Diagnostic Value of Omental Arteriography
The Significance of Dilatation and Proliferation of Omental Vessels

Takashi Kishikawa
Department of Radiology, Faculty of Medicine, Kyushu University

Research Code No. 599
Key Words: Angiography, Omentum, Omental artery, Omental diseases

大網動脈造影の診断的価値
— 大網血管の拡張・増生の意義について —

九州大学医学部放射線科学教室
岸　川　　高

（昭和53年10月30日受付）

正常100例，異常84例の大網動脈造影所見をもとに，大網動脈造影の大網病変における診断的価値について検討した．

正常100例の腹腔・上腸間膜動脈造影について，大網動・静脈の内径，走行，分岐様式を検討し，分類した．大網動脈は小数の分枝を有し，滑らかな曲線を描きながら，ゆるやかに先細りしていた．両側胃大網動脈からの分岐様式は，(1) 大網の外側部に左・右2本の大きな大網動脈を有するもの（52%），(2) 大網の左側にのみ1本の大きな大網動脈を有するもの（18%），(3) 比較的大きな数本の大網動脈を有するもの（15%），(4) 大網の中央部にのみ1本の大きな大網動脈を有するもの（10%），(5) 大網の右側にのみ大きな大網動脈を有するもの（5%）の5型に分類された．大網動脈の最大内径は0.4−1.7mmの間にあり，平均値は1.1±0.3mmであった．大網静脈の描出は見られなかった．

病変を有する84例について，その血管造影像を分析した．大網血管のびまん性の拡張・増生を来したものは，びまん性大網腫瘍〔中皮腫，偽粘液腫，悪性腫瘍の腹膜播腫〕，汎発性腹膜炎，大網動脈側副血行路を伴う血管閉塞性疾患で，大網のほぼ全域に拡張・増生が認められた．悪性腫瘍では大多数に血管増生がみられ，約半数に血管壁の不整が認められた．限局性の拡張・増生を示したものは，結節状の原発性・転移性の悪性腫瘍，限局性腹膜炎，膿瘍，黄色肉芽腫，大網ヘルニアで，このうち悪性腫瘍では全例に血管壁の不整，一部に動静脈短絡が認められた．

大網血管の拡張・増生は大網病変の存在を強く示唆する所見であり，血管壁の不整と動静脈短絡は，悪性腫瘍に特有な所見であった．大網動脈造影は大網病変の存在及び質的診断に有用な検査法であると考える．

The omental or epiploic arteries are small vessels in the greater omentum, which are nearly always visualized on routine celiac or superior mesenteric arteriography. Arteriographically, these vessels occasionally dilate and increase in number in diseases of the abdominal viscera. However, despite the frequent use of arteriography in recent years, the arteriographic manifestations of omental lesions have rarely been documented (1–4), and the clinical implications of dilatation and proliferation of omental vessels have not been well understood. This study established criteria for judging dilatation and proliferation of omental vessels as pathological, and criteria for evaluating their diagnostic significance in diseases affecting the greater omentum.

Materials and Methods

The consecutive celiac and superior mesenteric arteriograms of one hundred normal subjects were scrutinized for the courses, patterns and widths of their omental arteries and veins. There were 62 males and 38 females averaging 53 years of age, whose arteriograms were normal and who had no definite evidence of pathology in the abdominal viscera (Table 1). Most of them were examined because of a questionable defect on liver scintigraphy or because of unexplained abdominal pain. The celiac and superior mesenteric arteriograms of seventy-three patients with omental lesions were also reviewed (Table 2). These were performed in the Kyushu University Hospital from 1968 through 1977. All diagnoses were confirmed; sixty-three at autopsy or surgery; and ten, clinically. Three of the latter had generalized peritonitis; seven, peritoneal dissemination. There were eleven additional cases with omental vessel dilatation on arteriography which were collected from five-hundred consecutive cases with the diseases of the abdominal viscera other than of the greater omentum. All of these had vascular occlusive processes in the abdomen. Their dilated omental vessels appeared as collateral channels (Table 2).

Table 1. Age Distribution of 100 Normal Subjects and Mean Widths of Dominant Omental Arteries

Age	Number of Subjects (Male, Female)	Mean Width (mm) (Male, Female)
21–30	7 (4, 3)	1.0 (0.9, 1.0)
31–40	11 (7, 4)	1.2 (1.4, 1.2)
41–50	19 (11, 8)	1.1 (1.1, 1.1)
51–60	26 (16, 10)	1.2 (1.2, 1.2)
61–70	29 (19, 10)	1.1 (1.1, 1.1)
71–80	8 (5, 3)	1.1 (1.1, 1.1)
Total	100 (62, 38)	1.1*(1.1, 1.1)

*Standard Deviation ±0.3, Range 0.4–1.7 mm

For each arteriogram, 40–60 ml 76% Urografin (diatrizoate) were injected via a transfemoral catheter using a pressure injector (Gidlund). The pressure was 3.5–4.0 kg/cm²—approximately equal to an injection rate of 10–15 ml/sec. The focus—film distance was 100 cm. Exposures were made using an AOT film changer at 2 per second for two seconds, 1 per second for three seconds, and 1 per every two seconds for fourteen seconds.

Table 2. Case Material

I. 73 Cases with Omental Lesions

Inflammatory Lesions	
Generalized peritonitis	5
Localized peritonitis	2
Abscess	3
Other Benign Lesions	
Xanthogranuloma	1
Fat necrosis	1
Postoperative abdominal wall hernia	1
Neoplastic Lesions	
Sarcoma	3
Mesothelioma	1
Pseudomyxoma peritonei	3
Metastasis	38*
Direct invasion of neighbouring malignant tumor	15

*32 were diffuse and 6 were nodular.

