Nagoya J. Med. Sci. 46. 95 ~ 107, 1984

ULTRASONOGRAMS AND HISTOLOGICAL FINDINGS OF THE POSTMORTEM PANCREAS

KENJI TANEHIRO

First Department of Internal Medicine
Nagoya University School of Medicine
Nagoya 466, Japan

ABSTRACT

The exact relationship between ultrasonograms and histological findings of the pancreas was investigated in 24 postmortem materials consisting of 11 cases of normal pancreas, 9 of pancreatic tumor and 4 of chronic pancreatitis. Normal pancreas showed a smooth contour and a homogeneous echo pattern with uniform echo intensity which was 10 dB higher than that of the normal liver. Pancreatic tumor generally showed an irregular contour, low echo intensity and a heterogeneous echo pattern. Mild chronic pancreatitis manifesting acinar atrophy, fatty replacement and fibrosis showed a smooth contour and a homogeneous, dense echo pattern with elevated echo intensity. The pancreas with only marked fatty replacement showed the same ultrasonographic image as mild chronic pancreatitis. Pancreatic calculi produced scattered reflective echoes making a heterogeneous echo pattern. The pancreas with advanced chronic pancreatitis, in which the parenchyma was entirely replaced by fibrous tissue associated with ductal dilatation, showed an irregular contour and low echo intensity, almost the same as that of pancreatic tumor, but the homogeneous echo pattern enabled the author to differentiate advanced chronic pancreatitis from pancreatic tumor.

Keywords: Ultrasonogram, Histological finding, Normal pancreas, Pancreatic tumor, Chronic pancreatitis

INTRODUCTION

Ultrasonography is indispensable to the diagnosis of pancreatic diseases. It has been used not only as a screening method, but recently with the rapid technological advances also as a detailed examination method.[1] And a highly resolutive image could be obtained with the advent of endoscopic or laparoscopic ultrasound. A precise histological analysis of the pancreatic tissue is now necessary to make a correct diagnosis on ultrasonography of the pancreas. However, there may be no report clarifying the exact relationship between an ultrasonogram of the pancreas and the histological findings. The author attempted to compare the ultrasonograms of the pancreas with their histological findings using postmortem materials.

MATERIALS AND METHODS

Materials

Materials were 24 postmortem pancreata, obtained within 4 hours after death, consisting of 11 normal pancreata, 9 with pancreatic tumor, and 4 with chronic pancreatitis.

種広健治
Received for Publication November 21, 1983

Equipment

All scans were performed on a commercially available ultrasonographic unit, TOSHIBA Sonolayer L (SAL-20A) employing a 3.5-MHz (5.0 cm) focused transducer. Evaluation was made directly from the recorded image (Polaroid film).

Procedures

The pancreas was removed from the body with some of its surrounding tissue. It was marked serially at 5-mm intervals on its surface from the head to the tail in order to compare the ultrasonogram with the histological findings in the same section. Ultrasonographic scans were performed at every marked spot on the pancreas, which was retracted and fixed by 4 threads in a saline-filled bath, perpendicular to the long axis of the pancreas and parallel to it on occasion. An ultrasonic probe was held just beneath the surface of the water by a supporting apparatus and slid at 5-mm intervals. The distance from the probe to the pancreas was 7 ± 1 cm. All scans were performed under the same conditions of the ultrasonographic unit: echo enhancement A_2, dynamic range 3, far gain 0.2, near gain 6.2, but major gain variable from 25 dB to 65 dB for obtaining the best ultrasonographic image in each material. The pancreas was cut serially at the marked spots into 30 to 40 blocks after fixation with formalin and submitted to the histological studies. The blocks were routinely stained with a Hematoxyline and Eosin, Elastica van Gieson or PAS staining.

Antemortem pancreas

Five patients were placed on percutaneous ultrasonic scans before death with the same ultrasonographic unit as employed in this experiment for comparison of ultrasonograms between antemortem and postmortem pancreas.

RESULTS

1) *Comparison of ultrasonograms of antemortem versus postmortem pancreas*

Two ultrasonograms of antemortem and postmortem pancreas were compared in 5 normal cases. Both showed homogeneous echo patterns composed of many uniform echo spots or short echo lines in all cases. Figure 1-a is an ultrasonogram of the head and body of the pancreas scanned percutaneously just before death. Figure 1-b is an ultrasonogram of the head and body of the sme pancreas scanned in saline after death. Both images demonstrated basically the same appearance.

2) *Ultrasonogram of normal pancreas*

Ultrasonograms of 11 normal pancreata were anlaysed. The age distribution of the patients was from 14 to 72 years with the mean age of 53 years at death.

(a) *Discrimination of pancreatic structures* (Figure 2)

Pancreatic parenchyma was well distinguishable and less echogenic by 5—10 dB than the surrounding connective tissues. The pancreatic capsule was recongnized as a linear element with echo intensity 5 dB higher than that of the pancreatic parenchyma except in one case which had a very thin capsule. The main pancreatic duct was recongnized in 8 of 11 cases as a double-lined or tubular element with a strong marginal echo, while branches could not be noted. The intrapancreatic bile duct was visualized as a tubular hypoechonic element with a weak marginal echo. Each pancreatic structure was well discriminated as mentioned above; however, it could not be clarified what sort of tissue was the origin of echo spots or short lines as main components of the pancreatic ultrasonogram.

