

# Clinical outcome of endoscopic retrograde cholangiopancreatography for choledocholithiasis in end-stage renal disease patients on hemodialysis

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## ABSTRACT

**Background/Aims:** Endoscopic retrograde cholangiopancreatography (ERCP) is used as a curative method for choledocholithiasis, but little is known about ERCP for patients with end-stage renal disease (ESRD) on hemodialysis (HD). The aim of the current study was to evaluate the efficacy and safety of ERCP for patients with ESRD on HD and to identify the risk factors of ERCP-related bleeding.

**Materials and Methods:** The medical records of 61 ESRD patients with choledocholithiasis who underwent ERCP were retrospectively investigated with respect to successful bile duct stone removal and procedure-related adverse events such as pancreatitis, bleeding, and cholangitis.

**Results:** For the study subjects, the overall stone removal success rate was 96.7%, and the overall ERCP-related adverse event rate was 21.3% (pancreatitis, 4.9%; bleeding, 13.1%; cholangitis, 6.6%). Endoscopic sphincterotomy (EST) was found to be associated with hemorrhage ( $p=0.02$ ), and the occurrence of hemorrhage in patients who underwent EST with or without endoscopic papillary balloon dilation (EPBD) was significantly higher than that in patients who underwent EPBD alone (Odds ratio 1.27, 95% confidence interval 1.075-1.493,  $p=0.02$ ).

**Conclusion:** ERCP for ESRD patients was found to be feasible and safe. However, EST was significantly related to hemorrhagic events. EPBD reduced the risk of hemorrhage and was as effective as EST in terms of stone removal.

**Keywords:** Endoscopic retrograde cholangiopancreatography, hemodialysis, bleeding, choledocholithiasis

## INTRODUCTION

Gallstone disease is a major cause of morbidity and the prevalence of gallstones in the general adult population is about 10% (1). However, in contrast to the general adult population, the prevalence of gallstone disease in hemodialysis (HD) patients is as much as 30% (2). It is believed that increase in bile cholesterol level and cholesterol saturation index in bile by HD is associated with the higher prevalence of gallstones in this patient population (3). In addition, the gallbladder is innervated by the autonomic nervous system, which malfunctions in uremia, and it has been suggested gallbladder stasis increases stone formation (4). Furthermore, since gallstones are present in 15% to 20% of patients with common bile duct (CBD) stones

(5), endoscopic retrograde cholangiopancreatography (ERCP) is frequently required for CBD stone removal.

Generally, patients with end-stage renal disease (ESRD) on HD are considered high-risk candidates for invasive endoscopic treatments because tissue vulnerability and the tendency to bleed increase the risk of tissue penetration. The mechanism responsible for excessive bleeding in patients with HD is still unclear but platelet dysfunctions like impaired platelet adhesiveness and altered platelet-vessel wall interactions are believed to play important roles (6). In addition, the endoscopic procedures required for CBD stone removal, such as endoscopic biliary sphincterotomy (EST) and endoscopic papillary bal-

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loon dilatation (EPBD), have substantial bleeding risks (7). From this perspective, ERCP should be treated as a different entity with high operative risks in patients with ESRD on HD. However, no previous study has been conducted on ERCP in this background, although several reports have been issued on clinical outcomes, including bleeding risks, of open surgery and other invasive endoscopic procedures for patients with ESRD on HD (8, 9).

The aim of the present study was to assess the clinical outcomes and safety of ERCP for patients with ESRD on HD, especially the bleeding risk associated with ERCP. In addition, we also tried to identify the risk factors of procedure-related bleeding in these patients.

## MATERIALS AND METHODS

### Study design and patients

Multi-site retrospective analysis was performed at six Korean tertiary institutions. The study protocol was approved by institutional review boards at all participating centers. Consecutive patients with ESRD and choledocholithiasis who underwent ERCP between January 2007 and December 2017 were enrolled in the study. Inclusion criteria were as follows: (1) age >18 years; (2) choledocholithiasis, as demonstrated by retrograde cholangiography; (3) deep cannulation of the bile ducts without pre-cutting or infundibulotomy; (4) naïve major duodenal papilla status; and (5) ESRD with undergoing HD (ESRD was defined as described by the Kidney Disease Outcomes Quality Initiative (K/DOQI) working group: individuals with kidney failure (glomerular filtration rate of <15 mL/min/1.73 m<sup>2</sup>) with signs and symptoms of kidney failure (10)). Exclusion criteria were as follows: (1) concurrent coagulopathy (liver cirrhosis or coagulation dysfunction); (2) unsuccessful cholangiography; (3) a history of EST or EPBD; and (4) a history of gastrointestinal surgery. Medical records were retrospectively reviewed, and the following information

was extracted: clinical characteristics, clinical course, and ERCP-related adverse events including bleeding, perforation and pancreatitis. In addition, we sought to identify factors related to procedure-related bleeding, such as the duration of HD, time interval between HD and ERCP, use of heparin in HD, use of anticoagulation, platelet count, and ERCP-related factors.

