

Usefulness of Combined Selective Arteriography and Hypotonic Duodenography in Evaluation of Cancer of the Pancreas

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ALTHOUGH various methods have been developed for the diagnosis of malignancy of the pancreas, there yet remain some instances in which an accurate diagnosis cannot be made. Among the several current approaches, radiologic procedures are in greatest use. However, no one method alone can satisfactorily delineate the accurate extent of the lesion in the pancreas. Selective arteriography and hypotonic duodenography have its own merit respectively, but each of them has admittedly limited accuracy in visualizing the detailed pathology of the pancreas. Selective arteriography fails to demonstrate clearly most lesions in the ampulla of Vater and duodenum, and hypotonic duodenography cannot reveal tumors which extend directly into the pancreatic parenchyma. Hitherto, each procedure has been performed separately, but the relative position of the duodenum and the arteries shows extremely wide variations, which make it difficult to evaluate the pathologic state accurately, when the roentgenograms are taken separately.

In this study, selective arteriography and hypotonic duodenography were projected simultaneously on the same film for the purpose of detailed delineation of lesions in the pancreas. Furthermore, the anatomic relationship between the duodenal loop and the arteries of the pancreas was investigated, and the significance of the additional information gained by this combined roentgenography was explored in connection with indications for operation.

Materials and Method

Combined selective arteriography and hypotonic duodenography was performed in 36 patients, 14 of whom had diseases of the pancreas.

With the patient fasting, the duodenal tube was introduced into the second portion of the duodenum under television fluoroscopy. In some cases, the tube was manually controlled with a flexible guide wire. With the tube fixed in this part of the duodenum, the patient was placed in the prone position. Ten ml. of 2% Xylocaine solution was infused through the tube for anesthesia of the anterior surface of the duodenal mucosa. With the tube still in place, the patient was turned to the supine position, and simple angiography of the upper abdominal arteries was performed by the Seldinger method² with the transfemoral approach. Under local anesthesia, a Kifa yellow catheter with a J-shaped tip was inserted into the celiac trunk and then into the superior mesenteric artery. These arteries were visualized in seriographs with 20–40 ml. of 66.8% iothalamate sodium (Conray 400). After arteriography, the catheter was kept in the orifice of the celiac trunk, an anti-cholinergic drug was injected intramuscularly or intravenously and about 10 ml. of 2% Xylocaine was infused through the duodenal tube in order to produce duodenal hypotonia. Then, about 50 ml. of 60% barium sulphate was infused after 10–20 minutes,

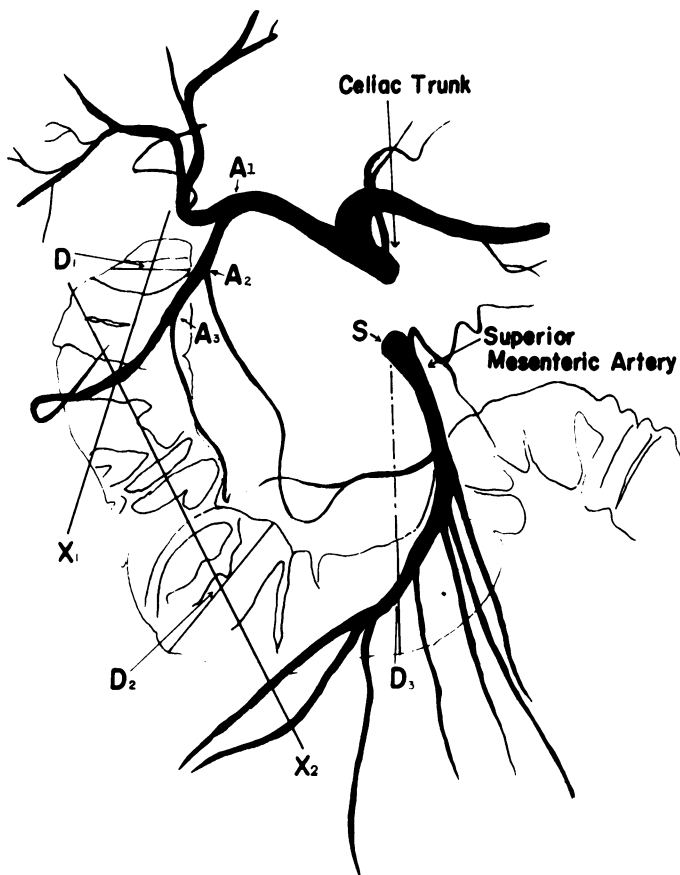


FIG. 1. Schematic presentation of several points relating to the duodenum and the arteries of the pancreas.