II. 11 Cases with Omental Vessel Dilatation as Collaterals

Arterial Collaterals	
Splenic artery ligation for portal hypertension	1
Splenectomy for portal hypertension	1
Venous Collaterals	
Pancreatitis with pseudocyst	2
Gastric cancer (extensive)	3
Pancreatic cancer (body and/or tail)	4

Results

A) Omental Vessels in Arteriograms of 100 Normal Subjects

The omental arteries were opacified on celiac and superior mesenteric arteriography during the late arterial to early venous phases. Normally these arteries are smooth, and their courses are slightly curved, and they taper gradually and have few branches. There were five distinct normal branching patterns. Fifty-two of 100 subjects had dominant right and left omental arteries, eighteen had a dominant left omental artery, fifteen had multiple omental arteries without dominance, ten had a dominant "middle" omental artery, and five had a dominant right omental artery (Table 3). The width of each dominant omental artery when measured at a point 1 cm distal to its origin, ranged from 0.4 to 1.7 mm, with a mean of 1.1 mm and a standard deviation of 0.3 (Table 1).

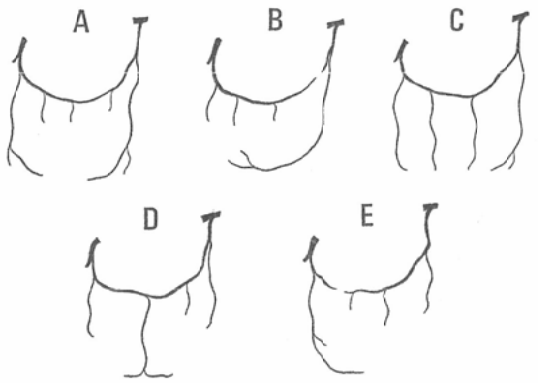
The omental veins parallel the omental arteries and drain into the gastroepiploic vein (5), but they were not opacified on the routine celiac or superior mesenteric arteriograms of these normal subjects.

B) Omental Vessels in Arteriograms of 84 Cases with Pathological Conditions

The inflammatory omental lesions of ten cases included five with generalized peritonitis, two of whom had tuberculosis; two with localized peritonitis following cholecystitis; and three with omental abscesses—two following acute pancreatitis, one following tuberculosis. The sixty with omental neoplasms included three with primary omental sarcomas; six with nodular omental metastases;

Table 3. Frequencies and Sketches of Five Branching Patterns of Omental Arteries

Patterns	Subjects Total (Male, Female)
A. Dominant right and left	52 (32, 20)
B. Dominant left	18 (13, 5)
C. Multiple, without dominance	15 (9, 6)
D. Dominant "middle"	10 (6, 4)
E. Dominant right	5 (2, 3)
Total	100 (62, 38)



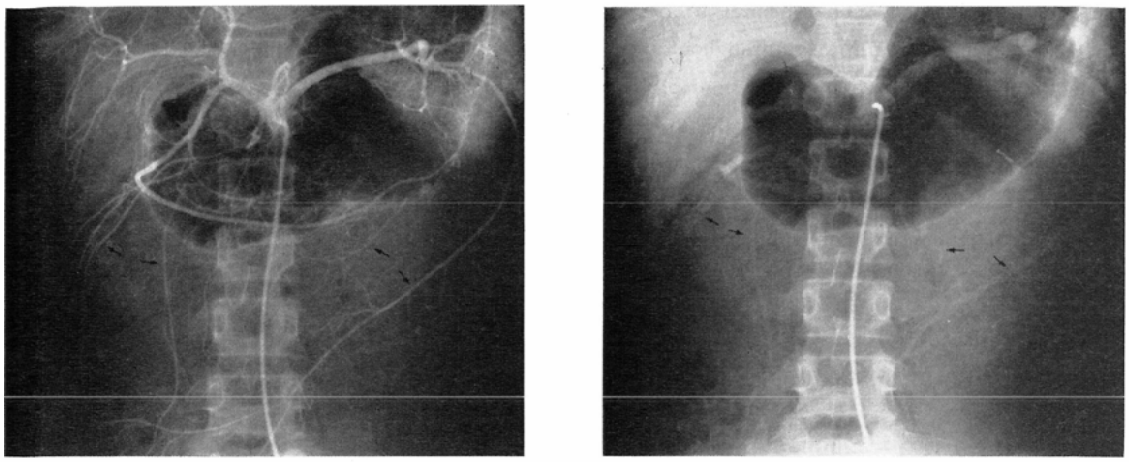
thirty-six with primary and secondary neoplasms diffusely involving the greater omentum, such as mesothelioma, pseudomyxoma, peritoneal dissemination from various sources; and fifteen with direct omental invasion, each from a malignant tumor in the abdominal viscera. The author also encountered one each case of omental xanthogranuloma, omental fat necrosis and postoperative omental hernia. Among these, sixty-four exhibited dilatation and/or proliferation of omental vessels arteriographically.