### ERCP procedure

ERCP was performed using standard duodenoscopes. All endoscopic procedures were carried out by one of seven endoscopists, who had each performed more than 400 ERCPs annually over the preceding 10 years. ERCP was performed with patients under conscious midazolam and meperidine hydrochloride sedation. Protease inhibitors (Gabexate mesilate, nafamostat mesilate, or ulinastatin) that might affect the occurrence of post-ERCP pancreatitis were administered before ERCP at the endoscopist's discretion. Briefly, after locating the major duodenal papilla, the bile duct was deeply cannulated with a 0.035 inch guidewire-loaded catheter (ERCP-Kathter; MTW EndosKopie, Wesel, Germany), and a diagnostic cholangiogram was obtained. Bile duct and stone diameters were measured on cholangiograms during ERCP. EST was performed according to standard guidelines using conventional pull-type sphincterotomes (11). All ESTs were performed using the normal blended current (cut 45W, coagulation 30W) from an Olympus electrosurgical unit (PSD-30). EST length depended on indications, that is, small for stent placement or as large as possible for choledocholithiasis. For EPBD, a guidewire was passed through a diagnostic catheter into the bile duct, and then the catheter was removed. When the maximum transverse diameter of the largest stone was  $\geq 10$  mm and distal CBD diameter was  $\geq 12$ mm, EPBD was performed using a 12-mm balloon catheter (CRE Wireguided dilator; Microvasive; Boston Scientific Corp, Natick, MA) for dilation. For smaller stones, an 8-mm balloon catheter (Olbert; Microvasive Endoscopy, Boston Scientific Corp., Natick, MA) was used for dilation. Balloon catheters were passed over a 0.035-inch guidewire (Boston Scientific Corp) and placed across the major papilla. Balloons were inflated gradually to maximum size by injecting diluted contrast using an inflation device (Indeflator; Abbott, Santa Clara, CA) under fluoroscopic guidance until they were estimated to be adequate for stone removal. After waists had disappeared, the balloons were left inflated for 60 seconds. After EST or EPBD, the stones were extracted using a Dormia basket and/or a retrieval balloon catheter. When stone extraction was impossible, mechanical lithotripsy was performed as necessary. Complete stone

### MAIN POINTS

- This study conducted on the medical records of 61 ESRD patients with choledocholithiasis who underwent ERCP to evaluate the efficacy and safety of ERCP for patients with ESRD on HD and to identify the risk factors of ERCP-related bleeding. In the results, the clinical outcomes of ERCP for stone removal showed satisfactory results. However, ERCP-related adverse event rate was high (21.3%), especially in bleeding (13.1%).
- In the analysis of bleeding risk factor, EST was significantly related to induce bleeding compared with EPBD (Odds ratio 1.27, 95% confidence interval 1.075-1.493,  $p=0.02$ ).

**Table 1.** Baseline characteristics of the study subjects.

Value	Total (n=61)
Gender (men/women)	36/25
Mean age, year (SD)	69.7 (10.7)
Etiologies for renal failure, n (%)	
Hypertension	21 (34.4)
Diabetes melitus	35 (57.4)
Polycystic kidney disease	1 (1.6)
Unknown cause	4 (6.6)
Mean time interval between HD and ERCP, Hour (SD)	26.1 (18.7)
Mean duration of hemodialysis, month (SD)	49.6 (55.8)
The routine schedule of hemodialysis	
Two times a week	8 (13.1)
Three times a week	53 (86.9)
The use of heparin in last hemodialysis, n (%)	43 (70.5)
The use of anticoagulation medication, n (%)	
Antiplatelet agent (Aspirin, Clopidogrel)	33 (54.1)
Anticoagulation agent	2 (3.3)
Antiplatelet and Anticoagulation agent	3 (4.9)
Hematologic result, mean (SD)	
Hemoglobin, g/dL	10.4 (1.4)
Platelet, 1000/ $\mu$ L	187.7 (99.2)
Creatinine, mg/dL	5.1 (2.9)
Prothrombin time, INR	1.1 (0.2)
aPTT, sec	30.6 (13.5)
Total bilirubin, mg/dL	2.6 (2.9)
amylase, IU/L	323.9 (874.9)
Lipase, IU/L	662.4 (1922.8)

removal was confirmed by the absence of any filling defect by balloon occlusion cholangiography. If stone clearance could not be achieved in the first session, stone removal was re-attempted 2 or 3 days later.

