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Cholescintigraphic Observation of the Sphincter of Oddi Motor Activity in Patients with Gallstone

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Summary

In 36 cases with gallstones, biliary scintigraphy was performed before and after operation to prepare the time-activity curve in the juxta-papillary duodenum. This curve showed different patterns depending on the conditions of disease, and seemed to represent one aspect of the sphincter of Oddi phasic activity, in view of the exerted effect of caerulein administration. This method is useful as a non-invasive one for the diagnosis of dynamic function of the sphincter of Oddi.

Introduction

Motor activity of the sphincter of Oddi is an important factor for elucidating the etiology of biliary tract diseases. This sphincter of Oddi motor activity has been elucidated clinically by intracholedochal pressure recording using a tube introduced operatively via the common bile duct[8], by electromyographic findings obtained with the strain gauge positioned at the sphincter in animal experiments[9], or more recently, by ERCP during which a microtransducer catheter is inserted in a retrograde way into the sphincter area, thereby inferring the motility from the pressure wave types[12,13]. Among them, especially endoscopy with improvement of the techniques including the pressure sensor has been most prevailing. We devised a method using biliary scintigraphy to evaluate the function of sphincter of Oddi from decrements of a scanning agent (radionuclide (RN) activity) in the distal biliary tract[1,2]. The aim of this study was to evaluate the sphincter of Oddi motor activity from decrements of RN activity in the juxta-papillary duodenum.

Key words: Cholescintigraphy, Sphincter of Oddi, Gallstone disease, Juxta-papillary duodenal diverticula, Endoscopic sphincterotomy.
索引用語：胆道シンチグラフィー，オッディ括約筋，胆石症，十二指腸旁乳頭部憩室，内視鏡的乳頭括約筋切開術.
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Materials and Methods

1. Subjects

A total of 36 patients were enrolled in this study. They consisted of 8 preoperative patients (7 with cholecystolithiasis and 1 with choledocholithiasis plus juxta-papillary diverticulum) and 28 postoperative patients (23 who underwent cholecystectomy for gallbladder stones, 2 who underwent cholecystectomy and transduodenal sphincteroplasty for gallbladder and common