during which the routine arteriograms could be developed and read. Four serial films were taken on the filling phase of the duodenum. Then, the barium was evacuated, and further serial films were taken on the phases of evacuation and insufflation. During insufflation, when the duodenum was semi-opacified and visualized in double contrast, angiography of the celiac trunk and then the superior mesenteric artery was superimposed with the catheter remaining in the artery. Usually the right oblique projection was added to the anteroposterior projection. These procedures should be carried out before the duodenum recovers its tonicity.

In a preliminary study, combined arteriography and duodenography were performed on specimens surgically resected by pancreatoduodenectomy: four specimens of cancer of the head of the pancreas and two of cancer of the ampulla of Vater. Immediately after resection, the catheter was inserted into the gastroduodenal artery of the specimen, and the vascular bed was irrigated with physiologic saline solution. A solution of 60% barium sulphate was infused through the catheter by hand pressure. Similarly, the digestive tract of the specimen was washed, and barium and air were infused into the duodenum from the resected stump of the stomach.

Duodenograms combined with arteriograms of the resected specimens were taken on the phases of filling, evacuation and insufflation, as was observed in living patients.

Correlation of Position of Duodenal Loop and Arteries of the Pancreas

The head of the pancreas is surrounded by the three parts of the duodenum. Roentgenologically, direct visualization of the duodenum can be obtained by hypotonic duodenography, and that of the pancreas by selective arteriography of the celiac trunk and superior mesenteric artery. With the object to clarify the anatomic relationship between the duodenal loop and the arteries of the pancreas, the following investigation was carried out.

In 22 patients in whom the pancreas was surgically confirmed to be normal, several distances between the

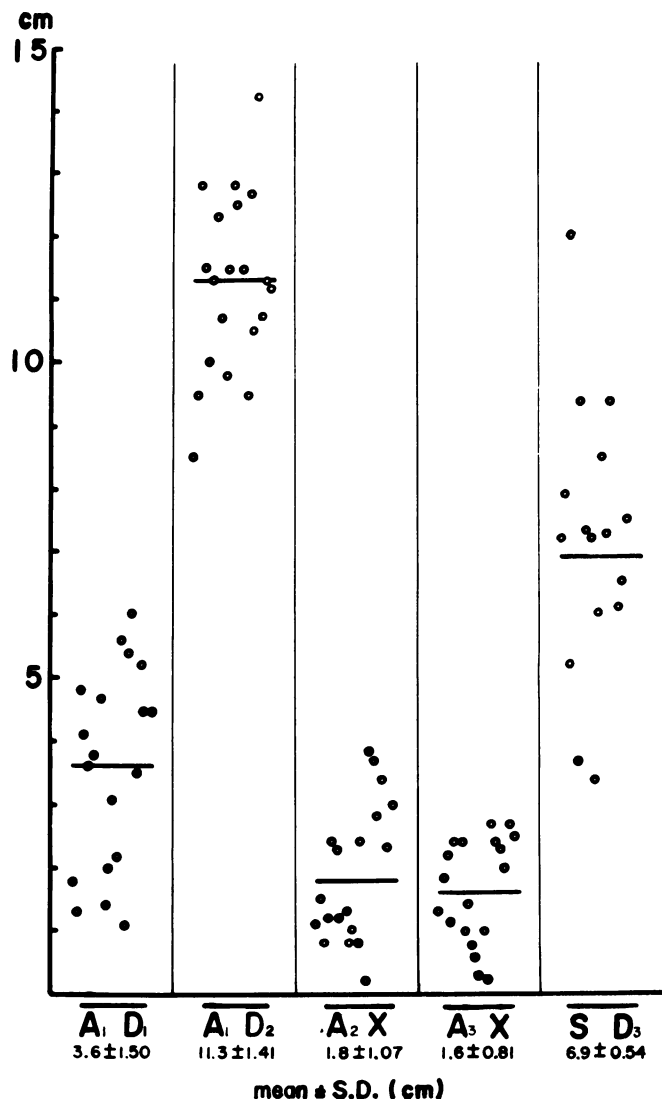


FIG. 2. Relative position between the duodenal loop and the arteries of the pancreas.

