Diagnosis of Intrahepatic Stone by Endoscopic Retrograde Intrahepatic Cholangiography —A Comparative Study with Intravenous Radionuclide Cholescintigraphy and Ultrasonography—

Chaur Shine Wang

Summary: In our analysis of the diagnostic result of ERIC in intrahepatic stone, it revealed that 74 among 93 patients with intrahepatic stone were correctly diagnosed by ERIC. On the other hand, 6 among 232 patients of non-intrahepatic stone were incorrectly diagnosed as intrahepatic stone by ERIC. As a result, the diagnostic sensitivity, specificity and accuracy of ERIC in intrahepatic stone were assessed to be 79.6%, 97.4% and 92.3% respectively. The ERIC would clearly show out the entire biliary tract, local stenosis, and location and size of stone. Preoperatively, it is one of the most useful and effective methods in accurate diagnosis on both intrahepatic stone and its associated abnormalities of biliary tree.

Comparing the sensitivity, specificity and accuracy among ERIC, IVRC and US, we find that: (a) both sensitivity and accuracy are the best in US, (b) the specificity shows no significant difference among ERIC, IVRC and US. Although US is the most sensitive diagnostic procedure for intrahepatic stone, the local stenosis of bile duct and spetial relationship between stone and entire biliary tree are unable to be clearly demonstrated by US. Therefore, preoperatively, a direct cholangiography by ERIC or PTC is further necessary for obtaining a better surgical result. IVRC is also effective in diagnosis of intrahepatic stone. However, because of having two dis-advantages of limited anatomic resolution and non-efficiency in detecting extrahepatic stone, the usefulness of IVRC in common practice has largely been reduced.

Introduction:
Before percutaneous transhepatic cholangiography (PTC) and endoscopic retrograde intrahepatic cholangiography (ERIC) were widely applied, the intrahepatic stone was rarely diagnosed correctly before operation. Since the success of endoscopic cannulation of the ampulla of Vater by McCune (1968), Oi (1970) and Takagi (1970), the endoscopic retrograde cholangiopancreatography (ERCP) has been proved to be one of the most effective methods in the diagnosis of pancreato-biliary tract diseases.

In order to avoid overlooking abnormalities of the intrahepatic duct, Ayoola, in 1976, did have a comment that the ERCP should include an attempt at filling the biliary system beyond the bifurcation of right and left hepatic duct. The pharmacological endoscopic pancreato-cholangiography using CCK-PZ, caerulein, reported by Tomatsu was able to provide a further information concerning the differential diagnosis of intrahepatic diseases. By using the ERIC, the preoperative diagnosis of intrahepatic stone became possible and easier. In 1979, Chen reported that ERCP (ERIC) had a 87.7% diagnostic
accuracy in intrahepatic stone, proving that the ERIC is one of the most effective methods.

On the other hand, several reports have indicated that the intravenous radionuclide cholecintigraphy (IVRC)\textsuperscript{7–9}, ultrasonography (US)\textsuperscript{10–12} and computed tomography (CT)\textsuperscript{12} are also effective in diagnosis of intrahepatic stone. It is therefore the preoperative diagnosis of intrahepatic stone can easily be made in nowadays by PTC\textsuperscript{10,11,13,14}, ERIC, IVRC, US, and CT. As the PTC is more invasive\textsuperscript{6,15}, it is not recommendable for outside patients. Whereas the CT is too expensive to be widely applied. Consequently, the ERIC, IVRC and US are more frequently being applied as screening test for intrahepatic stone.

In our selection of most efficacious approach to the patient, it is essential to have a full understanding in the particular usefulness of these three diagnostic procedures. The purpose of this paper is to evaluate the diagnostic abilities, advantages, and disadvantages of ERIC in detecting intrahepatic stone, and furthermore is to compare the result of ERIC with IVRC and US.

**Material:**

During the period between 1976 to 1983, 601 cases of benign biliary tract diseases, which include 120 cases of intrahepatic stone, 416 cases of extrahepatic stone and 65 cases of other benign diseases (Table 1), have received surgical intervention at Taipei Municipal Jen-Ai Hospital. The incidence of intrahepatic stone in this series is 22.4%.

**Method:**

The records of ERIC, IVRC and US of these 601 patients were analyzed and interpreted by the author. It was then further being proved by the surgical findings.

The intrahepatic stone is defined according to Nakayama\textsuperscript{15} as that the presence of stones in the intrahepatic bile duct is essential. But the stones originating in the gallbladder and migrating up to the intrahepatic duct, the so-called mouse stones, are excluded.