(b) *Contour of pancreas*

Contour of the pancreas was smooth in every case of 11 normal pancreata.

(c) Size and shape of pancreas

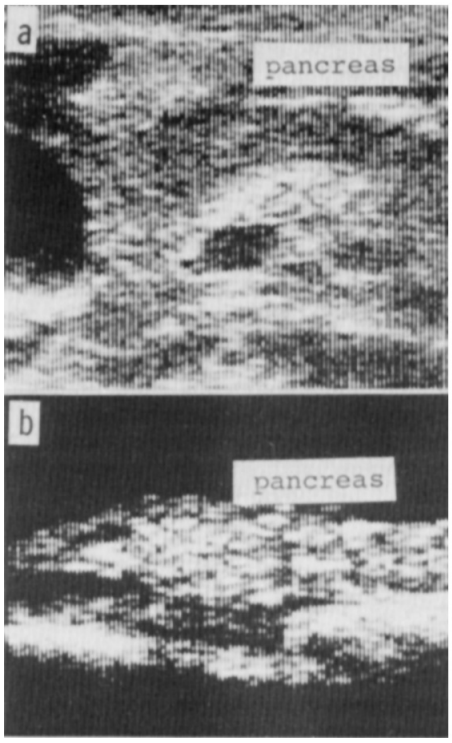

Fig. 1

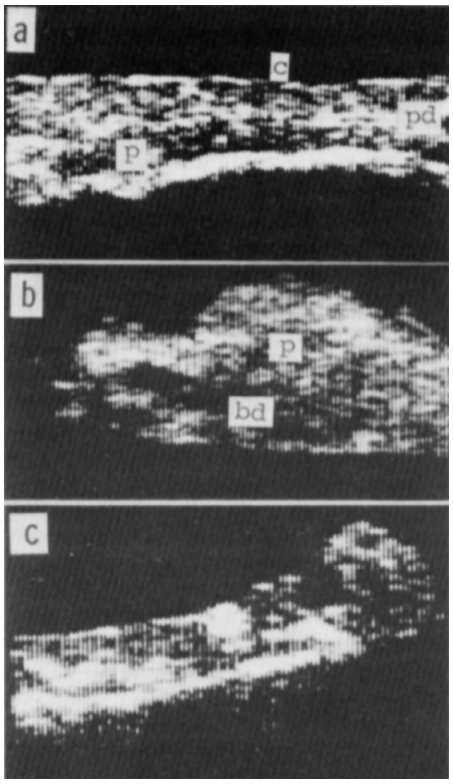

Fig. 2

Fig. 1
a; Ultrasonogram of the head and body of the normal pancreas scanned percutaneously just before death when the gain of the equipment was set at 55 dB.
b; Ultrasonogram of the head and body of the same pancreas scanned in saline after death when the gain of the equipment was set at 50 dB.
Fig. 2
a; Ultrasonogram showing capsule (c), parenchyma (p) and main duct (pd) of the pancreas.
b; Ultrasonogram showing the bile duct (bd) and the pancreatic parenchyma (p).
c; Ultrasonogram showing a localized enlargement of the tail of the normal pancreas.

The length of the pancreas was 18.0 ± 2.8 (mean ± S.D.) cm. Table 1 shows the thickness (dorso ventral) and width (cranio caudal) of the pancreas. Size was variable, especially in the thickness of the head and tail and in the width of the head. This variability of size was unrelated to the age and body weight of the patient on statistical analysis. Shape of the pancreas was most like a tadpole, and the tail was swollen like a tumor mass in 2 of 11 cases, as shown in Figure 2-c.

(d) *Ultrasonogram of pancreatic parenchyma*

Table 2 shows echo intensity and echo pattern of the pancreatic parenchyma in 11 cases. Echo intensity was almost the same in 9 cases. Only the body and tail of the pancreas in one case, and the whole pancreas in another case showed about 5 dB lower echo intensity than the others. An echo pattern was expressed as "homogeneous" when the image was composed of uniform echo spots and lines, and "heterogeneous" when some large, strong echo spots were scattered on the image. Homogeneous echo patterns were shown in the whole pancreas in 5

Table 1. Size of the Pancreas (11 cases)

	head	neck	body	tail
thickness				
mean ±S.D.	2.1 ±0.5	1.2 ±0.2	1.5 ±0.3	1.5 ±0.4
max.	3.0	1.7	2.0	2.3
min.	1.3	1.0	1.0	1.0
width				
mean ± S.D.	4.5 ± 1.1	3.1 ± 0.4	3.2 ± 0.6	2.8 ± 0.4
max.	7.0	3.5	4.0	3.4
min.	2.8	2.0	2.0	2.2

(cm)

Table 2. Echo Intensity and Echo Pattern of the Normal Pancreatic Parenchyma (11 cases)

Echo Intensity	head	body	tail
0*	10	9	9
−5 dB	1	2	2

* standard value (45dB)

Echo pattern	head	body	tail
homogeneous	9	9	7
heterogeneous	2	2	4

cases, and partly in 5 other cases. A heterogeneous echo pattern was recognized in the whole pancreas in only one case. Fig. 2-a shows the echo intensity and echo pattern of the normal pancreatic parenchyma when the gain of the equipment was set at 45 dB ("standard value" parenthesized in Table 2).