duodenum and arteries were measured on the film with combined arteriography and duodenography. For purposes of description, several points relating to the duodenum and arteries were determined arbitrarily (Fig. 1). A_1 was the point where the gastroduodenal artery originated from the common hepatic artery; A_2 , where the posterior superior pancreaticoduodenal artery originated from the gastroduodenal artery; A_3 , where the anterior superior pancreaticoduodenal artery originated from the gastroduodenal artery; and S, where the superior mesenteric artery originated from the aorta. The points on the duodenal loop were labeled D_1 , D_2 and D_3 . On the midaxis of the duodenum, the boundary between the first and the second portion of the duodenum was defined as D_1 , and that between the second and the third portion of the duodenum was D_2 . D_3 was the point where the vertical line passing S crossed the midaxis of the third portion of the duodenum. The longitudinal axis of the second portion of the duodenum was labeled X. The distances between each point were measured on the combined roentgenogram in the anteroposterior projection. All the films were taken with the X ray tube fixed at a distance of 100 cm. As indices to show the relative position, the distances A_1D_1 , A_1D_2 , A_2X , A_3X and SD_3 were measured. A_1D_1 ranged from 1.1 to 6.0 cm. with a mean value of 3.6 cm. A_1D_2 ranged from 8.5 to 14.2 cm. with a mean value of 11.3 cm. A_2X

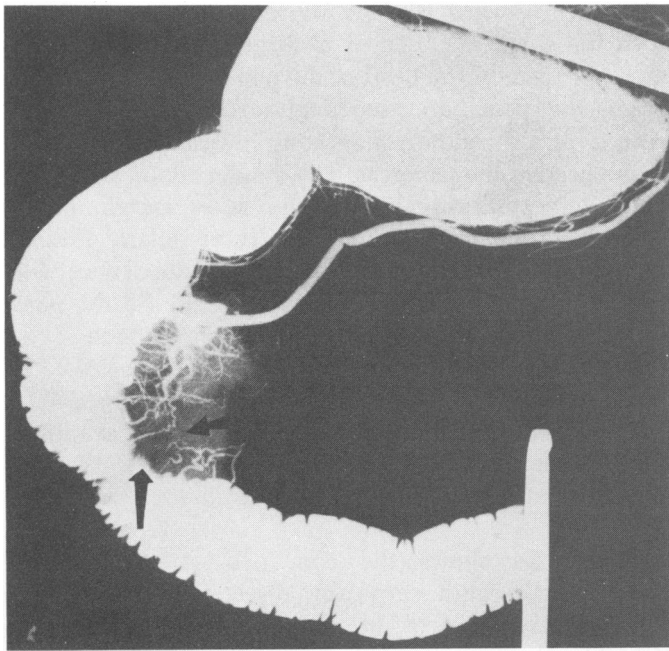


FIG 3A. Arteriogram combined with duodenogram of a surgically resected specimen of cancer of the head of the pancreas. The duodenogram is taken on the filling phase. In the arteriogram, the pancreaticoduodenal arteries show stenosis with a ragged contour (right arrow). The duodenum is also irregularly invaded by extension of the tumor of the pancreas (left arrow). The size of the tumor can be estimated on this combined roentgenogram.