**ERIC:** The patient was prepared with over night fasting. After intravenous injection of 2cc of Hyoscyn-N-Butylbromide (Buscopan), a side-viewing fiberduodenoscope (FDS) of Machida or JFB2/JFB3 of Olympus was gently introduced into the duodenum to visualize the orifice of ampulla of Vater. After cannulation, the duct system was injected, under fluoroscopic monitoring, with sodium diatrizoate (Hypaque) of 50\% or 25\% concentration. In order to obtain a detailed ductal configuration, the patient was kept in head-down position and was encouraged to take deep breath and to cough during injecting the contrast medium. Multiple recordings were taken in

<table>
<thead>
<tr>
<th>Table 1</th>
<th>Surgical cases of benign biliary tract disease. (1976~1983)</th>
</tr>
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<tbody>
<tr>
<td></td>
<td>1976</td>
</tr>
<tr>
<td>IHS</td>
<td>0</td>
</tr>
<tr>
<td>IHS+CBDS</td>
<td>4</td>
</tr>
<tr>
<td>IHS+CBDS+GBS</td>
<td>0</td>
</tr>
<tr>
<td>IHS+GBS</td>
<td>0</td>
</tr>
<tr>
<td>CBDS</td>
<td>2</td>
</tr>
<tr>
<td>CBDS+GBS</td>
<td>0</td>
</tr>
<tr>
<td>GB5</td>
<td>13</td>
</tr>
<tr>
<td>total</td>
<td>19</td>
</tr>
<tr>
<td>others#</td>
<td>0</td>
</tr>
<tr>
<td>total</td>
<td>19</td>
</tr>
</tbody>
</table>

\# including the cases other than biliary tract stone.
various positions of supine, prone, oblique and standing after the whole biliary system was fully filled.

The diagnosis of intrahepatic stone was made when radiolucent stone was demonstrated in the intrahepatic duct (Figure 1-5). In addition, the intrahepatic stone was suspected when multiple stones compacted the entire extrahepatic bile duct making the contrast medium unable to fill the intrahepatic duct (Figure 6), and when a local stenosis with tapering off was found in a segment of intrahepatic duct (Figure 7).

IVRC: The serial cholescintigrams were taken at 5, 15, 30, 60, 120, 240 and 360 min. after an intravenous injection of 3-5 mci of either Tc-99m-PG or Tc-99m-HIDA.

The intrahepatic stone was diagnosed when IVRC
illustrated the following: (1) intrahepatic cold area in the initial image, and (2) prolonged retention of radioactivity at the corresponding area in the images after 4 hours of injection (Figure 12).

**US:** The US examination was performed using Aloka SSD-256 or SSD-202 real time scanner. The diagnosis of intrahepatic stone was made when strong
echoes in shapes of stripe, round and/or oval with acoustic shadows in a dilated intrahepatic bile duct (Figure 13) or strong echoes with acoustic shadows in the liver parenchyma (Figure 14) were demonstrated.

Result:
The diagnostic results of ERIC, IVRC and US in intrahepatic stone are shown in table II. In the 601 patients, ERIC was performed in 93 cases of intrahepatic stone and 232 cases of nonintrahepatic stone. Among the 93 patients with intrahepatic stone, the cholangiography was successfully obtained in 86 patients and technical failure in 7 patients.

The endoscopic retrograde cholangiogram of these
86 patients are classified into following 8 groups (Table 3).

**Group I**: Radiolucent stone in the dilated intrahepatic bile duct (IHBD) which associated with a proximal stenosis and post-stenotic dilation (Figure 1–4).—48 patients

**Group II**: Multiple stones in both extra and intrahepatic bile duct (Figure 5)—15 patients

**Group III**: Multiple stones compacting in the

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**Figure 11** Group VIII, left intrahepatic stone, unable to fill IHBD by ERIC caused by stone compacted at the end of common bile duct.

**Figure 12** Left intrahepatic stone, IVRC showing cold area in the initial image (5 min.) and prolonged retention of radioactivity at the late image (4 hrs after injection of Tc-99m-HIDA).

**Figure 13** Right intrahepatic stone, US demonstrating strong echo with acoustic shadow within dilated IHBD.
Figure 14  Right intrahepatic stone, US demonstrating strong echo with acoustic shadow in the liver parenchyma.

Table 2  Diagnostic result of ERIC, IVRC and US in intrahepatic stone.