1. Inflammatory and Other Benign Omental Lesions (Table 4)

The omental arteries and veins of ten patients with inflammatory omental lesions were dilated

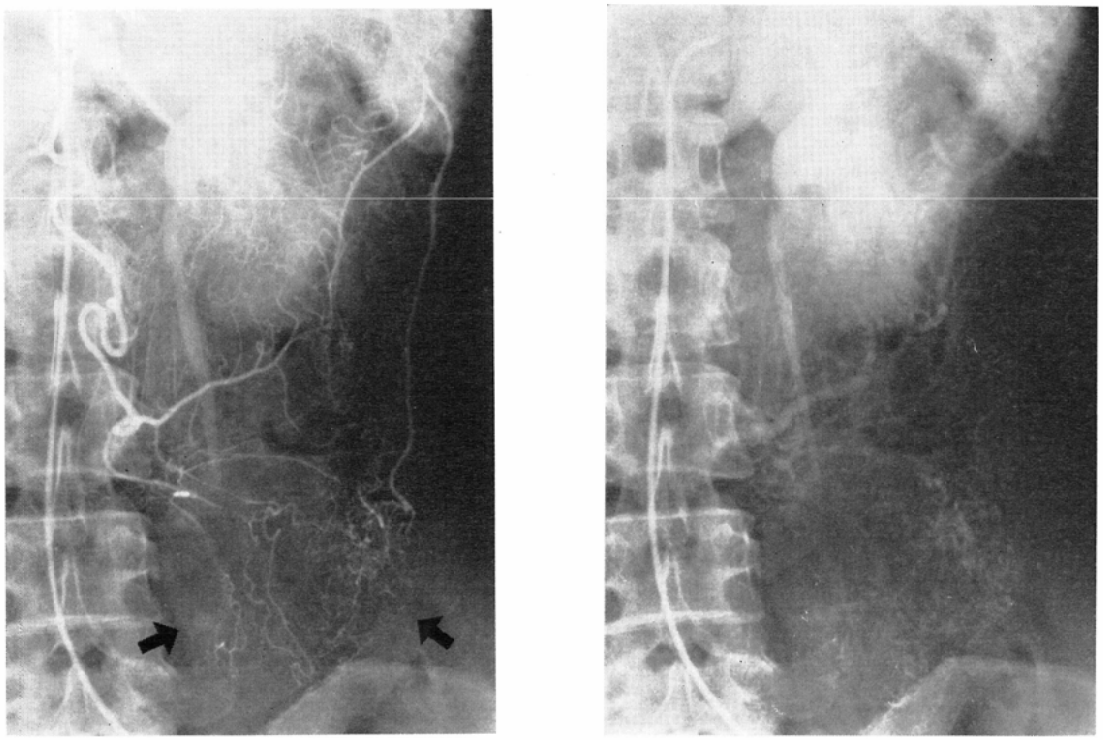
Table 4. Omental Arteriography in Benign Omental Lesions

Diagnosis	Number of Cases	Number of Positive Cases				
		Arterial Dilatation	Neovascularity	Vascular Irregularity	Staining	A-V Shunting
Generalized peritonitis	5	5	5 (diffuse)	0	3	0
Localized peritonitis	2	2	2 (local)	0	2	0
Abscess	3	3	3 (local)	0	3	0
Xanthogranuloma	1	1	1 (local)	1	0	0
Fat necrosis	1	0	0	0	0	0
Abdominal wall hernia	1	1	1 (local)	0	1	0
Total	13	12	12	1	9	0



A B

Fig. 1. A 14-year-old female with tuberculous peritonitis.
A. Celiac arteriogram, arterial phase, shows generalized dilatation and proliferation of omental arteries (arrows).
B. Venous phase shows dilated omental veins (arrows).



A B

Fig. 2. A 32-year-old female with tuberculous omental abscess.
A. Celiac arteriogram, arterial phase, shows localized dilatation and proliferation of omental arteries in the left side of the abdomen (arrows).
B. Venous phase shows faint staining, and localized dilatation and proliferation of omental veins.

and had proliferated. The omental arteries of all patients with generalized peritonitis had increased in size and number diffusely throughout the greater omentum (Fig. 1). Their omental veins were also dilated. Localized dilatation and proliferation of omental arteries were observed in all patients with localized peritonitis and omental abscesses (Fig. 2). Slight staining and dilated draining veins were also present. There was no irregularity of the vessel walls.

There was slight localized proliferation of the omental arteries with some irregularity of their walls in a patient with omental xanthogranuloma (Fig. 3). In a case of postoperative abdominal

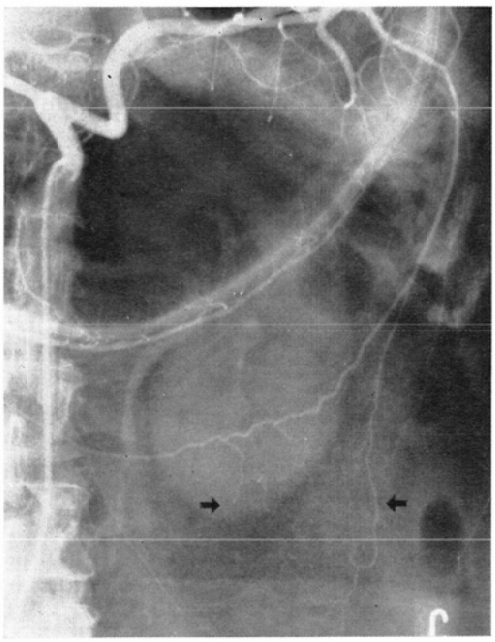


Fig. 3. A 40-year-old male with omental xanthogranuloma. Celiac arteriogram, arterial phase, shows the slightly dilated left omental artery and its branches, more localized at the lower left, with some vessel wall irregularity (arrows).

wall hernia of the greater omentum in the ileocecal region, arteriography demonstrated the omental arteries converging on the herniated site, as well as their local proliferation. The author encountered a patient whose proven omental fat necrosis produced a palpable abdominal mass, but arteriography revealed no vascular dilatation or proliferation of omental vessels.