#### Outcome measures

The outcome measures evaluated were overall procedural success rate and procedure-related adverse events.

Overall procedural success rate was defined as the rate of complete stone retrieval from the CBD after EST and/or EPBD, irrespective of whether mechanical lithotripsy was required or the number of ERCP sessions needed. All patients were hospitalized for at least 24 hours after the procedure. All adverse events were classified and graded according to consensus guidelines with some modifications (12). Procedure-related ERCP pancreatitis was diagnosed when new-onset pancreatitis or increased abdominal pain (lasting >24 hours) associated with an increased serum amylase level of >3 times the normal upper limit developed the next morning (after ERCP) (13). Bleeding was identified when clinical evidence of bleeding, such as melena or hematemesis, in association with hemoglobin concentration decrease of  $\geq 2$  g/dL in the hematologic results after the procedure was present (14). Delayed bleeding that occurred 48 hours after the procedure was not measured in the current study. Cholangitis was diagnosed as elevated body temperature ( $>38^{\circ}\text{C}$ ) over 24 hours with abdominal pain. Perforation was defined by the presence of free air or contrast leakage during a radiologic examination.

#### Statistical Analysis

Continuous variables are presented as means and standard deviations (SDs). The analysis was performed using the chi-squared test or the Fisher exact test for categorical variables and the student *t* test for continuous variables. Logistic regression analysis was used to identify factors affecting procedure-related bleeding. Statistical significance was accepted for *p* values  $<0.05$ , and the analysis was conducted using the Statistical Packages for the Social Sciences (SPSS) Ver. 19.0 (IBN Corp., Armonk, NY, USA).

#### RESULTS

##### Clinical characteristics

In total, 61 patients with ESRD and choledocholithiasis were enrolled in the current study. Demographic and clinical characteristics are shown in Table 1. The patients included 36 men and 25 women with mean age 69.7 years (SD, 10.7 years). The reasons for HD were hypertension (n=21), diabetes mellitus (n=35), polycystic kidney disease (n=1), and unknown cause (n=4). The mean duration of HD was 49.6 months (SD, 55.8 months) and mean time from last HD to ERCP was 26.1 hours (SD, 18.7 hours). In 43 patients, heparin had been administered for last HD. Thirty-eight patients had received antiplatelet agents and/or anticoagulation agents for concomitant cardiovascular disease or diabetes mellitus, and ERCPs were performed urgently without dis-

**Table 2.** Outcomes and adverse events of ERCP in ESRD patients on HD.

Value	Total (n=61)
Bile duct clearance	59 (96.7)
Kinds of ERCP procedure, n (%)	
EST	30 (49.2)
EPBD	23 (37.7)
EPBD with EST	8 (13.1)
Number of endoscopic sessions, n (%)	
1	53 (86.9)
2 or more	8 (13.1)
Use of lithotripsy, n (%)	5 (8.2)
Use of ERBD, n (%)	25 (41)
Adverse events, n (%)	
Bleeding	8 (13.1)
Post-ERCP pancreatitis	3 (4.9)
Cholangitis	4 (6.6)
Perforation	0 (0)

ERCP: endoscopic retrograde cholangiopancreatography; EST: Endoscopic sphincterotomy; EPBD: Endoscopic papillary balloon dilation.

continuation of these agents. Their medications were discontinued for 24-48 hours after the endoscopic procedure and re-started if there was no bleeding.

### **Bile duct clearance**

Deep cannulation into the bile duct was achieved in all patients, and EST (n=30), EPBD (n=23), or EST with EPBD (n=8) resulted in complete bile duct stone removal. CBD stones were completely removed in 59 (96.7%) patients; in 2 cases, stone removal was unsuccessful due to stone impaction. The two patients concerned underwent surgical stone removal. The mean number of endoscopic sessions required for complete bile duct clearance was 1.2 (range 1-3), 8 patients required additional ERCP sessions (one session in 6 patients and 2 sessions in 2 patients). Mechanical lithotripsy was used in 5 (8.2%) patients (Table 2).

### **Adverse events**

Adverse events occurred in 13 patients (21.3%) after ERCP. One patient experienced cholangitis and pancreatitis simultaneously. Results are summarized in Table 2.

