had intermittent claudication and decreased femoral arterial pulsation before the angiography, and despite two operative interventions, gangrene of the foot ensued. In the second case thrombectomy was successful in re-establishing normal femoral blood flow. Bleeding from the arterial puncture site can occur after the procedure and haematomata formed in three patients. The pain that was produced by the rapid injection of contrast material in the catheterized artery was transient and persisted no more than a few seconds. There was no untoward reaction attributable to the injection of large amounts of contrast material.

SUMMARY

Selective abdominal angiography has been performed

in 44 patients, in several of them giving more than one arterial injection. Thrombosis of the femoral artery occurred in two patients and haematoma developed in three. The artery could not be entered in four and the examination was unsatisfactory because of mechanical failure of the equipment in one case.

This procedure was well tolerated by clinically ill patients. Cancers in the liver were consistently identified correctly. The procedure has demonstrated mass formation in the pancreas, distorted arterial pattern associated with chronic pancreatitis, with cancer of the colon and with cirrhosis of the liver, and primary vascular lesions of the abdominal viscera. During the venous phase the mesenteric or splenic and portal veins were satisfactorily visualized. Patients with decreased or absent femoral pulsation should not be candidates for this procedure.

Since the completion of this manuscript, Nebesar, Pollard, Edmunds, and McKhann (1964) reported their experience with selective abdominal angiography which was similar to that reported in this communication.

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