2. Neoplastic Omental Lesions

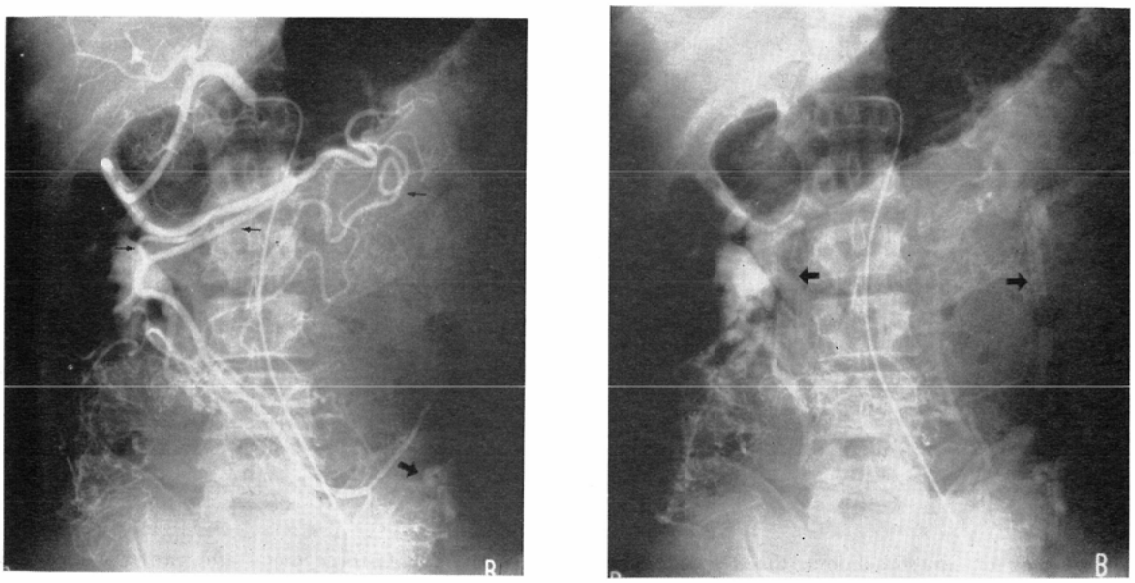
Fifty-two of sixty patients with neoplastic omental lesions had dilatation and/or proliferation of their omental arteries and veins.

Primary omental sarcomas (Table 5): These included a leiomyosarcoma, a fibrosarcoma and an unclassified sarcoma. All produced large nodular abdominal masses. Prominent irregular tumor vessels and tumor stains fed by dilated omental arteries were observed in all three patients (Fig. 4). Arteriovenous shunting occurred in two of them.

Table 5. Omental Arteriography in Malignant Omental Tumors

Diagnosis	Number of Cases	Number of Positive Cases				
		Arterial Dilatation	Neovascularity	Vascular Irregularity	Staining	A-V Shunting
Sarcoma	3	3	3 (local)	3	3	2
Nodular metastasis	6*	6	6 (local)	6	5	1
Invasion from neighbouring malignant tumor	15	13	15 (local)	14	13	0
Total	24	22	24	23	21	3

*2 were multiple



A B

Fig. 4. A 35-year-old male with omental leiomyosarcoma.

A. Common hepatic arteriogram, arterial phase, shows enlarged omental arteries (small arrows) supplying a huge abdominal mass. Note the prominent tumor vessels and early venous drainage in the lower portion (large arrow).

B. Parenchymal to venous phase shows patchy tumor stains and numerous veins draining into markedly dilated right and left omental veins (arrows).

Nodular omental metastases (Table 5): In six patients with nodular metastases in the greater omentum, arteriography demonstrated localized dilatation and proliferation of omental arteries and veins (Fig. 5). The primary tumors were gastric cancer in three, pancreatic cancer in two and colonic cancer in one patient. Irregular tumor vessels were evident in all and tumor stains, in five. Two had multiple metastases. There was arteriovenous shunting in the case with metastatic colonic cancer.

Neoplasms diffusely involving the greater omentum (Table 6): There were thirty-six patients,

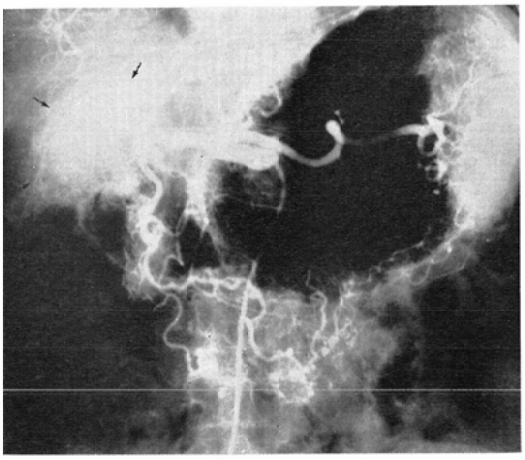


Fig. 5. A 74-year-old female with nodular omental metastasis from colonic cancer. Celiac arteriogram, arterial phase, shows tumor vessels fed by several dilated omental arteries near the greater curvature of the stomach. Note metastasis in the liver hilum (arrows).

Table 6. Omental Arteriography in Diffuse Omental Neoplasms

Diagnosis	Number of Cases	Number of Positive Cases				
		Arterial Dilatation	Neovascularity	Vascular Irregularity	Staining	A-V Shunting
Mesothelioma	1	1	1 (diffuse)	0	1	0
Pseudomyxoma	3	3	3 (diffuse)	3	1	0
Diffuse metastasis	32	19	24 (diffuse)	15	17	0
Total	36	23	28	18	19	0

including one mesothelioma, three pseudomyxoma peritonei, twenty-three metastatic gastric cancers, four metastatic pancreatic cancers, two malignant lymphomas, and one each metastasis from cancer of the gall bladder, duodenal papilla and an unknown primary. Twenty-eight cases had generalized dilatation and/or proliferation of omental vessels (Fig. 6). Irregularity of the vessels and diffuse stains were seen in eighteen and nineteen patients, respectively (Fig. 7, 8). Eight cases with peritoneal dissemination had neither dilatation nor proliferation of omental vessels.