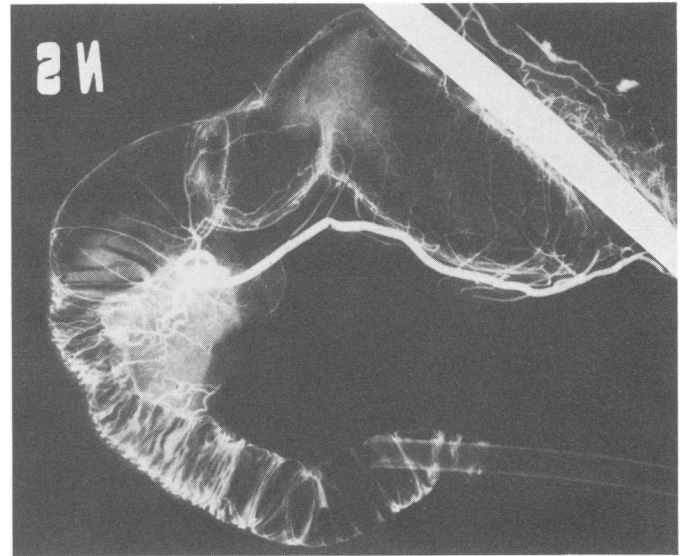
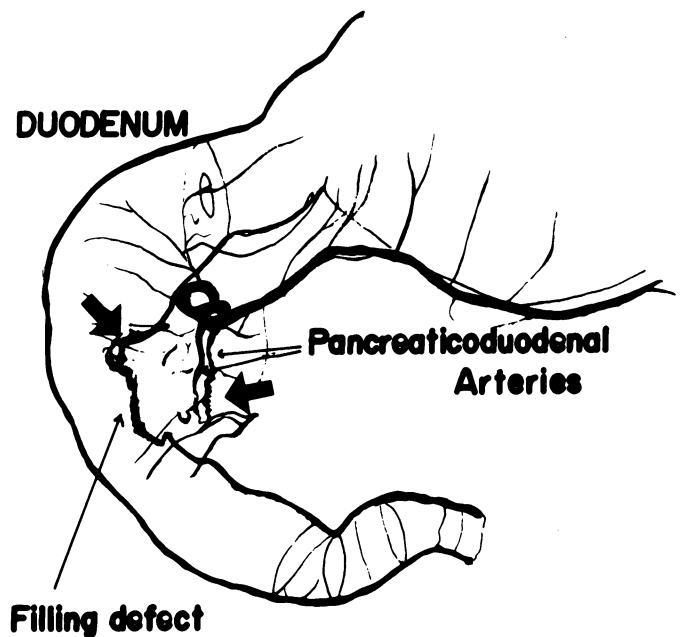


FIG. 3B. The duodenogram is taken on the phase of insufflation after evacuation.

ranged from 0.2 to 3.9 cm. with a mean value of 1.8 cm. A_3X ranged from 0.2 to 2.7 cm. with a mean value of 1.6 cm. SD_3 ranged from 3.4 to 12.0 cm. with a mean value of 6.9 cm. These data suggest that, even in normal subjects, there are great variations in the relative position between the duodenal loop and the arteries of the pancreas. These results are shown in Figure 2.



↑: Lesion in the head of the pancreas

FIG. 3C. Schematic illustration of these combined roentgenograms.

