# Ultrasonographic Diagnosis of Pneumobilia
## —An Experimental and Clinical Study—

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# Pneumobiliaの超音波診断
## —基礎および臨床的検討—

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従来よりPneumobiliaの診断は腹部単純X線検査が主であったが，最近，超音波検査による診断も行なわれるようになってきた．しかしながら超音波検査時に肝内結石とまぎらわしい像として臨床的に問題となってきた．そこでわれわれはPneumobiliaの超音波像に関して基礎的ならびに臨床的検討を行なった．この結果Pneumobiliaの基本的超音波像は弱い音響陰影をともなう高エコーとして描出できた．さらに臨床的には，胆管分枝内の空気の状態によりStairs typeとBranching typeの2種類に大別できた．すなわちStairs typeは胆管内の胆汁と混在する場合であり，高エコーが階段状に散在するように描出できる．一方Branching typeは胆管内がほとんど空気で満たされた場合であり，高エコーが胆管分枝に一致してbranch状に描出できる．臨床的には，体位変換によりStairs typeからBranching typeへ，またはその逆に容易に変化することが認められた．

## Introduction

Pneumobilia is a gas image that is found but should not naturally be present in the intrahepatic or extrahepatic bile ducts. General causes have been frequently attributed to biliary-digestive anastomosis and the presence of internal biliary fistulas[1)~5)]. Although the pneumobilia could be diagnosed with abdominal plain radiographs, the ultrasonographical study became a first diagnostic aid in acute abdomen. On the ultrasonograph, the pneumobilia may make their diagnoses ambiguous in hepatobiliary disorders such as intra- and extrahepatic calculi due to the strong echo of the gas in the biliary tract. The authors carried out an experimental study on ultrasonographical images of pneumobilia and the ultrasonographs of 65 cases of pneumobilia experienced in our hospital were reviewed.

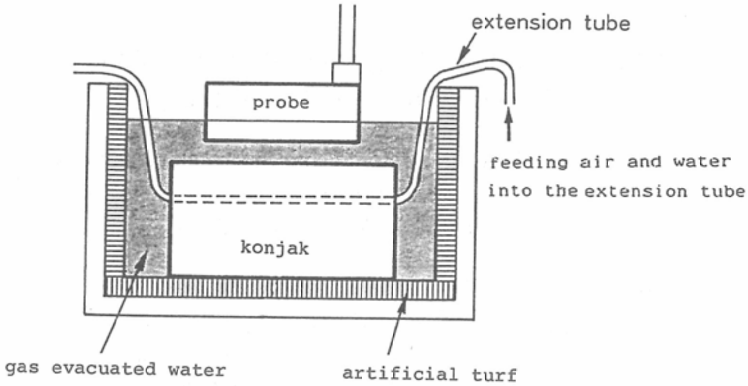



Fig. 1 Schematic diagram showing the method used in the experimental study.

Table 1 Pneumobilia Cases (1981.11—1984.6)

| | |
|---|---|
| Pancreatoduodenectomy | 28 |
| Choledochojejunostomy Roux Y-anastomosis | 14 |
| Hepatico-jejuno-duodenoplasty | 7 |
| Choledochoduodenostomy | 2 |
| Endoscopic Sphincteroplasty | 5 |
| Cholecysto-duodenal fistula | 4 |
| Cholecysto-colonic fistula | 3 |
| Choledocho-duodenal fistula | 2 |
| Total | 65 |

## Materials and Methods

1) Experimental study

After filling an artificial turf lined tank with gas evacuated water, "konjak" (a paste made from the arum root) which served as a substitute for the liver was fixed in the tank. A polyvinyl tube to take place of the bile duct was inserted into the "konjak". By feeding air and/or water into the polyvinyl tube, ultrasonographs were taken using an Aloka SSD-256 model with a 3.5 MHz probe (Fig. 1).

2) Clinical study

We have experienced sixty five cases of pneumobilia from November, 1981 to June, 1984 at the First Department of Surgery, Teikyo University School of Medicine (Table 1). The causes of pneumobilia included 51 biliary-digestive anastomosis, 5 endoscopic sphincteroplasty, and 9 intrabiliary fistula (cholecystoduodenal fistula, cholecystocolonic fistula, choledochoduodenal fistula).

## Results

1) Experimental study

i) The ultrasonographic image with the polyvinyl tube filled with water.

A clear delineation of the anterior and posterior walls of the polyvinyl tube was obtained as an echogenic double line (Fig. 2, left).

ii) The ultrasonographic image with the polyvinyl tube filled with air.

An echogenic single line which looked like a branch of the substitute tube, accompanied with weak acoustic shadowing was displayed, however, the difference between the anterior and posterior wall was undistinguishable (Fig. 2, center).