(e) *Comparison with normal liver*

Each ultrasonogram of the pancreas was compared with that of histologically normal liver in 5 patients. Each liver, producing a homogeneous echo pattern, had about 10 dB lower echo intensity than the pancreas.

3) *Ultrasonogram of pancreatic tumor*

(a) *Ultrasonogram of primary pancreatic tumor*

Table 3a. Histological and Ultrasonographic Findings of the Primary Pancreatic Tumor

Tab. 3a Histological and Ultrasonographic Findings of the Primary Pancreatic Tumor

Case	Histological findings			Size (cm)	Contour	Echo Intensity (dB)*	Echo pattern (quantity of internal echo)
	type	stroma	necrosis				
No. 1	tubular adenoca.	little	much	5 x 5 x 3	irregular	− 20	heterogeneous (little)
No. 2	tubular adenoca.	much	much	5 x 4 x 3	irregular	− 15	heterogeneous (much)
No. 3	islet cell ca.	much	little	6 x 4 x 4	regular	− 15	heterogeneous (much)
No. 4	tubular adenoca.	much	much	9 x 6 x 6	irregular	− 15	heterogeneous (much)
No. 5	cyst - adenoca.	much	little	7 x 6 x 6	irregular	− 10	heterogeneous (much)
No. 6	papillo - tubular adenoca.	much	much	4 x 4 x 4	irregular	− 10	heterogeneous (much)

Tab. 3b Histological and Ultrasonographic Findings of the Metastatic Pancreatic Tumor

Case	Histological findings			Size (cm)	Contour	Echo Intensity (dB)*	Echo pattern (quantity of internal echo)
	type	stroma	necrosis				
No. 7	tubular adenoca. (bile duct ca.)	much	little	3 x 3 x 3	irregular	− 10	heterogeneous (much)
No. 8	tubular adenoca. (colon ca.)	much	much	2 x 2 x 2	irregular	− 10	heterogeneous (much)
No. 9	lymphoma	little	little	8 x 3 x 3	irregular	− 20	heterogeneous (little)

* compared with the echo intensity of the normal pancreatic parenchyma

Table 3-a shows histological and ultrasonographic findings of 6 primary pancreatic tumors. Histologically, 5 were ductal carcinomas and 1 was islet cell carcinoma. The largest tumor was $9 \times 6 \times 6$ cm and the smallest one was $4 \times 4 \times 4$ cm. Tumor contour was irregular in all ductal carcinomas, but smooth in the islet cell carcinoma. Echo intensity of each tumor was 10—20 dB lower than that of normal pancreas. The echo pattern of each tumor was heterogeneous because of an irregularly scattered internal echo. In case 2 and case 6, mottled internal echo was also recognized. There was little internal echo in case 1 and much in the other cases when the gain of the equipment was set at the same level. As a result of investigation of the relationship between the ultrasonogram of the tumor and its histological findings, lower echo intensity or less internal echo was noted in the tumor with abundant tumor cells and little stroma. No apparent relationship was present between ultrasonographic characteristics and histological types of the tumor or amount of necrosis. Figure 3 shows the ultrasonogram of pancreatic carcinoma (Case 2) (a), the cross-section of the tumor at the scanned spot (b) and its schema (c). The tumor was $5 \times 4 \times 3$ cm in size and its histological type was a poorly differentiated tubular adenocarcinoma. The tumor contour was irregular. Echo intensity of the tumor was 15 dB lower than that of normal pancreas. Internal echo was abundant and heterogeneous, but its pattern did not correspond well to the distribution of necrosis. Figure 4 shows the ultrasonogram of another pancreatic carcinoma (Case 3) (a), the cross-section of the tumor at the scanned spot (b) and its schema (c). The main tumor was an islet cell carcinoma of $6 \times 4 \times 4$ cm in size associated with an extrapancreatically growing tumor of $4 \times 3 \times 3$ cm. The tumor contour was regular and echo intensity of the tumor was 15 dB lower than that of normal pancreas. Internal echo was great and heterogeneous. On the other hand, echo intensity of the extrapancreatic tumor (not listed in Table 3) was much lower than that of the main tumor, and there was little internal echo. Histological examination revealed that there was a large amount of stroma in the main tumor but little in the