Direct omental invasion from neighbouring malignant tumors (Table 5): Dilatation and/or proliferation of omental arteries were observed in fifteen patients with direct omental invasion, including ten with gastric cancer and one each with malignant ovarian teratoma, colonic cancer, pancreatic cancer, gastric leiomyosarcoma and a hepatoma. All but one had irregular vessel walls, and thirteen had tumor stains at the invasion site (Fig. 9). In all patients, arteriography demonstrated the blood supply from the arteries of a primary organ.

3. Dilatation of Collateral Omental Vessels

Only two patients had dilatation of the omental arteries, apparently functioning as collateral

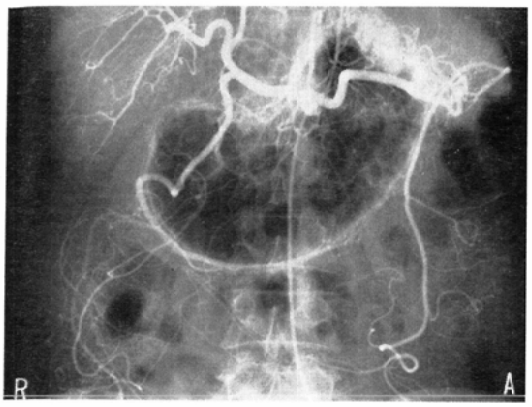


Fig. 6. A 43-year-old male with peritoneal mesothelioma. Celiac arteriogram, arterial phase, shows dilatation and diffuse proliferation of omental arteries in the greater omentum. No definite irregularity of the vessel walls is seen.

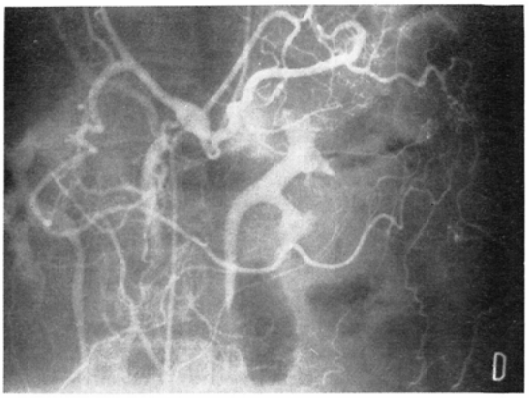


Fig. 7. A 67-year-old male with pseudomyxoma peritonei. Celiac arteriogram, arterial phase, demonstrates dilatation and proliferation of omental arteries diffusely in the greater omentum. Irregularity of the arterial walls is evident.

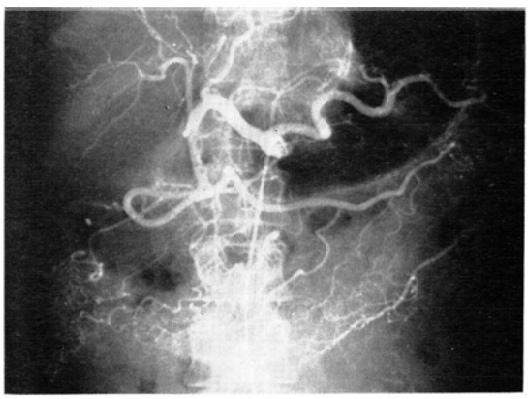


Fig. 8. A 52-year-old male with peritoneal dissemination of cancer of the pancreas. Celiac arteriogram, arterial phase, shows generalized dilatation and proliferation of omental arteries. Note some wall irregularity in the small peripheral branches.

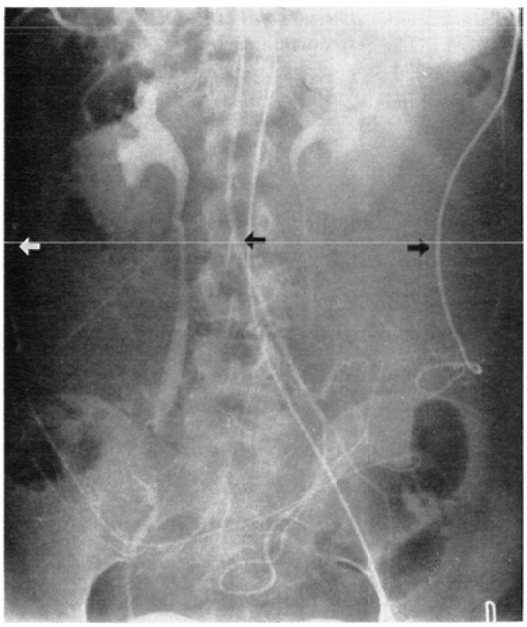
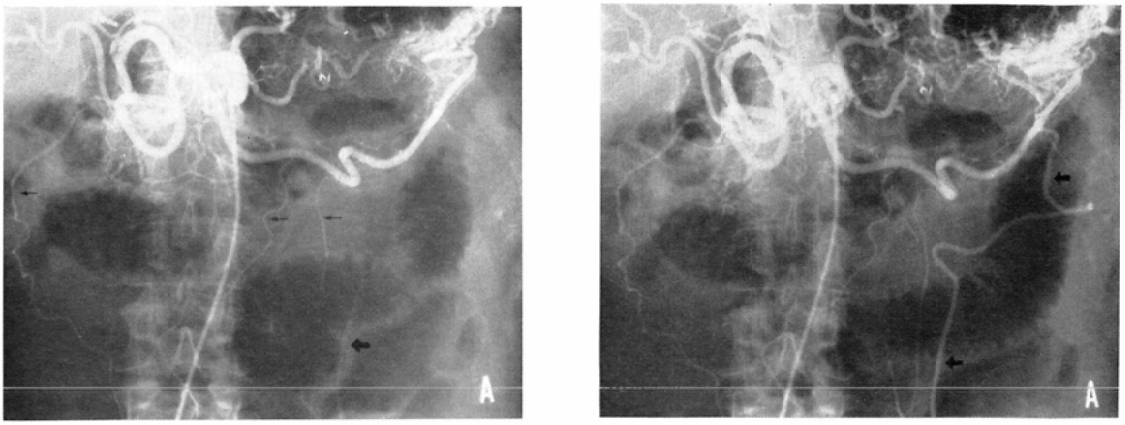