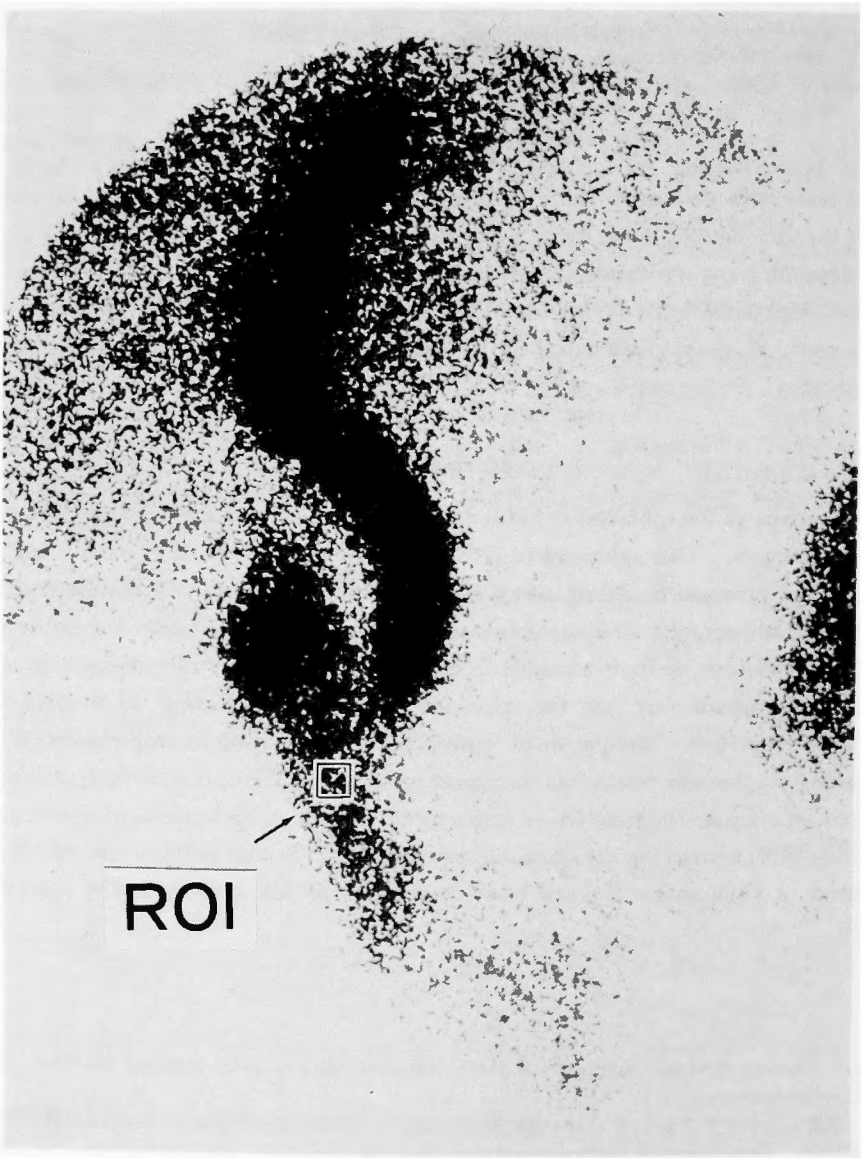

Fig. 1. Region of interest (ROI) seet up on the site of juxta-papillary area.

bile duct stones, and 3 who underwent endoscopic sphincterotomy for recurrent biliary calculi). The preoperative patients had no history of hepatic and biliary tract diseases. The postoperative patients were in two or three postoperative months and were noted to have normal liver function, being free from anemia or such lesions as would have possible influence on the present study.

2. Cholescintigraphy

The patients was intravenously injected 10 mCi of Tc-99m-E·HIDA. When a biliary tract image appeared 20 to 30 min later, a vitelline agent (Daiyan®, 13 g, Maruishi Seiyaku, Japan) was orally administered; then, the breathing was stopped for 30 seconds during which the biliary image was photographed 10 times at three second intervals using scinticamera (Pho/Gamma LFOV, Searle, West Germany) and recorded on a computer (Scintipac 1,200, NOVA 32 KW, Shimadzu, Japan), according to the method of KAWASHIMA for scintiphotographing[10,11]. In some patients, caerulein (Ceosunin®, Kyowa Hakko, Japan) was given intramuscularly 0.2 μg/kg of body weight, and imaging and recording were done after 5, 10, and 20 min according to the same method.

3. Preparation and analysis of time-activity (T–A) curve

The region of interest (ROI) was set up on the site of image corresponding to the juxtapapillary area of the duodenum (Fig. 1). With the RN activity of ten times in total in ROI, the ratio of RN activity at the start of imaging (R_o) and that in each frame (R_n), R_n/R_o was calculated to prepare the T–A curve. The wave type in these T–A curve were used to compute the maximal amplitude, frequency (waves/min, the number of wave during 30 seconds doubled), and duration of monophasic waves during 30 seconds.

Results

1. Pre- and postoperative cases of cholecystolithiasis

Fig. 2 shows the T–A curve in a representative preoperative case of cholecystolithiasis and in the same case cholecystectomized. Before operation, three distinct, regular waves with a wide amplitude appeared. After operation, similar waves were also observed, but the amplitude was rather narrow.

2. Transduodenal sphincteroplasty and endoscopic sphincterotomy

The T–A curve in a case which underwent cholecystectomy plus transduodenal sphincteroplasty for gallbladder and common bile duct stones is shown in Fig. 3. Compared with the T–A curves in the pre- and post-operative cases of cholecystolithiasis alone, this T–A curve was characterized by the wave which was obscure and narrow in amplitude. Besides, the T–A curve in a case which underwent endoscopic sphincterotomy did not show any distinct wave, additionally with a very narrow amplitude.

3. Properties of wave in the T–A curve

Based on the T–A curves, the maximal amplitude of wave, frequency in a minute, and duration of monophasic waves in each group were compared. The maximal amplitude tended to be wide in cases of pre- and post-cholecystectomy and narrow in other groups (Table 1). Fre-