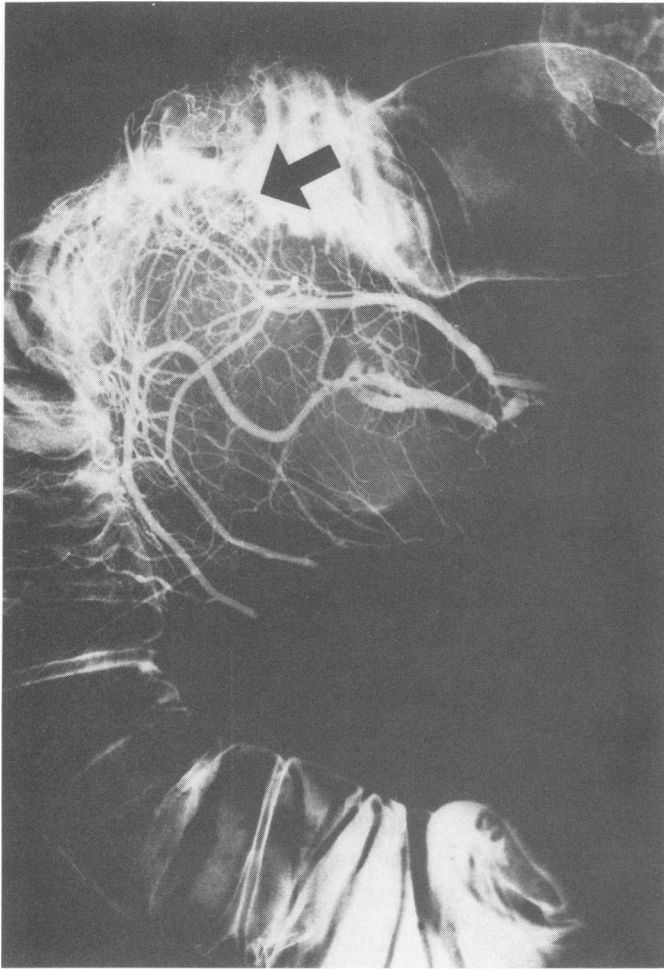
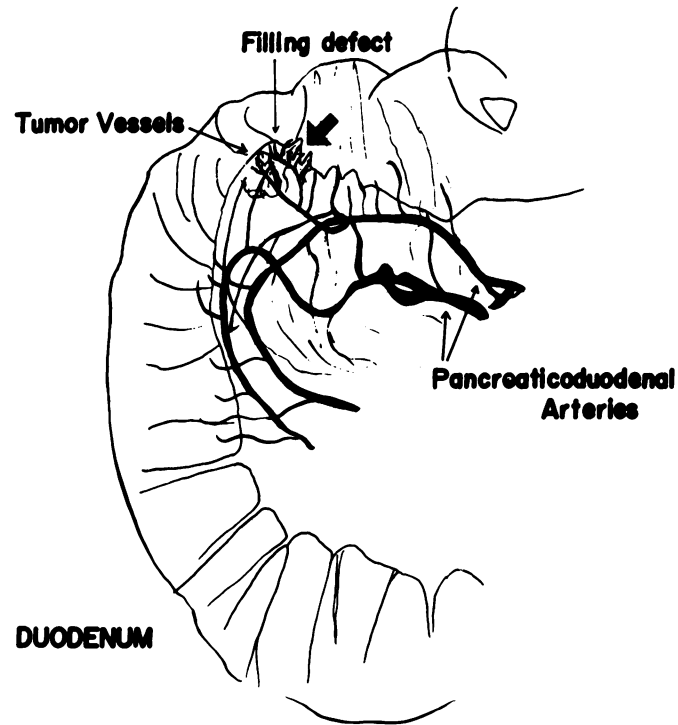


FIG. 4A. Arteriogram combined with duodenogram of a surgically resected specimen of cancer of the ampulla of Vater. The filling defect in the inner margin of the duodenal mucosa (arrow) is revealed on the duodenogram, where a slight increase of abnormal vessels is noted angiographically. The size of the tumor can be estimated on the film.

Diagnostic Usefulness of Combined Roentgenography

From roentgenograms of the resected specimens with barium sulphate infused into both artery and duodenal lumen, the size of the tumors was estimated on the basis of the maximum distance between the site of invasion of the artery and that of the duodenum. These results were compared with the net size of the lesion measured directly in cut section of the specimens. In four specimens of cancer of the head of the pancreas, the tumors were estimated on the film to be 3.0×3.0 cm., 3.5×3.5 cm., 3.0×4.0 cm. and 2.5×3.5 cm.; in cut sections these were all 3.0×3.5 cm. In two specimens of cancer of the ampulla of Vater, measurements on the films showed the tumors to be 1.2×2.5 cm. and 2.0×2.5 cm. in size, while in cut sections they were both 2.0×2.5 cm. These data show that the combined roentgenograms obtained by the present technic demonstrate fairly accurately the size of tumors in the pancreas.



: Lesion in the ampulla of Vater

FIG. 4B. Schematic illustration of this combined roentgenogram.

Figures 3A and B show the arteriograms combined with the duodenograms of a surgically resected specimen of cancer of the head of the pancreas. In the arteriogram, the pancreaticoduodenal arteries show stenosis with a ragged contour, suggesting invasion by the tumor of the head of the pancreas. The duodenogram simultaneously projected reveals that the inner margin of the second portion of the duodenum is irregularly invaded by extension of the tumor towards the duodenum. Figure 3A shows the filling phase, and Figure 3B the phase of insufflation after evacuation. By the method described above, this tumor was estimated to be 3.0×3.0 cm. on the film. On cut section, a mass measuring 3.5×3.0 cm. was found in the pancreas with extensions towards the adjacent duodenal mucosa. Figure 3C shows the schematic illustration of these combined roentgenograms.