Fig. 9. An 18-year-old female with left malignant ovarian teratoma with omental invasion. Celiac arteriogram, arterial phase, of the lower portion of the abdomen. Dilated omental arteries (arrows) supply the lower portion of a huge abdominal mass. Note irregular vessels in its central portion. An abdominal aortogram (not shown) demonstrated enlarged left ovarian and uterine arteries as the main feeders supplying this mass.



A　　B

Fig. 10. A 51-year-old male with portal hypertension who had undergone ligation of the splenic artery. There was no dilatation of omental arteries on the preoperative celiac arteriograms.
A. Celiac arteriogram one month after surgery. Arterial phase demonstrates occlusion of the splenic artery and collateral flow to the spleen via the left gastric and right gastroepiploic arteries. The omental arteries, arising from the right gastroepiploic arteries, are dilated (small arrows). The left omental artery is faintly visualized in a retrograde manner (large arrow).
B. Later arterial phase. The dilated left omental artery functions as a collateral to the spleen and is well-opacified (arrows).

channels. One had collaterals to the spleen; the other, to the left side of the omentum. Both had undergone ligation of the splenic artery or splenectomy for palliative treatment of portal hypertension, and reverse flow in the left omental artery occurred in all of them (Fig. 10).

Nine patients were encountered with omental venous dilatation as collaterals. Two had acute pancreatitis, each with a large pseudocyst in the left upper quadrant, producing splenic vein obstruction and compression of the gastroepiploic vein. Arteriography revealed marked dilatation of the left omental vein as the main collateral in each (Fig. 11). Three cases had extensive gastric cancer with invasion of the splenic and/or gastroepiploic veins, with the moderately dilated left omental vein as a minor collateral. Four had cancer in the body and/or tail of the pancreas with invasion of the splenic and/or gastroepiploic veins, producing dilatation of the omental veins as a major collateral in one and minor collaterals in three.

Discussion

The greater omentum is supplied by multiple arteries arising from the right and left gastroepiploic arteries. According to classic descriptions (5,6), the right and left omental arteries near the lateral margins of the greater omentum are usually larger than the others. They course downward around the free margin of the greater omentum and anastomose with each other, forming "the Arc of Barkow". This branching pattern of omental arteries occurs in approximately half of all persons. The remainder has four distinct patterns; by order of frequency, (1) a dominant left omental artery,

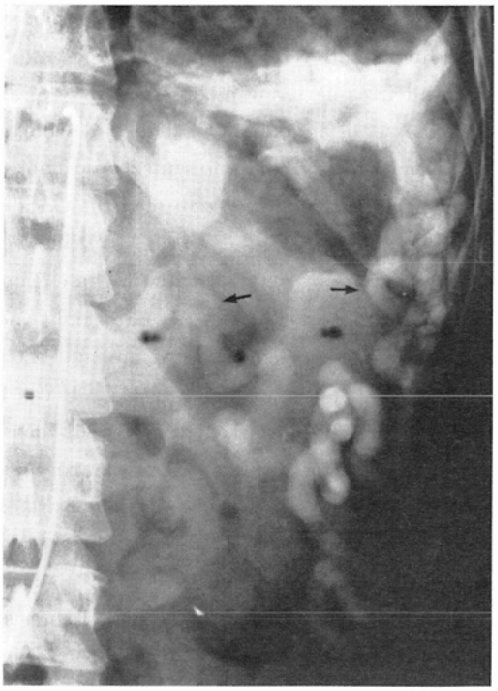


Fig. 11. A 31-year-old female with acute pancreatitis and a large pseudocyst in the left upper quadrant. Celiac arteriogram, venous phase, demonstrates the tortuous dilated left omental vein emptying into the gastroepiploic vein (arrows) as a main collateral to the portal vein. The splenic vein is not visualized.

(2) multiple omental arteries, none of them dominant, (3) a dominant "middle" omental artery, and (4) a dominant right omental artery. Recognition of these branching patterns of omental arteries is mandatory for the arteriographic evaluation of omental lesions. Since the greater omentum may have only one dominant or multiple, equal-sized omental arteries, the entire gastroepiploic arteries should be opacified even when the lesion is localized in one side of the abdomen. If the unilateral gastroepiploic artery is opacified, the dominant omental artery or main feeder to the lesion may not be visualized.

The omental artery is regarded as probably dilated when its diameter exceeds 1.4 mm; and definitely dilated, when it exceeds 1.7 mm. An even more reliable sign of pathology is an increase in the number of omental vessels—neovascularity—even if the diameter of the omental artery is within normal limits. If there is dilatation and/or proliferation of omental vessels arteriographically, one must consider it pathological.