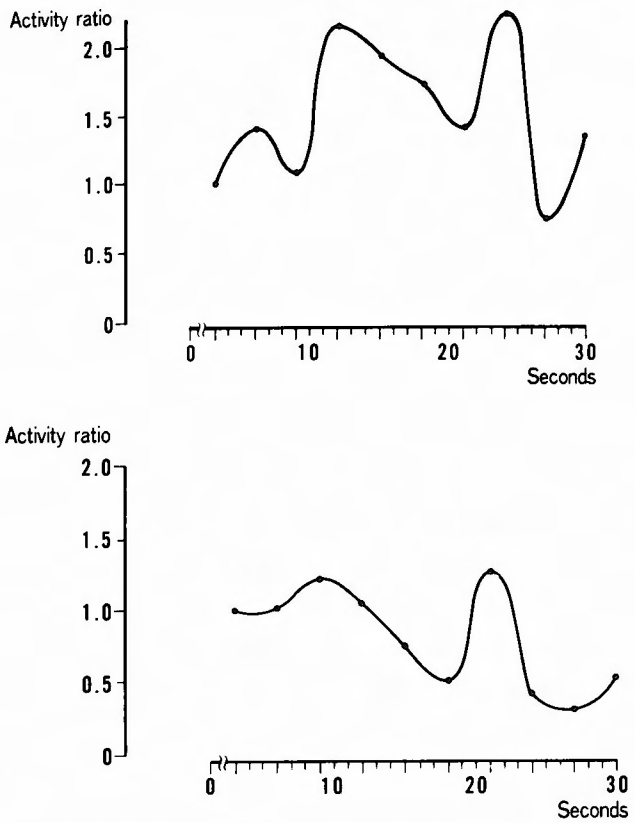

Fig. 2. Time-activity curves in a preoperative (top) or postoperative (bottom) case of gallbladder stones.

quency of wave was somewhat lower in pre-cholecystectomy group than in post-cholecystectomy group; duration tended to be longer in the former than in the latter. In post-cholecystectomy group, the waves with narrow amplitude tended to increase in number. In both groups of transduodenal sphincteroplasty and endoscopic sphincterotomy, it was not possible to measure the frequency and duration of wave, because of no appearance of waves being capable of such measurements on the T–A curve.

4. Influence of caerulein

In the preoperative case of cholecystolithiasis shown in Fig. 4. the bile volume showed a gradual increase after administration of caerulein; it increased six times the basal level 10 minutes later, and decreased but kept a higher level than the basal level 20 minutes later. In the postcholecystectomy case, the bile volume reached a peak five minutes after caerulein administration, showing only a four-fold increase compared to the basal level; thereafter it declined gradually and recovered to the basal level 20 minutes later.

5. A case with choledocholithiasis plus juxta-papillary diverticulum

Unlike the T–A curves in cases of cholecystolithiasis, the only waves that were irregular and

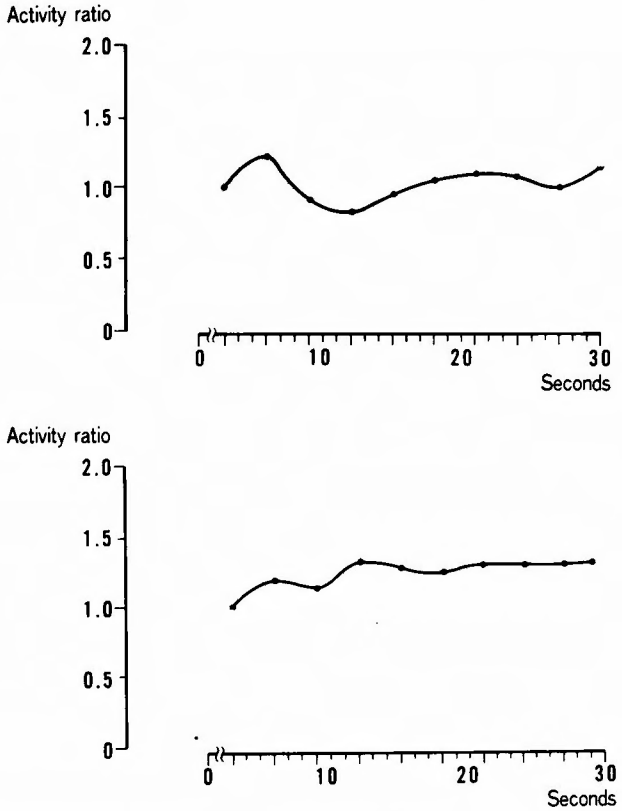

Fig. 3. Time-activity curves in a case underwent transduodenal sphincteroplasty with cholecystectoy (top), or endoscopic sphincterotomy (bottom).

Table 1. Scintigraphic characteristics of the sphincter of Oddi phasic contractions.