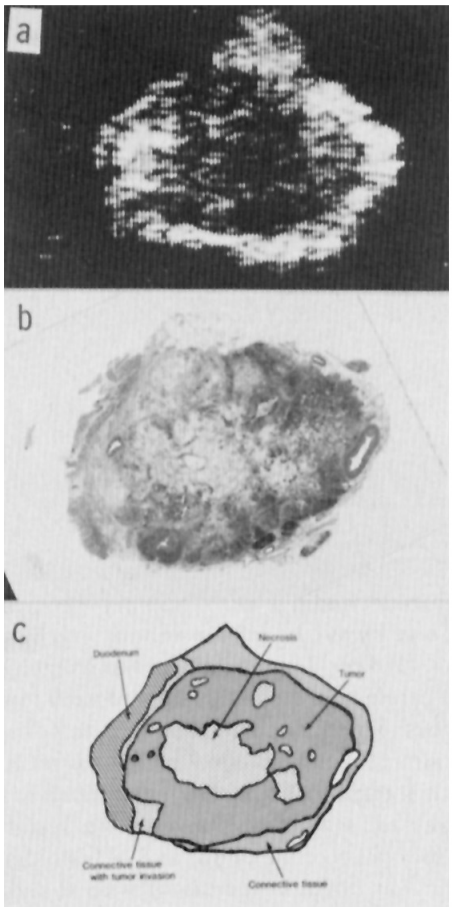

Fig. 3

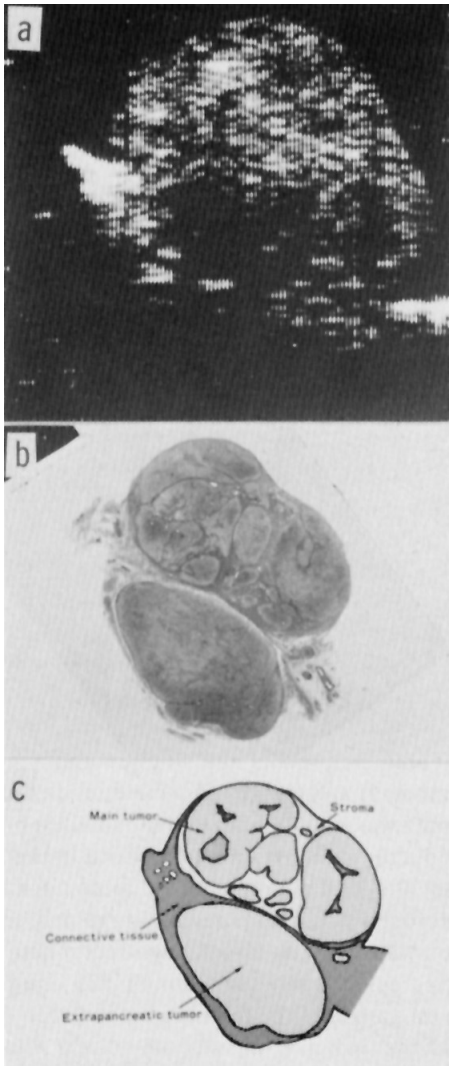

Fig. 4

Fig. 3
a; Ultrasonogram of the pancreatic carcinoma (Case 2) when the gain of the equipment was set at 50 dB.
b; Histological picture of the cross-section of the tumor scanned in Fig. 3-a at low power view.
c; Scheme of Fig. 3-b.
Fig. 4
a; Ultrasonogram of the islet cell carcinoma (Case 3) when the gain of the equipment was set at 55 dB.
b; Histological picture of the cross-section of the tumor scanned in Fig. 4-a at low power view.
c; Scheme of Fig. 4-b.

extrapancreatic tumor, which was almost entirely occupied by tumor cells.

(b) *Ultrasonogram of metastatic pancreatic tumor*

Table 3-b shows histological and ultrasonographic findings of 3 metastatic pancreatic tumors, (a bile duct carcinoma, a lymphoma, and a colon carcinoma). The largest tumor was