The greater omentum is commonly affected in generalized peritonitis caused by microorganisms or chemical agents and during the spread of inflammation from abdominal organs. Acute pancreatitis caused by leakage of pancreatic juice commonly results in inflammatory changes in the greater omentum. On arteriography, diffuse omental inflammation produce generalized dilatation

and proliferation of omental vessels, as exemplified in the cases reported here. Tortuosity without irregularity of the walls of the arteries and veins is common. Slight dilatation and proliferation of omental arteries without vessel wall irregularity were observed in several cases not included in this study, who had laparotomies for diseases of abdominal viscera, and who had no symptoms referable to an omental lesion. The author assumed these cases represented mild chronic postsurgical inflammatory changes in the greater omentum. The present study confirmed that localized peritonitis and abscesses cause localized dilatation and proliferation of omental vessels (1,2), but no irregularity of vessel walls.

Benign tumors of the greater omentum are very rare, and include leiomyomas, lipomas, hemangiopericytomas, neurofibromas and lymphangiomas (4,7). To date, only one case of arteriographically-visualized cystic lymphangioma has been reported. Dilated omental arteries supplied several round, poorly vascularized masses with marginal stains, in that case (4). It can be assumed that leiomyomas and hemangiopericytomas appear as richly vascularized tumors with dense tumor stains, supplied by dilated omental arteries. Xanthogranuloma, which is not a true neoplasm, produces localized neovascularity with slight irregularity of its vessels. This was demonstrated in this study.

Primary malignant tumors arising from the greater omentum are also very rare. They include leiomyosarcomas, fibrosarcomas, malignant hemangiopericytomas, malignant myxomas and mesotheliomas (7). Documentation of the arteriographic manifestations of these tumors is sparse. Only two fibrosarcomas have been reported in the literature. Those reported by Deutsch et al. (3) were hypovascular masses with slight dilatation and proliferation of omental arteries. Stretching and bifurcation at right angles were also noted. Contrary to reported findings, all present cases of leiomyosarcoma, fibrosarcoma and unclassified sarcoma were richly vascular, with prominent tumor vessels and stains. Arteriovenous shunting occurred in two of these patients.

Mesothelioma and pseudomyxoma peritonei, which usually involve the peritoneum diffusely, may have the generalized dilatation and proliferation of omental vessels, as reported here. Vascular wall irregularity occurred in the cases of pseudomyxoma peritonei, but not in the mesothelioma case.

Omental metastases may be either nodular or diffuse. The latter is termed peritoneal dissemination. In nodular omental metastases, arteriography may demonstrate single or multiple vascular nodules, usually with tumor vessels and stains supplied by dilated omental arteries (8). Peritoneal dissemination may produce generalized dilatation and proliferation of omental vessels, not infrequently with vessel wall irregularity and diffuse stains, as demonstrated here. Some may not exhibit any vascularity or irregularity of vessels (3, 9). Among the cases in the present study with peritoneal dissemination, neovascularity was observed in two thirds; irregularity of vascular walls, in approximately one-half.

Malignant tumors of the abdominal viscera—especially cancers of the stomach and colon, and, to a lesser extent, malignant tumors of the liver and ovaries—may invade the greater omentum. In these instances arteriography usually shows tumor vessels supplied by dilated omental arteries, occasionally with tumor stains at the sites of invasion as demonstrated here.

In herniation of the omentum through the abdominal wall, the omental arteries converge toward the herniated site and proliferate locally, probably due to associated inflammation, as in the present case. In herniation of the omentum through a diaphragmatic defect, the omental arteries are shown in the

thorax, arteriographically.

The greater omentum often migrates in an attempt to "wall off" an affected abdominal organ. Here, arteriography demonstrates the omental arteries converging toward the involved organ (3). The author observed several cases of liver cirrhosis with massive ascites, in whom arteriography demonstrated author the omental arteries, without dilatation or proliferation, converging on the liver.

The omental arteries and veins are reportedly potential visceral collaterals connecting both sides of the abdomen (5). However, the author feels that these vessels infrequently function as collateral pathways, even in abdominal vascular occlusive diseases. Omental collaterals develop in obstructive processes of large vessels, usually in the splenic and gastroepiploic arteries or veins. In such instances, the omental vessels are tortuous and dilated, and there is reversal of flow in the left, and perhaps the right, omental artery or vein. In the cases reported here, there were multiple arterial, but only one or two venous, collaterals.

Differential Diagnosis

Omental lesions producing localized dilatation and proliferation of omental vessels include localized peritonitis, abscesses, granulomas, hernias, benign tumors, primary malignant tumors and nodular metastatic tumors. Localized peritonitis, abscesses, hernias and benign tumors may only display tortuous dilated vessels without irregularity of vascular walls, while primary malignant and nodular metastatic tumors usually produce such irregularity and tumor stains, occasionally with arteriovenous shunting. Deutsch's cases of fibrosarcoma did not show definite irregularity of vessel walls (3); however, a benign xanthogranuloma reported here did have such irregularity, making differentiation difficult. Usually, localized peritonitis and abscesses are accompanied by signs and symptoms of an abdominal infection, but benign tumors are not. Avascular masses with marginal stains supplied by dilated omental arteries suggest benign cystic tumors of the greater omentum (4). Omental hernias may be diagnosed with relative ease; arteriography reveals the abnormally located omental arteries or their convergence on the herniated site. Sometimes it is difficult to differentiate primary from metastatic omental tumors. Multiple tumor nodules suggest metastases; whereas, a large solitary mass suggests a primary tumor (7).