	No. of patients	Amplitude (arbitrary)	Frequency (per min)	Duration (sec)
Preoperative state (Gallbladder stones)	7	0.9 ± 0.4	5.8 ± 1.5	5.4 ± 1.2
Postcholecystectomy	23	0.8 ± 0.4	6.5 ± 1.5	4.9 ± 0.9
Cholecystectomy plus transduodenal sphincteroplasty	2	0.3 ± 0.1		
Endoscopic sphincterotomy	3	0.6 ± 0.2		

Mean ± S.D.

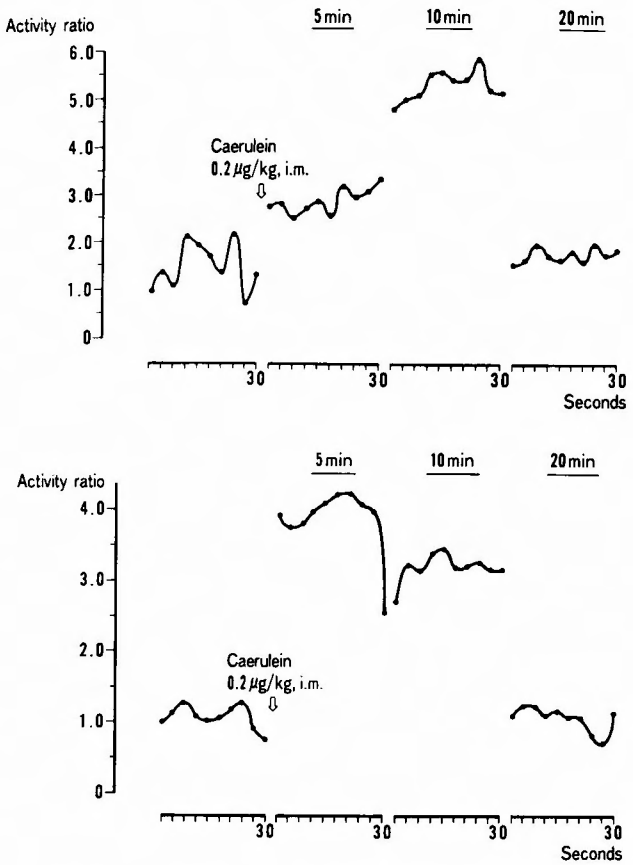

Fig. 4. Effect of caerulein on the sphincter Oddi motor activity in a preoperative (top) or postoperative (bottom) case of gallbladder stones.

narrow in amplitude appeared. Under caerulein loading as shown in Fig. 5, the bile volume remained under two-fold increase, and did not show any further increase 10 and 20 minutes later.

Discussion

We have an attempt to analyze the function of sphincter of Oddi by means of biliary scintigraphy and propose a method to infer the sphincter of Oddi function from the degree of decrements in RN activity in a distal area of the common bile duct[1,2,11]. This method has the following advantages: for the subject of study, the operative invasion is minimal and the dose of radioactivity is small; for the investigator, no specific technical skillfulness is needed. As a convenient method it has been applied in the clinical field. However, although the image can be enlarged to actual size by using a pinhole collimator[10,11], it takes as long as 30 seconds for photographing a time, and "blurring" of images due to the respiratory movement is not negligible. Consequently, although changes in RN activity in the distal common bile duct can be

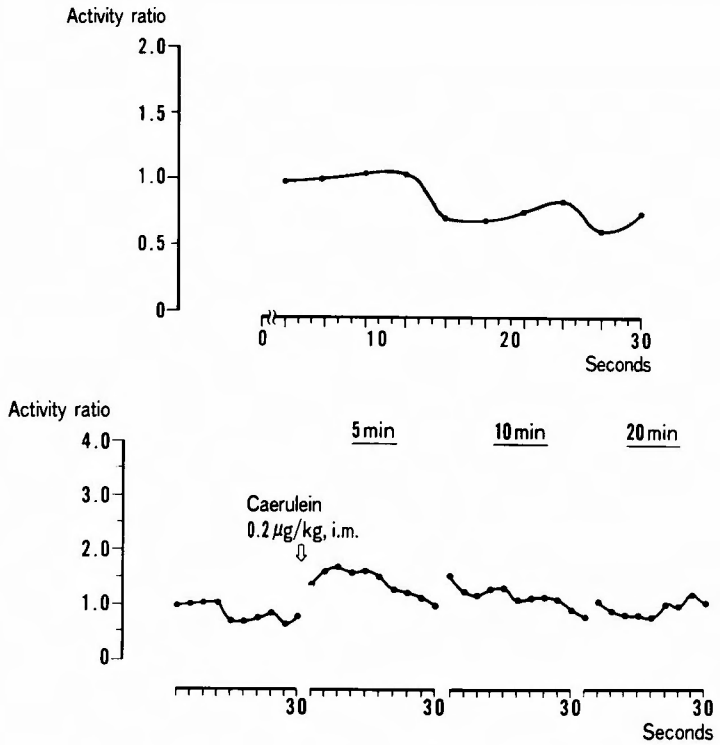

Fig. 5. Time-activity curve (top) and effect of caerulein on the sphincter of Oddi motor activity (bottom) in a case of common duct stones complicated with a juxta-papillary diverticulum.