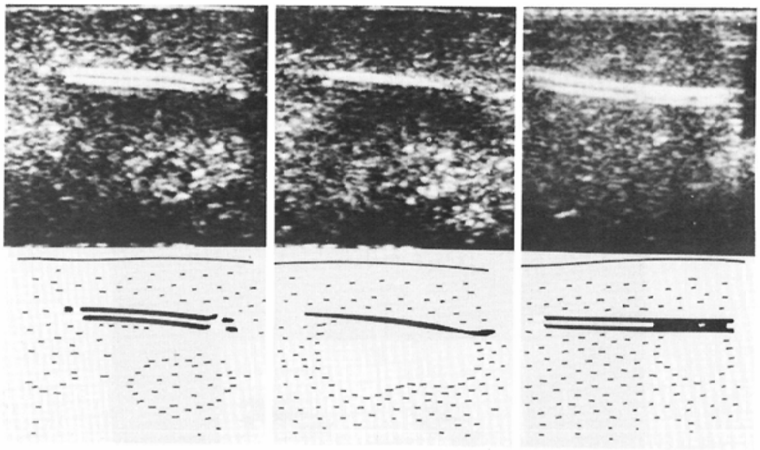
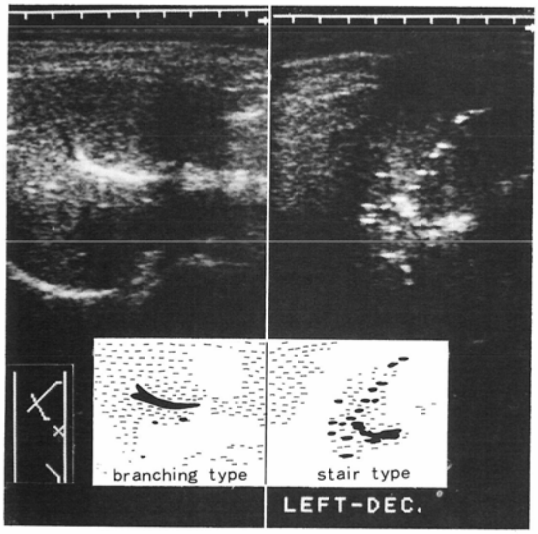
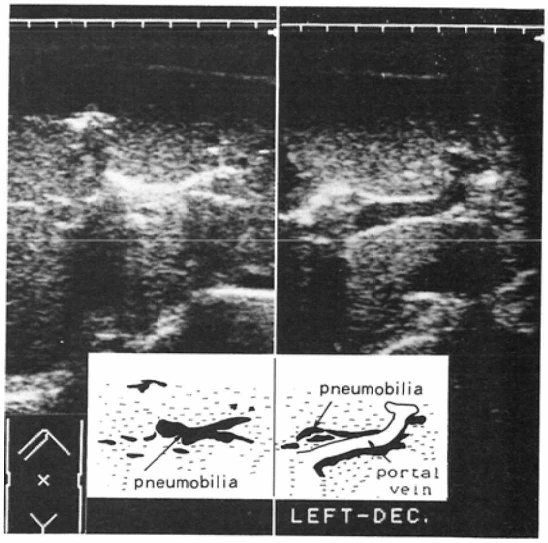



Fig. 2 Ultrasonographs of a substitute tube filled with water and/or air.




Left: Branching type.
A strong echo is reflected uniformly along the intrahepatic branches of the biliary tree.
Right: Stairs type.
A strong echo is reflected in a staircase like configuration within the intrahepatic bile duct.

Fig. 3 Ultrasonographic images of pneumobilia

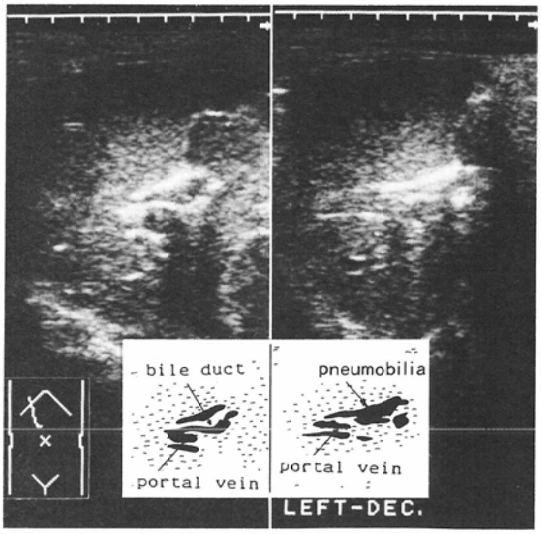



Left: Due to pneumobilia, the portal vein cannot be visualized.
Right: In a left decubitus position, transposing air in the bile duct and the portal vein can be clearly seen.

Fig. 4 Ultrasonogram taken after choledocojejuno-anastomosis.

iii) The ultrasonographic image with the polyvinyl tube filled with water and air.

The areas filled with water were displayed as clear echogenic lines showing the anterior and posterior walls of the polyvinyl tube. The air was displayed as a echogenic single line which looked to be one of stair of a staircase accompanying with a weak acoustic shadow (Fig. 2, right).




Left: In a spine position, the delineation of the common bile duct is possible when there is no gas in the common bile duct.
Right: In a left decutitus position, it is difficult to visualize the common bile duct due to the strong echo of the gas in the branches of the biliary tract.