Figure 4A shows the combined arteriogram and duodenogram of a surgically resected specimen in a patient with cancer of the ampulla of Vater. The filling defect in the inner margin of the duodenal mucosa was revealed on the duodenogram, where a slight increase of abnormal vessels was noted angiographically. Unlike the former case, the pancreaticoduodenal artery showed no pathologic signs. These findings suggest that the tumor arising from the ampulla of Vater extended into

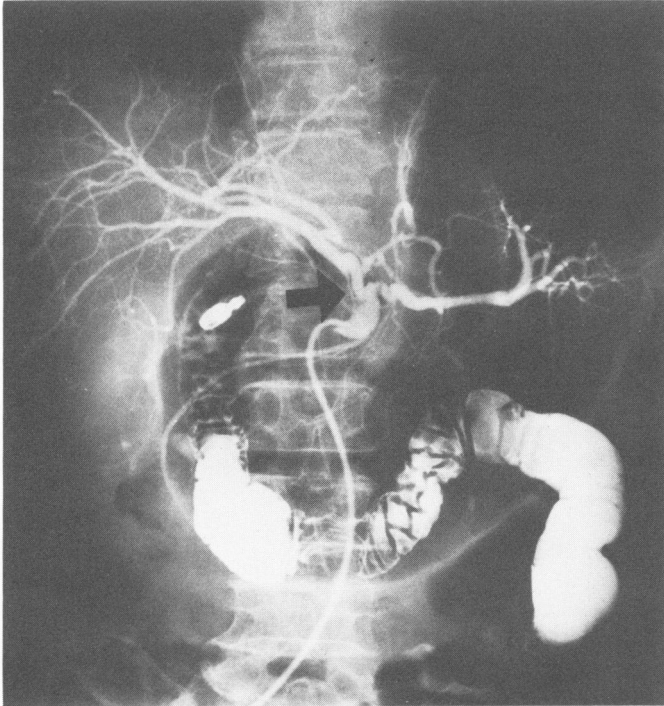


FIG. 5A. Arteriogram combined with duodenogram of a patient with cancer of the entire pancreas. The angiogram of the celiac trunk is superimposed. In the angiogram, the gastroduodenal artery is invaded and deviated medially (arrow). The celiac trunk, common hepatic artery and splenic artery are also invaded. By combined use of hypotonic duodenography, which shows irregularity and enlargement of the second portion of the duodenum, the growth and extension of the tumor can be seen.

the duodenal mucosa, not towards the head of the pancreas. In addition, extension of the tumor mainly towards the duodenum would preclude curative resection of this lesion. The tumor size estimated to be 2.5×1.2 cm. on the film showed good correspondence with that in the cut section of the specimen. Figure 4B shows the schematic illustration of the film.

In all patients with cancer of the pancreas, valuable information could be obtained by means of combined radiography performed prior to operation. Figures 5A and B show the arteriograms combined with duodenograms of a patient with cancer of the entire pancreas. As shown in Figure 5A, angiography of the celiac trunk revealed celiac trunk, common hepatic artery, splenic artery and gastroduodenal artery to be invaded, suggesting that the malignant lesion extended to the entire pancreas. The invaded gastroduodenal artery showed marked deviation medially. However, with the arteriogram alone, the extent of the tumor in the region of the head of the pancreas could not be evaluated, because no tumor stain was demonstrable. By combined use of hypotonic duodenography, which showed irregularity and enlargement of the second portion of