Omental lesions producing diffuse dilatation and proliferation of omental vessels include generalized peritonitis and neoplasms diffusely involving the greater omentum, such as mesotheliomas, pseudomyxoma peritonei and various metastases. Irregularity of vessel walls is a relatively common finding in neoplasms, but not in inflammations. However, no definite vascular wall irregularity was evident in approximately half of the cases with diffuse neoplasms reported here. In such instances, differentiation of inflammatory from neoplastic processes was difficult arteriographically, though the latter had more prominent vascular tortuosity. Collaterals of arteries in the greater omentum may show generalized dilatation, mimicking a diffuse omental lesion. In the former, however, there are occlusive processes in the large arteries, and there is reversal of flow in the omental artery.

In the direct invasion of the greater omentum by malignant tumors, the tumor vessels may be supplied by dilated omental arteries, similar to those of primary malignant or nodular metastatic tumors. When the primary site is obvious by other radiological means, or arteriography reveals the main blood supply of the primary tumor from the arteries of an organ, this differentiation is feasible. The differentia-

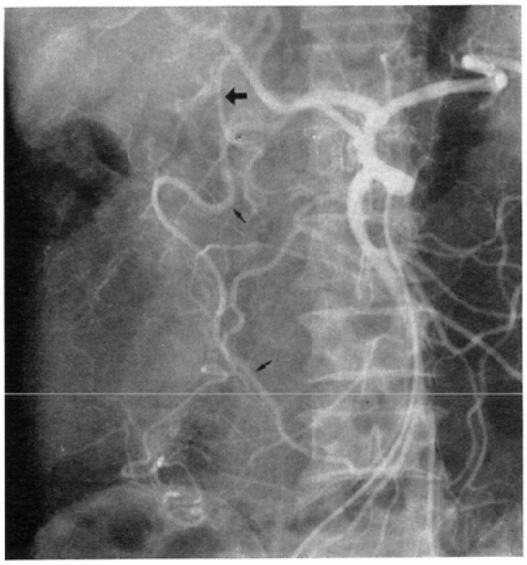


Fig. 12. A 73-year-old male with hepatoma of the left lobe of the liver, producing exophytic growth to form a mass in the right side of the abdomen and invading the greater omentum. Celiac arteriogram, arterial phase, demonstrates a relatively vascular mass supplied by the left hepatic artery (large arrow) and numerous omental branches arising from the right gastroepiploic artery (small arrows).

tion is sometimes difficult, as in the present case of hepatoma with exophytic growth and invasion of the greater omentum (Fig. 12).

Fibromuscular dysplasia is a rare lesion which produces morphological changes in the omental arteries, and displays characteristic alternate narrowing and dilatation of them, termed a "beaded appearance" (3).

Conclusion

1. Normally the omental arteries are smooth, slightly curved and gradually tapering, and they have few branches. Five distinct branching patterns of the omental arteries include; (1) dominant right and left omental arteries, (2) a dominant left omental artery, (3) multiple omental arteries without dominance, (4) a dominant "middle" omental artery, and (5) a dominant right omental artery. Dilatation of the omental artery is probable when its diameter exceeds 1.4 mm, and definite when it exceeds 1.7 mm.

2. Dilatation and/or proliferation of omental vessels strongly suggests the presence of a pathological process in the greater omentum. These include; (1) those exhibiting generalized dilatation and proliferation of omental vessels; generalized peritonitis, neoplasms diffusely involving the greater omentum and omental collaterals in vascular occlusive diseases; and (2) localized abnormalities of vessels in localized inflammatory or other benign omental lesions and primary or secondary nodular omental tumors.

3. Irregularity of vascular walls and arteriovenous shunting are, with few exceptions, suggestive of any malignant nature.

Thus, omental arteriography is of considerable value in the clinical assessment of diseases affecting the greater omentum.

Acknowledgments: I am grateful to Keiichi Matsuura, M.D., Chairman of the Department of Radiology, Kyushu University, for his invaluable suggestions, and to Walter J. Russell, M.D., Chief of the Department of Radiology, Radiation Effects Research Foundation, Hiroshima, for reviewing and editing the manuscript. I also wish to thank Yuji Numaguchi, M.D., Makoto Takahashi, M.D., Yoshiki Tsukamoto, M.D., and Jun Ikeda, M.D., for their suggestions and encouragement, and Mrs. Tomiko Miyachi and Mrs. Yoko Sakai for their secretarial assistance.

References

1) Benkö, G.: Das angiographische Bild des entzündlichen Netztumors und anderer Prozesse des Netzes. Rontgen-BL. 24: 289—292, 1974
2) Chudáček, Z. und Kohoutek, V.: Zum arteriographischen Bild der entzündlichen Infiltrate im Omentum maius. Fortschr. Geb. Röntgenstrahlen 106: 468—469, 1967
3) Deutsch, V., Adar, R. and Mozes, M.: Angiography of the greater omentum. Am. J. Roentgenol. 113: 174—180, 1971
4) Jacobsson, B., Mellgren, G. and Reuterskiöld, G.: Angiography of omental cysts in a child. Acta Radiol. (Diag) 17: 573—576, 1976
5) Ruzicka, F.F. and Rossi, P.: Normal vascular anatomy of the abdominal viscera. Radiol. Clin. N. Amer. 8: 3—29, 1970
6) Gray, H.: Anatomy of the Human Body. 29th American Edition (edited by C.M. Goss). pp 632—635, 1973, Len & Febiger, Philadelphia
7) Stout, A.P., Hendry, J. and Purdie, F.J.: Primary solid tumors of the great omentum. Cancer 16: 231—243, 1963
8) Reuter, S.R. and Redman, H.C.: Gastrointestinal Angiography. pp 107—110, 1972, W.B. Saunders, Philadelphia • London • Toronto
9) Wenz, W.: Abdominal Angiography. pp 104—105, 1974, Springer-Verlag, Berlin • Heidelberg • New York