quantitated, no detailed motor activity of the sphincter of Oddi can be explored.

In this study, we employed a method to take a photograph of the image 10 times at three second intervals, preventing "blurring" of the biliary tract image due to respiratory movement by means of breathing halt for 30 seconds. Further, the dose of a tracer was increased from 3 mCi to 10 mCi, so that it would be possible to examine delicate changes of RN activity in the juxta-papillary area of the duodenum even by photographing at three seconds intervals.

According to the previous studies on sphincter of Oddi phasic activity by endoscopic manometory, the frequency of contractions per minute was reported as 4 ± 0.5 (TOOULI et al.[15]), 4.1 ± 0.9 (GEENEN et al.[5]), 5.6 ± 2.4 (CARR-LOCKE et al.[3]), 6.89 ± 0.2 (MESHKINPOUR et al.[14]), and 7.5 ± 0.7 (CSENDES et al.[4]). Our results did not deviate from these values. Mean duration of monophasic waves was 4.3 ± 1.5 seconds (GEENEN et al.[5]) and 8.0 ± 0.6 seconds (TOOULI et al.[15]); our data of 5.4 ± 1.2 seconds in the pre-cholecystectomy case and 4.9 ± 0.9 seconds in the post-cholecystectomy case are median between them. It is most likely, therefore, that the T–A curve obtained by cholescintigraphy may seize one aspect of the sphincter of Oddi phasic activity.

The maximal amplitude of monophasic waves in the pre-cholecystectomy case was wider than in the post-cholecystectomy case. This finding ipmlies that if there exists the functioning

gallbladder even in the presence of gallstones, bile flows out from the gallbladder to the common bile duct, and the volume of bile excreted into the duodenum by the sphincter of Oddi phasic activity may be relatively increased as compared to that after cholecystectomy. Frequency of phasic activity tended to increase more or less after cholecystectomy, but no significant difference was noted statistically. Further investigations on functional changes of the sphincter of Oddi after cholecystectomy are indicated.

Since the aim of transduodenal sphincteroplasty and endoscopic sphincterotomy lies in opening of the sphincter of Oddi, it is easily conceivable that any distinct waves on the T–A curve may not be observed. This finding mean that bile from the bile duct flows out into the duodenum continuously due to loss of the sphincter of Oddi structure. However, in patients who underwent transduodenal sphincteroplasty or endoscopic sphincterotomy, GREGG et al.[6] examined the lost state of the function of sphincter of Oddi and reported that they were able to recognize the phasic activity, though reduced as compared with that before operation, in 60 percent of the former and in 21 percent of the latter. In view of these findings, it seems that the evaluation of the effect of these operations should be based on the long-term follow-up observations.

Caerulein contracts the gallbladder and relaxes the sphincter of Oddi thereby having the bile flow out into the duodenum[7]. When caerulein was loaded before and after cholecystectomy for gallbladder stones, the increase in RN activity on the T–A curve was more marked in the preoperative case. This seems to indicate that the bile accumulated in the gallbladder flows out into the common bile duct at a stroke by contraction of the gallbladder due to caerulein administration, and then the bile volume more increased by relaxation of the sphincter of Oddi flows out into the duodenum. In postoperative state, the excision of the gallbladder as a reservoir of bile resulted in the reduction of outflow of the bile into the duodenum. Some of duodenal juxta-papillary diverticula have been drawing attention in that they induce impairment of the sphincter of Oddi phasic activity which may be responsible for cholestasis, ascending infection, or common bile duct stones. In the patient of this disease which we encountered, no distinct phasic activity was observed, and even when caerulein was loaded, no effect was exerted in spite of the presence of the functioning gallbladder. In this case, cholecystectomy and choledocho-duodenostomy with jejunal interposition were performed for reconstruction of biliary tract. The analysis of calculi by infrared absorption spectrum revealed bilirubin-calcium as main ingredient, and bacterial culture of bile from the common bile duct evidenced E. coli.