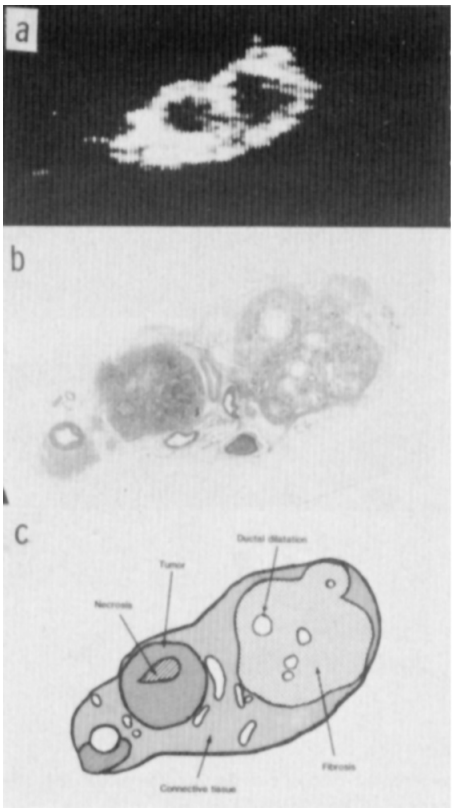

Fig. 5

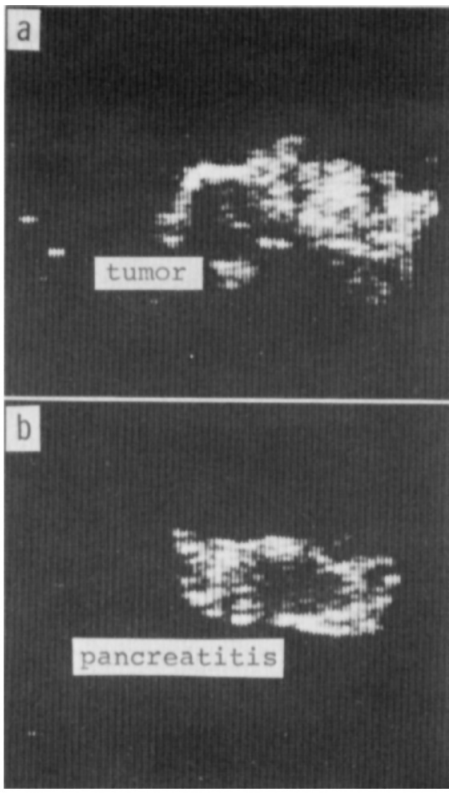

Fig. 6

Fig. 5
a; Ultrasonogram of the tumor and the tumor-associated advanced chronic pancreatitis, of which the parenchyma was entirely replaced by fibrous tissue with ductal dilatation.
b; Histological picture of the cross-section of the lesion scanned in Fig. 5a at low power view.
c; Scheme of Fig. 5b.
Fig. 6
a; Ultrasonogram of the metastatic tumor of the head of the pancreas (Case 8).
b; Ultrasonogram of the tumor-associated advanced chronic pancreatitis with prominent fibrosis and acinar disappearance at the body of the same pancreas shown in Fig. 6a.

$3 \times 3 \times 3$ cm and the smallest one was $2 \times 2 \times 2$ cm. The tumor contour was irregular in all cases. Echo intensity of each tumor was 10 — 20 dB lower than that of the normal pancreas. Echo patterns were all heterogeneous. The quantity of internal echo was great in case 7 and case 8, but little in case 9. The relationship of echo intensity and echo pattern to histological tumor types, the amount of stroma or tumor cells, and the amount of necrosis in the metastatic pancreatic tumor was almost the same as in the primary pancreatic tumor.

4) *Ultrasonogram of chronic pancreatitis*

(a) *Ultrasonogram of tumor-associated pancreatitis*

Figure 5 shows the ultrasonogram of the tumor (case 1 in Table 3) and the tumor-associated advanced chronic pancreatitis (a), the cross-section of the pancreas at the scanned spot (b) and its schema (c). Histological picture of the tumor showed a tubular adenocarcinoma with central necrosis, and that of the advanced chronic pancreatitis revealed prominent fibrosis

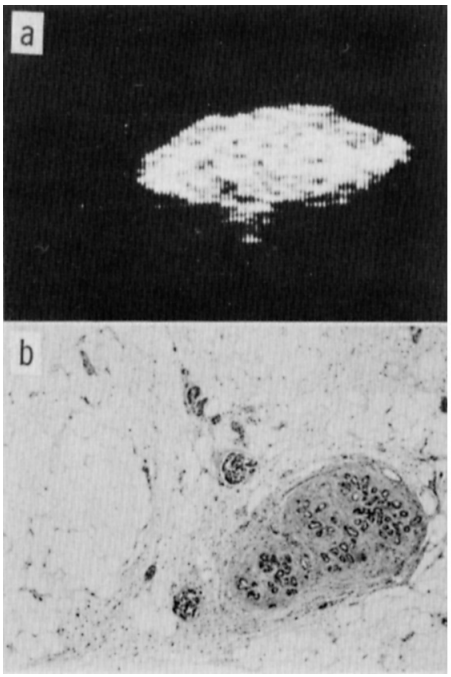

Fig. 7

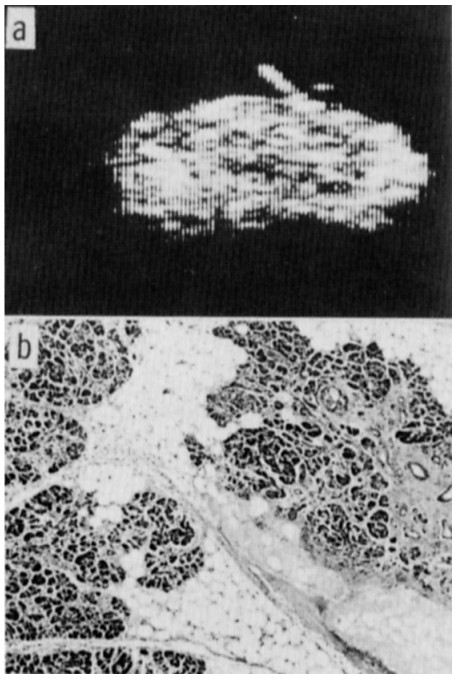

Fig. 8

Fig. 7.
a; Ultrasonogram of the pancreas with marked fatty replacement when the gain of the equipment was set at 50 dB.
b; Histological picture of the cross-section of the lesion scanned in Fig. 7a (H&E, × 32).
Fig 8.
a; Ultrasonogram of the pancreas with acinar atrophy, fibrosis and fatty replacement when the gain of the equipment was set at 45 dB.
b; Histological picture of the cross-section of the lesion scanned in Fig. 8a (H&E, ×32).

and acinar disappearance with ductal dilatations. Both ultrasonograms of the lesions had irregularly-contoured, round and hypoechoic appearances without the apparent internal echo, making differentiation between the lesions difficult. Meanwhile, Figure 6 shows different ultrasonographic images of the tumor (a) and the tumor-associated advanced chronic pancreatitis (b). The tumor, metastatic from colon carcinoma (Case 8), was visualized as an irrregularly-contoured, round and hypoechoic mass with "heterogeneous" echo pattern. The advanced chronic pancreatitis, characterized by prominent fibrosis and acinar disappearance, was visualized as an irregularly-contoured, round and hypoechoic mass with "homogeneous" echo pattern. Difference of the echo patterns made differentiation of the lesions possible.