Fig. 5 Ultrasonographs taken after endoscopic sphincteroplasty.

vi) Brief outline

The results of this experiment suggested that the basic ultrasonographic image of pneumobilia is a strong echo with a weak acoustic shadow. The ultrasonographic images of fluid mixed with air in the tube showed strong echos which looked like a part of a staircase.

2) Clinical study

i) Ultrasonographic findings of pneumobilia

The ultrasonographic images in the 65 cases of pneumobilia were classified into the branching and stairs types. The branching type in which a strong echo accompanied with a weak acoustic shadow was shown throughout the biliary branches (Fig. 3, left) and the stairs type in which a strong echo accompanied with a weak acoustic shadow is exhibited in a staircase-like configuration (Fig. 3, right). However these types of images were interchanged followed with the change of the patient position.

ii) Pneumobilia following biliary-digestive anastomosis

A characteristic ultrasonographic images of 51 cases following biliary-digestive anastomosis was a strong echo accompanied with a weak acoustic shadow in a supine position. These cases variably showed both branching and stairs types. Due to the strong echo of the gas, the portal vein could be rarely delineated (Fig. 4, left). When the patient was placed in a left decubitus position, the gas which produced the strong echo around the portal vein in the bile duct moved and thus the portal vein was clearly delineated (Fig. 4, right).

iii) Pneumobilia following endoscopic sphincteroplasty

The ultrasonographic images of the 5 cases following endoscopic sphincteroplasty differed from those in biliary-digestive anastomosis. There were no gas in the common bile duct of these cases in a spine position, and thus the common bile duct could be delineated (Fig. 5, left). However, in a left decubitus position, because the gas flew in the common bile duct, it was difficult to delineate the common bile duct due to the strong echo and weak acoustic shadow of the gas (Fig. 5, right).

## Discussion

Surgical causes of pneumobilia include biliary-digestive anastomosis, sphincteroplasty, endoscopic sphincteroplasty and biliary fistula[1)2)]. Other causes include incompetence of the sphincter of Oddi and emphysematous cholecystitis[3)~5)] in which pneumobilia used to be diagnosed with abdominal plain radiographs. In these cases biliary gas images appeared to be branches of the biliary tree. As stated previously, care should be taken to differenciate pneumobilia from the cases of mesenteric infarction, necrotic enterocolitis and the cases of the umbilical vein catheterization in which the gas may enter the portal veins[12)].

However the gas in the portal vein can be distinguished because the gas image distributes to the peripheral portion of the liver shadow on the plain radiographs. The gases of liver abscess could be seen as characteristic multiple small air bubbles and thus it is possible to differenciate such cases from pneumobilia in which the gases could be found as branching shadows.

Weill[8)] stated that abundant intraductal air gave rise to multiple strongly echogenic linear refflections, and acoustic shadowing could be minimal. Chu et al.[9)] also stated that the gas in the biliary tract may be mimicked by intrahepatic calculi, calcified tumors and granulomas. It also becomes difficult to delineate the intrahepatic structure, and to diagnose the liver metastasis with pneumobilia. In the present study, there were some cases in which it was difficult to delineate the portal vein due to the strong echo of pneumobilia. However, when the patient was placed in a left decubitus position, and thus the strong echo of the gas was eradicated from the bile duct, the portal vein was clearly demmonstrated. The alteration of the patient position enables not only to diagnose pneumobilia but also to demonstrate the intrahepatic structures which were not clearly seen due to the strong echoes. Furthermore, Prando et al.[10)] have reported that it was possible to distinguish pneumobilia from intrahepatic calculi, because the gas tended to be a linear, branching configuration corresponding to the distribution of the biliary tree. Ichikawa[11)] also reported that it was possible to differenciate between pneumobilia and intrahepatic calculi because the acoustic shadow was narrow and weak in pnuemobilia and the acoustic shadow was generally large and strong in intrahepatic calculi.

As the results of the present study, the basic ultrasonographic image of pneumobilia has strong echoes accompanied with weak acoustic shadowing. Furthermore, ultrasonographic images were characteristically changed by the alteration of the patient positions.

With these characteristic sonographic images of pneumobilia, it would be easy to differenciate pneumobilia from intrahepatic calculi, calculi of the gallbladder, as well as, calculi of the common bile duct. In respect to the ultrasonographic patterns of pneumobilia, Ichikawa[11)] classified them into 6 types namely scattering pattern, branching pattern, lined pattern, single pattern, diffused pattern, and mixed pattern. And if a small amount of air was gradually injected through a T-tube into the biliary tract, all of these 6 types could be sequentially observed.

In the present experimental study, the ultrasonographic images of the substitute biliary tract showed the branching type patterns when the air was entirely filled, whilist the ultrasonographic images looked the stairs pattern when the small amount of air was mixed with water.

These facts could indicate that the differencies of 6 types of ultrasonographic images in pneumobilia classified by Ichikawa[11)] depended on the quantity of gas rather than the quality in the biliary tract.

The ultrasonographic image of pneumobilia, thus, could be primalily classified into only the branching and stairs types according to the features of the gas whether which was diffused with the fluid or entirely filled in the biliary tract.

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