These findings obtained in this study indicate that our devised method is a useful diagnostic technique for the function of the sphincter of Oddi.

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References

1) Aoki Y, Shimada K, Kakihara M, et al: Study on the function of sphincter of Oddi in patients with gallstone disease by dynamic hepatobiliary scintigraphy. J Jpn Surg Soc **86**: 1131–1134, 1985. (in Japanese with English abstract).

2) Aoki Y, Katsumi M, Kawashima H, et al: Cholescintigraphic study on the function of sphincter of Oddi in gallstone disease patients. Proceedings in 8th Annual Meeting of International Biliary Association, Sendai, Japan, 1986.
3) Carr-Locke DL, Gregg JA: Endoscopic manometry of pancreatic and biliary sphincter zones in man: basal results in healthy volunteers. Dig Dis Sci **26**: 7–15, 1981.
4) Csendes A, Kruse A, Funch-Jensen P, et al: Pressure measurements in the biliary and pacreatic duct systems in controls and in patients with gallstones, previous cholecystectomy, or common bile duct stones. Gastroenterology **77**: 1203–1210, 1979.
5) Geenen JE, Hogan WJ, Dodds WJ, et al: Intraluminal pressure recording from the human sphincter of Oddi. Gastroenterology **78**: 317–324, 1980.
6) Gregg JA, Carr-Locke DL: Endoscopic pancreatic and biliary manometry in pancreatic, biliary, and papillary disease, and after endoscopic sphincterotomy and surgical sphincteroplasty. Gut **25**: 1247–1254, 1984.
7) Hogan WJ, Dodds WJ, Geenen JE: The biliary tract. *In* A Guide to Gastrointestinal Motility edited by Christensen J, Wingate DL, Bristol, London, Boston, Wright·PSG Inc, 1983, p. 157–197.
8) Honda R, Toouli J, Dodds WJ, et al: Relationship of sphincter of Oddi spike bursts to gastrointestinal myoelectric activity in conscious opossums. J Clin Invest **69**: 770–778, 1982.
9) Ishioka T: Electromyographic study of the choledochoduodenal junction and duodenal wall muscle. Tohoku J Exp Med **70**: 73–84, 1959.
10) Kawashima H: Evaluation of motility in the terminal part of the common bile duct by hepatobiliary scintigraphy——Imaging magnification with pinhole collimator——. Jpn J Gastroenterol Surg **18**: 89–96, 1985. (in Japanese).
11) Kawashima H: A study on the function of sphincter of Oddi by biliary scintigraphy using pinhole collimator. Jpn J Gastroenterol Surg **20**: 739–747, 1988. (in Japanese).
12) Kobayashi K, Mitani E, Yamada H: Studies on the functional disturbances of the papillary region using a pressure sensor. Gastroenterol Jpn **11**: 293–299, 1976.
13) Masi ED, Corazziari E, Habib FI, et al: Manometric study of the sphincter of Oddi in patients with and without common bile duct stones. Gut **25**: 275–278, 1984.
14) Meshkinpour H, Mollot M, Eckerling GB, et al: Bile duct dyskinesia: clinical and manometric study. Gastroenterology **87**: 759–762, 1984.
15) Toouli J, Roberts-Thomson IC, Dent J, et al: Manometric disorders in patients with suspected sphincter of Oddi dysfunction. Gastroenterology **88**: 1243–1250, 1985.

和文抄録

胆道シンチグラフィーによる胆石症例の Oddi 括約筋律動運動の観察

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胆石症手術前後の36例において胆道シンチグラフィーを施行し，十二指腸乳頭部近傍に関心領域を設定することにより，この time-activity (T-A) curve から Oddi 筋の律動運動を観察する方法を工夫した．胆嚢結石症では術前後を問わず，比較的規則正しい，5秒前後持続する律動運動が5～6回／分の割合で観察されたが，胆摘・経十二指腸的乳頭括約筋形成術症例，胆摘・内視鏡的乳頭括約筋切開術症例，十二指腸旁乳頭部憩室合併総胆管結石症では，T-A curve 上明瞭な波型は出現しなかった．さらに，これらの症例にセルレイン 0.2 μg/kg b.w. を負荷したところ，それぞれ特徴あるパターンを示した．

本法は，Oddi 筋の動態機能を診断に，有用，かつ非侵襲的方法の1つと思われる．