Figure 7 shows the ultrasonogram of another tumor-associated pancreatitis (a) and its histological picture (b). The pancreas with prominent fatty replacement and acinar atrophy showed 5 dB higher echo intensity than normal pancreas and a dense homogeneous echo pattern.

(b) *Ultrasonogram of chronic pancreatitis*

Table 4 shows histological and ultrasonographic findings of 4 cases of chronic pancreatitis. The age distribution of the patients was from 57 to 79 years with the mean age of 70 years at death. Contour of the pancreas was smooth in all cases except for case 4. Main histological

Table 4 Ultrasonographic and Histological Findings of the Chronic Pancreatitis

		Echo intensity (dB)[c]	Echo pattern	Histological findings: Acinar atrophy	Fatty replacement	Fibrosis	Ductal dilatation	Cell infiltration	Calculi
No. 1	head	+5	dense, homogeneous	+	##	##	−	+	−
	body	+5	dense, homogeneous	+	+	+	−	+	−
	tail	+5	dense, homogeneous	+	##	##	−	+	−
No. 2	head	+5	heterogeneous	+	+	+	−	−	−
	body	+5	dense, homogeneous	+	+	+	+	−	−
	tail	+5	dense, homogeneous	+	+	+	−	−	−
No. 3	head	0	dense, homogeneous	+	+	+	+	−	−
	body	+5	dense, homogeneous	+	+	+	+	−	−
	tail	+5	dense, homogeneous	+	+	+	+	−	−
No. 4	head	+5	heterogeneous	##	+	+	+	−	##
	body	+5	heterogeneous	##	+	+	+	−	##
	tail	+5	heterogeneous	##	+	+	+	−	##

[c] compared with the echo intensity of the normal pancreatic parenchyma

histological change ; −: none, +: minimal, ##: moderate, ###: marked

findings seen in these cases were acinar atrophy, fatty replacement, and intralobular or interlobular fibrosis. Other findings such as ductal dilatation, cell infiltration, and calculi were also noted. Echo intensity of all pancreata was 5 dB higher than that of the normal pancreas. Echo patterns were dense and homogeneous in 3 of 4 cases, but a heterogeneous echo pattern was recognized in case 4, which had small, multiple scattered calculi. Figure 8 shows the ultrasonogram of the pancreas with mild chronic pancreatitis and its histological picture. The pancreas with acinar atrophy, fibrosis, and fatty replacement showed 5 dB higher echo intensity than normal pancreas and a dense homogeneous echo pattern.

DISCUSSION

Postmortem pancreata were submitted to investigation of the relationship between ultrasonogram and histological picture of the pancreas, because the exact analysis of an ultrasonogram and histological picture of the pancreas, because the exact analysis of an ultrasonographic image was impossible on the basis of clinical diagnosis without histological confirmation. The ultrasonograms of the postmortem pancreas were compared with those of the antemortem pancreas. As a result, both images were very similar even though the scanning conditions were different. The findings of the ultrasonogram of the postmortem pancreas were thought to be applicable to the reading of the ultrasonogram of the antemortem pancreas.

parenchyma was well distinguished from the pancreatic capsule and the surrounding tissues by the difference of echo intensity. And the pancreatic coutour was smooth. The main pancreatic duct was recognized as a double-lined or tubular element. It was probably due to the collapse of the pancreatic duct that the main pancreatic duct could not be detected in 3 cases, since it can now be commonly visualized on conventional ultrasonographic scans. The pancreas sometimes may not be discriminated from the surrounding tissues when there are no differences in echo intensity and echo pattern between the two. All the histologically normal pancreata were distinguishable from the surrounding tissues because of their lower

echogenicity. However, the pancreas such as that with acinar atrophy, fatty replacement and fibrosis — fatty replacement is considered to be most causative — became echogenic and indistinguishable from the surrounding tissues. Consequently, careful attention must be paid to judgement of the shape and size of the echogenic pancreas. It is also important to keep in mind that some histological changes might be present in the pancreas which are indistinguishable from the surrounding tissues.

There are many reports[2-5] investigating the size and shape of the normal pancreas, but they are based on clinical diagnosis. The results in this study show so many individual variations in the size and shape of the normal pancreas that circumspection is required for judgement of "swelling" or "atrophy," which is one of the findings suggesting the presence of pancreatic tumor or pancreatitis. Echo intensity and echo pattern should be referred to for making a precise diagnosis.

It is generally said that the normal pancreatic parenchyma has an echo intensity which is similar to or higher than that of the normal liver, and has an echo pattern which is homogeneous.[1,4-11] These reports but one by Filly *et al.*[9] were based on clinical materials and diagnosis. In the present results, echo intensity of the normal pancreatic parenchyma was almost the same and about 10 dB higher than that of the normal liver. Echo pattern was homogeneous in almost all cases. Heterogeneous echo pattern, rarely seen in normal pancreas, is thought to be an artifact due to the bubble trapped in the vessels, pancreatic ducts and common bile duct in the postmortem pancreatography, for there was no histological difference between homogeneous and heterogeneous pancreas on ultrasonogram. Histological sources of echo spots or echo lines producing a main ultrasonic image of pancreatic parenchyma could not be identified with our euqipment. They may possibly be acini, ducts, and interstitium of the pancreas.