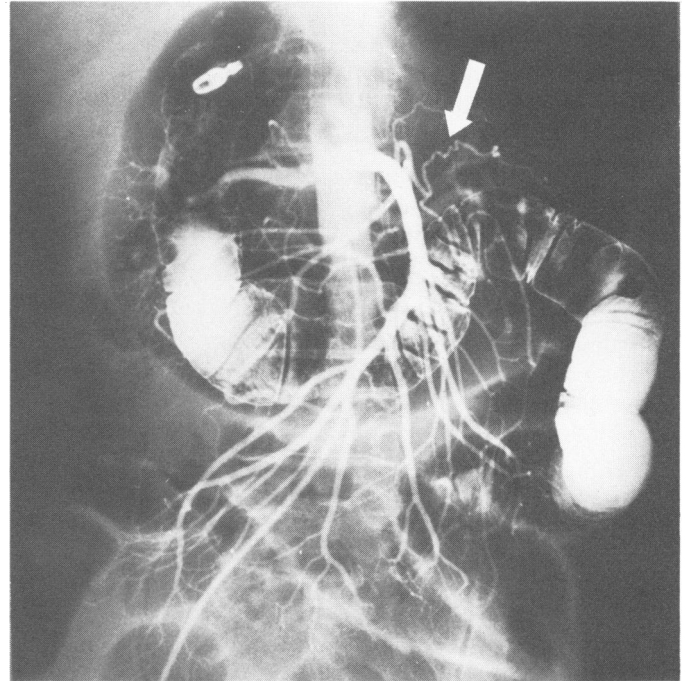


FIG. 5B. The angiogram of the superior mesenteric artery is combined. The middle colic artery (arrow) is infiltrated by the tumor, which has not yet invaded directly to the duodenum. Gastrojejunostomy is added, because these findings give predictive information of impending obstruction of the duodenum due to invasion.

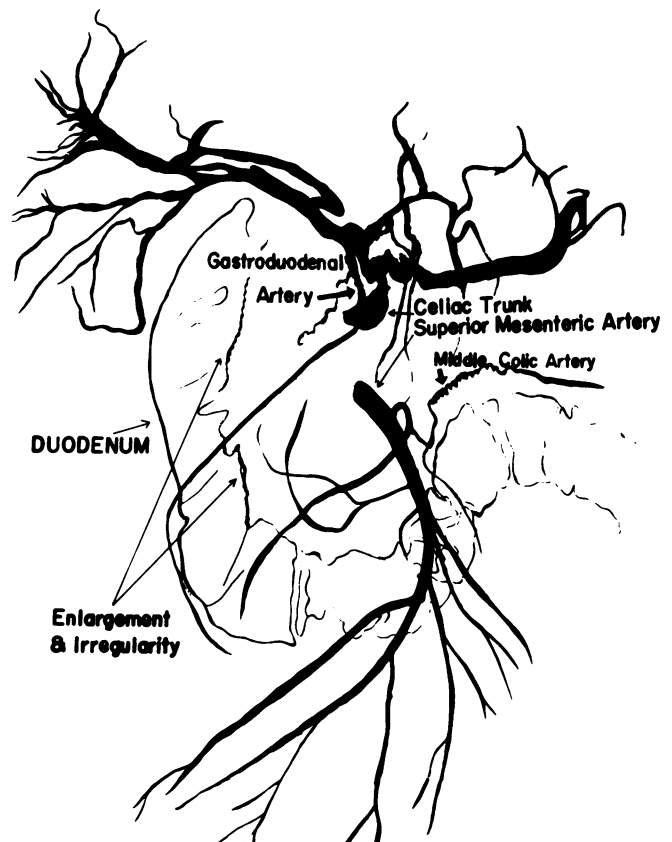


FIG. 5C. Schematic illustration of these combined roentgenograms.

the duodenum, the growth and extent of the tumor in the head of the pancreas could be clearly seen (Fig. 5A). Figure 5B shows a superior mesenteric arteriogram combined with a duodenogram. Irregularity of the arterial wall was revealed in the middle colic artery, suggesting invasion of the tumor into the mesocolon. Combined radiography showed the tumor extending towards the fourth portion of the duodenum, to which the lesion had not yet invaded directly. Consequently, gastrojejunostomy was performed in addition to cholecystojejunostomy, because these findings gave predictive information of impending obstruction of the duodenum due to invasion. The simple sum of each roentgenogram taken separately could not provide this suggestive information. Figure, 5C shows the schematic illustration of the combined roentgenograms of this patient.