<table>
<thead>
<tr>
<th></th>
<th>ERIC</th>
<th>IVRC</th>
<th>US</th>
</tr>
</thead>
<tbody>
<tr>
<td>Intrahepatic stone</td>
<td>93</td>
<td>58</td>
<td>92</td>
</tr>
<tr>
<td>Correct diagnosis</td>
<td>74</td>
<td>45</td>
<td>88</td>
</tr>
<tr>
<td>Incorrect diagnosis</td>
<td>19</td>
<td>13</td>
<td>4</td>
</tr>
<tr>
<td>Non-intrahepatic stone</td>
<td>232</td>
<td>86</td>
<td>271</td>
</tr>
<tr>
<td>Correct diagnosis</td>
<td>226</td>
<td>82</td>
<td>266</td>
</tr>
<tr>
<td>Incorrect diagnosis</td>
<td>6</td>
<td>4</td>
<td>5</td>
</tr>
</tbody>
</table>

Sensitivity 79.6% 77.6% 95.7%
Specificity 97.4% 95.3% 98.1%
Accuracy 92.3% 88.2% 97.5%

*Fisher exact test

entire extrahepatic bile duct (EHBD) making the contrast medium unable or improper to fill the IHBD (Figure 6) — 6 patients

Group V : Non-visualization of either left or right HBD (Figure 8) — 5 patients

Group VI : Stenosis at the point of bifurcation of right and left HBD (Figure 9A) — 1 patient

Group VII : Chronic cholangitis pattern due to obstruction at the orifice of a branch of bile duct containing stones (Figure 10A) — 2 patients

Group VIII : None or improper filling of IHBD caused by the compacted stone at the end of common bile duct (Figure 11) and/or technical difficulty — 4 patients

The total number of 74 cases of intrahepatic stone including those group V to group W were successfully diagnosed by ERIC preoperatively. In the cases of incorrect diagnosis, we came to note that there were 19 cases including 7 cases of technical failure and those cases indicated from group V to VIII. Of the 6 false positive cases of ERIC, there were two cases of pneumobilia (in Group II), two cases of chronic cholangitis with local stenosis (in Group IV), one case of cholangiocarcinoma (in Group V) and one case of improper filling of intrahepatic bile duct (Group III). By assuming that group III and IV are being regarded as negative, the specificity will increase from 97.4% to 99.6%.

In IVRC examination, there were 58 cases of intrahepatic stone and 86 non-intrahepatic stone. 45 among 58 cases of intrahepatic stone were correctly diagnosed by JVRC. Of 13 cases which were incorrectly diagnosed, there were 6 of hepatic parenchymatous fibrosis, 2 of deep jaundice, 3 of stone within cholangiocarcinoma, and one each on cirrhosis and that unknown. The 4 false positive cases of IVRC were 3 of common bile duct stone and one of calculous acute cholecystitis.

In US examination, there were 92 cases of intrahepatic stone and 271 non-intrahepatic stone. 88 of 92 intrahepatic stone were correctly diagnosed by US. The 4 cases which were incorrectly diagnosed were as follows: (1) peripheral location of stone, (2) scanty small stones in cholangiocarcinoma, (3) intrahepatic
stone with pneumobilia, and (4) unskillful technique. In false positive cases of US, we noted there were 5 cases in total, 3 cases were pneumobilia, one case was chronic cholangitis and the other was metastatic carcinoma of the liver.

Comparing the sensitivity, specificity and accuracy among ERIC, IVRC and US, we come to know that:

(a) both sensitivity and accuracy are the best in US and no significant difference between ERIC and IVRC,
(b) the specificity shows no significant difference among ERIC, IVRC and US.

**Discussion:**

The intrahepatic stone is one of the most difficult and troublesome diseases encountered by abdominal surgeons because they usually require reoperation for recurrent or retained stones\(^{15,16}\). Therefore, in order to obtain a better surgical result, it is preoperatively essential to have a direct cholangiogram to locate the position of stone and to demonstrate pathological abnormalities of biliary tract. One of the characteristics of ERIC is a retrograde direct cholangiography which can clearly show the entire biliary tract, local stenosis, and location and size of stone. Preoperatively, both ERIC and PTC are the only ones that have been the most useful and effective methods in accurately diagnosing both intrahepatic stone and its associated pathologic abnormalities of biliary tract. Since ERIC is less invasive and safer in diagnostic procedure\(^ {15,16}\), it appears to be more acceptable than PTC. The serious complication of PTC including bile leakage and hemorrhage may otherwise happen even with this needle\(^ {17-19}\). Aside from this,