The contour of the pancreatic tumor is said to be irregular or lobular.[11,12] All of the cases reported in this study except one islet cell tumor had irregular contours. The islet cell tumor, which was a nodular tumor with a capsule, showed a smooth contour. As an islet cell tumor generally has a well-circumscribed capsule,[13] a specific tumor may exist when ultrasound demonstrates a smoothly-contoured solid tumor in the pancreas. Echo intensity of pancreatic cancer is said to be varied, being mainly either hypoechoic or hyperechoic.[6,14] Fukuda[11] reported that 73.3% of the pancreatic cancers were hypoechoic and 21.2% hyperechoic and that echo intensity of the hypoechoic tumor was 6 dB lower than that of normal pancreas. In this study, each pancreatic tumor had 10—20 dB lower echo intensity than normal pancreas. Echo pattern was heterogeneous in all cases, like other reports,[11,12] with the internal echo variable in quantity. And as a result of investigation of the relationship between the ultrasonogram of the tumor and its histological findings, higher echo intensity or more internal echo was noted in a tumor with much stroma. I did not encounter a hyperechoic pancreatic tumor, but it is presumed that the tumor with more abundant stroma, necrosis or fatty degeneration may have a hyperechoic appearance with more internal echo. Generally, however, characteristic ultrasonograms of the pancreatic tumor show an irregularly-contoured hypoechoic mass with a heterogeneous echo pattern that can be clearly distinguised from the surrounding tissues. This finding coincides with that of the operative ultrasonogram of 15 pancreatic cancers as reported by Miyashita *et al.*[15]

An ultrasonogram of chronic pancreatitis has been characterized by pancreatic atrophy or enlargement, irregular contour, heterogeneous echo pattern, scattered strong echo spots, ductal dilatation, etc..[1,12] However, this concept depends on clinical diagnosis without exact comparison of the ultrasonogram and histology. In my experience, the pancreas of advanced chronic pancreatitis entirely replaced by fibrous tissue associated with acinar disappearance and ductal dilatation produced a hypoechoic appearance. This result agrees with the report

by Kimoto *et al.*[16] that connective tissue proliferation of severe degree causes slight decrease in echo intensity, but disagrees with the concept of Kitamura[17] that an ultrasonogram of chronic pancreatitis is characterized by a diffuse hyperechoic pattern originating in fibrous tissue and irregularly dilated ducts. On the other hand, in mild chronic pancreatitis the pancreas with histological changes such as acinar atrophy, fatty replacement and fibrosis produced elevated echo intensity and a homogeneous, dense echo pattern. And the pancreas replaced by abundant fatty tissue also produced elevated echo intensity and a homogeneous, dense echo pattern. As the fatty tissue is essential to an increase in echo intensity,[7,16,18-21] fatty replacement, when coexisting with acinar atrophy and fibrosis, is considered to be an important factor of echogenicity. Consequently, it is necessary to take into consideration that mild chronic pancreatitis or pancreatic fatty replacement induced by various disorders such as obesity, diabetes mellitus, etc., could be present in the pancreas with elevated echo intensity and a homogeneous, dense echo pattern.

Concerning the tissue characterization, Behan *et al.*[18] said that the echogenicity might be explained by the presence of multiple fat/non-fat interfaces and not purer fatty or fibrous tissue. Davis *et al.*[19] summarized their study by saying that collagen-containing connective tissue was not necessary for echoes and that the wide difference in echogenicity for fatty tissues was due to the differences in the thickness of their connective tissue stromata. These reports suggest that many interfaces with high ultrasonic impedance, the main determinants of echogenicity, may exist in the pancreas that has a complex histological change of acinar atrophy, fatty replacement and fibrosis, but not in the pancreas which has been entirely replaced only by fibrous tissue. These results may explain the reason why mild chronic pancreatitis showed echogenic appearance and advanced chronic pancreatitis showed conversely hypoechoic appearance.

Clinically, the echo pattern of chronic pancreatitis has been described as heterogeneous, occasionally associated with scattered, strong echo spots and with irregular contour.[1,12] The author presented 3 cases of chronic pancreatitis with homogeneous, dense echo pattern and smooth contour, and one case of irregularly-contoured chronic pancreatitis with calculi which produced reflective echoes making the echo pattern heterogeneous. The reason why the 3 cases of chronic pancreatitis showed smooth contour is considered to be the mild histological changes which do not induce the deformity of the pancreas.

On ultrasonogram it comes into question to differentiate the tumor from advanced chronic pancreatitis. Differentiation of both lesions was difficult by the difference of echo intensity or contour in this study, because the pancreas that had been entirely replaced by abundant fibrous tissue appeared as an irregularly-contoured hypoechoic mass similar to the tumor. But the difference of each echo pattern enabled me to differentiate the tumor with a heterogeneous echo pattern from the advanced chronic pancreatitis with a homogeneous echo pattern in one case. Also, setting the gain of the equipment at higher level might have made it possible to clearly visualize the internal echo and differentiate the tumor from the advanced chronic pancreatitis in another case, of which the lesions showed no apparent internal echo in this experiment. With the advent of much more resolutive ultrasonic equipment, it will become more feasible to differentiate lesions on the basis of analysis of texture of the internal echo.