Discussion

Selective arteriography has made a valuable contribution to the preoperative diagnosis of cancer of the pancreas. Besides diagnosis, this procedure is also of additional value in evaluating the resectability of the lesion³ and in predicting its clinical course.⁴ On arteriography, cancer of the pancreas is usually demonstrated with the characteristic appearance of irregular tapering or encasement of the artery. However, there are some disadvantages in the diagnostic capacity of this procedure. First, the cancerous area in the pancreas is visualized mostly as a hypovascular area, which makes it difficult to assess the precise extent, size and form of the tumor. Second, direct exploration of the abnormality in the region of the duodenum and the ampulla of Vater is not possible. This may be because the duodenal branches of the pancreaticoduodenal arteries fail to be clearly visualized in routine arteriography. According to our previous study,³ selective arteriography revealed the definite findings directly related to the lesion only in one of six patients suffering from cancer of the ampulla of Vater. Third, interpretation of the fine tumor vessels projected on the film is not infrequently obscure and complex. The previous references on the diagnostic accuracy of arteriography for cancer of the pancreas indicated a high incidence of false positive cases. Thus, certain limitations exist in selective arteriography in identifying the lesions of the pancreas, but they might be complemented by another combined technic, if this were readily available. In this study, we have proposed the simultaneous projection of the hypotonic duodenogram with the arteriogram for the purpose of precise delineation of the lesion. In contrast to angiography, hypotonic duodenography is a particularly sensitive procedure to demonstrate the lesion in the duodenum. This can reflect very slight changes in the duodenal mucosa as well as in the ampulla of Vater. Consequently,

hypotonic duodenography taken together with arteriography will be of much help in the accurate assessment of lesions which extend from the pancreas towards the duodenum. In addition, when it is difficult to say whether the findings on arteriography are pathologic or normal, the combined use of duodenography will answer with much certainty.

In order to evaluate the jaundiced patient, Boijesen¹ attempted the combined use of selective arteriography and percutaneous transhepatic cholangiography. The complementary nature of these examinations in revealing both the vascular and bile duct anatomy contributed to more accurate diagnosis. However, these two roentgenograms were taken separately, and then superimposed. No other studies on combined technic with arteriography have been found.

The anatomical variations of the arteries of the pancreas have been widely investigated by anatomists. Similarly, the topographic anatomy of the duodenum has also been described in detail in textbooks. However, only slight information is available on the correlative anatomy of the duodenum and arteries of the pancreas, especially *in vivo*. Since this is of paramount importance in the diagnosis and treatment of cancer of the pancreas, the present study was undertaken to clarify this anatomical relationship by means of combined roentgenography. It was found that, even in normal subjects, unexpectedly wide variations were demonstrable in the position of the duodenal loop relative to the arteries of the pancreas. In pathologic conditions, much more deviation as well as displacement of each position might be expected. Under these circumstances, an accurate assessment of the lesion might be impossible if the roentgenograms were made separately.

In addition to the celiac trunk, the superior mesenteric artery is also important in the diagnosis of cancer of the pancreas. Anatomically, the artery derives from the upper part of the neck of the pancreas, runs downwards through the dorsal surface of the pancreas and appears in the abdominal cavity over the uncinate process of the pancreas. Therefore, angiograms of this artery can reflect sensitively pathology of the posterior surface of the pancreas and the uncinate process. However, extreme variations were also noticeable in the relative position between the superior mesenteric artery and the third portion of the duodenum. In cancer of the pancreas, accurate identification of the abnormality in the superior mesenteric artery could not be attained, unless the duodenogram was superimposed on the angiogram of this artery.

With the proposed combined technic, it seems to be possible to illustrate the extension and growth of the tumor in the pancreas and duodenum. Such valuable informations obtained before operation might enable

surgeons to make appropriate therapeutic plans, either palliative or curative, and to save consuming the time before and during the operation. Each procedure has its own limitations and its own advantages which cannot be obtained from the other procedure. These two examinations, in combination, complement and supplement each other. The information gained from combined arteriography and duodenography has much more significance than the simple sum of the two roentgenograms obtained separately.

Summary

Extreme variations were shown in the relative position of the duodenum and the arteries of the pancreas, even in normal subjects. By means of combined selective arteriography and hypotonic duodenography, much more valuable information could be obtained than from the simple sum of each roentgenogram used separately. With the combined technic, the extension and size of

the tumor in the pancreas were clearly demonstrable. Such information, gained prior to operation, can help surgeons to plan the operative procedure and control the time factor. The new combined technic proposed in this study adds a further dimension to the radiologic evaluation of the pancreas.

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