### Table 3 Endoscopic Retrograde Cholangiogram of 86 Patients with Intrahepatic Stone.

<table>
<thead>
<tr>
<th>Group No.</th>
<th>Schema</th>
<th>No. of Patients</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.</td>
<td>Radiolucent stone in the dilated IHBD (Fig. 1.4)</td>
<td>48</td>
</tr>
<tr>
<td>11.</td>
<td>Multiple stones in both IHBD and EHBD (Fig.5)</td>
<td>15 (2)</td>
</tr>
<tr>
<td>111.</td>
<td>Multiple stones compacting in the entire EHBD (Fig.6)</td>
<td>6 (1)</td>
</tr>
<tr>
<td>IV.</td>
<td>Local stenosis with tapering off (Fig. 7)</td>
<td>5 (3)</td>
</tr>
<tr>
<td>V.</td>
<td>Non-visualization of either Lt or R't HBD (Fig.8)</td>
<td>Lt: 4, R't: 1</td>
</tr>
<tr>
<td>VI.</td>
<td>Stenosis at the point of bifurcation of R't and Lt HBD (Fig. 9A)</td>
<td>1</td>
</tr>
<tr>
<td>VII.</td>
<td>Chronic cholangitis pattern (Fig. 10A)</td>
<td>2</td>
</tr>
<tr>
<td>VIII.</td>
<td>None or improper filling of IHBD (Fig. 11)</td>
<td>4</td>
</tr>
</tbody>
</table>

Total: 86 ( ) indicate false positive case
IHBD: intrahepatic bile duct, R't : right, EHBD: extrhepatic bile duct, L't : left, HBD : hepatic bile duct.

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several authors\cite{19,20,21,22} have also denoted that the intrahepatic stone is almost always accompanied with bacterial infection in the bile. Therefore, leakage of infected bile in the peritoneal cavity may have serious consequence. ERIC is further effective in detecting other associated diseases of intrahepatic stone such as common bile duct stone, pancreas diseases, hemobilia and ampulla lesion.

The two major disadvantages of ERIC are noted to be in technical limitation and complications. It has technical limitation in case of post Billroth II subtotal gastrectomy and anatomical variation such as poor direction of ampulla orifice, duodenal diverticulum, inner rotation of duodenal loop... etc. The incidence of complication in ERCP was reported to be in the range from 0.6 to 3.1\%\cite{23}. The main complications among them are ascending infection, pancreatitis, drug allergy, hemorrhage and intestinal injury. The ERIC is also contraindicatory in case of hypersensitivity to contrast medium, acute pancreatitis, cholangitis and severe heart disease.

The IVRC is one of the methods in functional and morphologic study of biliary tract. It has been proven very effective in diagnosing acute cholecystitis\cite{24,25}. The two major disadvantages of IVRC are its limited anatomic resolution and the necessity for preserving some degree of hepatocyte function. For examples: the IVRC does not have the resolution to visualize gallstones, and the IVRC May be limited in case of fibrosis of hepatic parenchyma, deep jaundice, impaired hepatic function and contraindicatory in pregnancy. Because of limited anatomic resolution and non-efficiency in detecting extrahepatic stone, the usefulness of IVRC in common practice has largely been influenced and reduced. Whereas, IVRC is the best way to differentiate between pneumobilia and intrahepatic stone or to expressly clarify the coexistence of pneumobilia and intrahepatic stone. Additionally, from our experience, a persistent cold area through the course of IVRC in patient of intrahepatic stone indicates severe fibrosis of hepatic parenchyma or possible neoplasm (most probable cholangiocarcinoma) coexisting with intrahepatic stone.

US is a non-invasive, non-hazard and most sensitive diagnostic procedure for intrahepatic stone. It is also effective in detecting gallbladder stone, common bile duct stone, space occupying lesion, pancreas disease and complications of intrahepatic stone such as liver abscess, pancreatitis... etc. The ultrasonic guided percutaneous transhepatic cholangiography (UGPTC), which has a very high efficiency in diagnosing intrahepatic stone\cite{26,27}, may be further applied when requested. One of the major advantages of US is its ability in showing stone shadow without relying on organ function or using contrast agents. The main disadvantages of US are that (1) it is difficult to demonstrate the local stenosis of bile duct, and (2) it is unable to show out the entire biliary tract in a tomographic picture. The US is the best ideal modality in the screen test for intrahepatic stone. But, a direct cholangiography by ERIC or PTC is further necessary for a patient with intrahepatic stone who is going to have surgical intervention.

Conclusion:

All ERIC, IVRC and US have a high sensitivity, specificity and accuracy in diagnosing intrahepatic stone. Among these, US is the most sensitive diagnostic procedure for intrahepatic stone. It is the most ideal modality to be used in a routine screen test. But, US is difficult in demonstrating the precise location of local stenosis and pathological abnormalities of biliary tract. These are very important and essential in obtaining a better surgical result. Even though the IVRC is very effective in diagnosing intrahepatic stone, the usefulness of IVRC in common practice has largely been reduced because of limited anatomic resolution and non-efficiency in detecting extrahepatic stone. Nevertheless, ERIC is able to demonstrate clearly the entire biliary tract, local stenosis and stone location. Therefore, preoperatively ERIC is one of the most useful and effective methods at present for accurately diagnosing both intrahepatic stone and its associated abnormalities of biliary tree.

Acknowledgement

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References