CONCLUSION

The author attempted to compare the ultrasonogram of the postmortem pancreas with the histology. Normal pancreatic parenchyma was well distinguished from the surrounding

tissues with homogeneous echo spots and short echo lines possessing almost regular echo intensity. Echo intensity or echo pattern was recognized according to its corresponding histological appearance in tumor or chronic pancreatitis. From this study, it is concluded that the ultrasonogram corresponds well to the histological findings of the pancreas.

ACKNOWLEDGEMENT

The author wishes to thank Professor Itsuro Sobue, 1st Department of Internal Medicine, Nagoya University School of Medicine and Director Tatsuzo Kasugai, 1st Department of Internal Medicine, Aichi Cancer Center Hospital for their review of this paper. I would also like to extend my thanks to Harumi Suzuki, M.D., Yoshiaki Kato, M.D., Hajime Kato, M.D., Hideki Tada, M.D. for their helpful criticism of this paper. The help of the Radiology Department and the Internal Medicine Department of Aichi Cancer Center Hospital is greatly appreciated.

REFERENCES

1) Weill, F.S., Ultrasonography of digestive diseases. Mosby St. Louis, Tronto, London, 2nd Ed., part 4, pp.275—381, 1982.
2) Weill, F.S., Schraub, A., Eisenscher, A., *et al.* Ultrasonography of the Normal Pancreas. *Radiology*, **123**, 417—423, 1977.
3) De Graaff, C.S., Taylor, K.J.W., Simonds, B.D., *et al.* Gray-Scale Echography of the Pancreas. *Radiology*, **129**, 157—161, 1978.
4) Haber, K., Freimanis, A.K. and Asher W.M., Demonstration and dimensional analysis of the normal pancreas with gray-scale echography. *Am. J. Rent.*, **126**, 624—628, 1976.
5) Arger, P.H., Mulhrtn, C.B., Bonavita, J.A. *et al.* An analysis of pancreatic sonography in suspected pancreatic disease. *J. Clin. Ultrasound,* **7**, 91—97, 1979.
6) Weinstein, D.P., wolfman, N.T. and Weinstein, B.J., Ultrasonic Characteristics of Pancreatic Tumors. Gastrointest. *Radiol.*, **4**, 245—251, 1979.
7) Worthen, N.J. and Beabeau, D., Normal Pancreatic Echogenicity: Relation to Age and Body Fat. *Am. J. Rent.*, **139**, 1095—1098, 1982.
8) Filly, R.A. and London, S.S., The normal pancreas: Acoustic characteristics and frequency of imaging. *J. Clin. Ultrasound,* **7**, 121—124, 1979.
9) Filly, R.A. and Freimanis, A.K., Echographic Diagnosis of Pancreatic Lesions: Ultrasond Scanning Techniques and Diagnostic Findings. *Radiology*, **96**, 575—582, 1970.
10) Ghorashi, B. and Rector, W.R., Gray scale sonographic anatomy of the pancreas. *J. Clin. Ultrasound,* **5**, 25—29, 1977.
11) Fukuda, M., Diagnosis of Pancreatic Carcinoma by Greyscale Echography — Diagnostic Criteria and Echo Pattern Classification. Early Diagnosis of Pancreatic Cancer. pp.79—89, Edited by Kawai K., Igaku-Shoin, Tokyo, 1980.
12) Husband, J.E., Meire, H.B. and Kreel, L., Comparison of ultrasound and computer-assisted tomography on pancreatic diagnosis. *Br. J. Radiol.*, **50**, 855—862, 1977.
13) Haubrich, W.S., Tumors of the pancreas. Gastroenterology. pp.1102—1153, Edited by Bockus, H.L, 3rd Ed., Vol. III, W.B. Saunders Company, Philadelphia, 1976.
14) Wright, C.H., Maklad, F. and Rosenthal, S.R., Grey-scale ultrasonic characteristics of carcinoma of the pancreas. *Br. J. Radiol.*, **52**, 281—288, 1979.
15) Miyashita, T., Suzuki, T., Uchida, K., *et al.* Intraoperative ultrasonography for pancreatic surgery. *Journal of Clinical Surgery,* **37**, 63—71, 1982.
16) Kimoto, E., Nakazawa, S. and Naito, Y., Ultrasonography of the pancreas compared with pathological fondings. *Japanese Journal of Gastroenterology,* **79**, 86—95, 1982.
17) Kitamura, T., Ultrasonogram of pancreatic parenchyma. *IGAKUNOA YUMI,* **121**, 143—152, 1982.
18) Behan, M. and Kazam, E., The Echographic Characteristics of Fatty Tissues and Tumors. *Radiology,* **129**, 143—151, 1978.

19) Davis, P.L., Filly, R.A. and Goerke, J., In Vitro Demonstration of an Echogenic Emulsion: Relationship of Lipid Particle Size to Echo Detection. *J. Clin. Ultrasound,* **9**, 263—266, 1981.
20) Marks, W.M., Filly R.A. and Callen, P.W., Ultrasonic Evaluation of Normal Pancreatic Echogenicity and Its Relationship to Fat Deposition. *Radiology,* **137**, 475—479, 1980.
21) Hayakawa, T., Miyaji, M., Katagiri, K., *et al.* Comparative study on echogenicity and histological findings of the pancreas in the elderly. *Japanese Journal of Gastroenterology,* **79**, 2305—2313, 1982.