### **Hemorrhage**

Minor bleeding occurred frequently during the endoscopic procedures, and most minor bleeding was controlled by spraying epinephrine solution on the bleeding site and by using a balloon tamponade. This minor bleeding was not encountered as ERCP-associated hemorrhage. The rate of ERCP-associated hemorrhage was 13.1% (n=8). Bleeding in 7 of the 8 patients was controlled with endoscopic management. To control bleeding, epinephrine (1:10,000) was sprayed on the bleeding site and a balloon tamponade was initially applied. If these measures failed, consecutive injections of epinephrine were administered. For exposed vessels, epinephrine was injected around the bleeding sites, and exposed vessels were hemoclipped. Despite multiple sessions of endoscopic injection therapy including fully covered metal stent insertion, massive blood transfusion, angiography and intensive care, one patient bled to death (Figure 1). An analysis of the risk factors of bleeding showed that EST was significantly related to hemorrhagic events (P=0.02). Other factors including age, gender, use of antiplatelet agents or anticoagulation agents, HD factors, the number of endoscopic sessions, mechanical lithotripsy, and hematologic factors were not significantly related to hemorrhage (Table 3).

### **Pancreatitis and cholangitis**

Post-ERCP pancreatitis occurred in three patients (4.9%) and was graded as mild; cholangitis occurred in four patients (6.6%). All patients with pancreatitis and/or cholangitis recovered uneventfully on conservative treatment. None of the patients developed acute cholecystitis or perforation.

### **EST vs. EPBD**

For this analysis, patients were allocated to either of the 2 groups: an EST group (n=38, comprising EST only and EST plus EPBD) and an EPBD group (n=23, EPBD only). The overall success rates for complete bile duct clearance in the EST and EPBD groups were similar at 94.7% and 100%, respectively (p=0.52), as were the mean number of sessions required for clearance (p=0.69). Mechanical lithotripsy was performed in three (7.9%) patients in the EST group and in 2 (8.7%) patients in the EPBD group (p=0.63). An analysis of the risk factors of hemorrhage showed that the type of papillary dilation was associated with hemorrhage (p=0.02). Hemorrhage occurred in 5 (16.7%) of the 30 patients who underwent EST alone and in 3 (37.5%) of the 8 patients who underwent EST plus EPBD. Hemorrhage did not occur in any patient who underwent EPBD alone. The occurrence of hemorrhage among patients in the EST group was significantly higher

**Table 3.** Associations between variables studied and bleeding.

Value	Patient with Bleeding (n=8)	Patients without bleeding (n=53)	p
Age, mean year (SD)	61.4 (14.6)	70.9 (9.5)	0.11
Gender			
Male/Female	6/2	30/23	0.45
Use of antiplatelet or anticoagulation agent, n (%)	4 (50)	34 (64.2)	0.46
Hemodialysis factors			
Duration of hemodialysis, mean month (SD)	35.13 (57.8)	51.8 (55.7)	0.44
Time to ERCP from last hemodialysis, mean hour (SD)	27.3 (26.2)	25.9 (17.6)	0.85
Heparin use during hemodialysis, n (%)	5 (62.5)	38 (71.7)	0.68
Endoscopic factors			
Number of endoscopic sessions, n	1.3 (0.5)	1.1 (0.3)	0.29
Mechanical lithotripsy, n (%)	1 (12.5)	4 (7.5)	0.52
ERCP procedure, n (%)			0.02
EST	5 (16.7)	25 (83.3)	
EPBD	0 (0)	23 (100)	
EST+EPBD	3 (37.5)	5 (62.5%)	
Hematologic factors			
Hemoglobin, g/dL	10.9 (1.1)	10.3 (1.5)	0.28
Platelet count, 1000/ $\mu$	191.9 (110.7)	186.6 (95.5)	0.83
Prothrombin time, INR	1.1 (0.3)	1.1 (0.2)	0.89
Creatinine, mg/dL	5.6 (1.8)	4.9 (3.1)	0.57
aPTT, sec	28.6 (10.9)	30.9 (13.9)	0.65

ERCP: endoscopic retrograde cholangiopancreatography; EST: Endoscopic sphincterotomy; EPBD: Endoscopic papillary balloon dilation.

than in the EPBD group (Odds ratio 1.27, 95% confidence interval 1.075-1.493,  $p=0.02$ ). ERCP-related pancreatitis occurred in 2 (5.3%) patients in the EST group and in one (4.3%) patient in the EPBD group ( $p=0.55$ ) (Table 2). Cholangitis occurred in 2 (5.3%) patients in the EST group and in 2 (8.7%) in the EPBD group and was not statistically significant ( $p=0.63$ ). No procedure-related perforation occurred in either group.

### DISCUSSION

This study shows that ERCP in the ESRD patients undergoing HD is a reasonable treatment for CBD stone removal. Adverse events were found to be acceptable and the

overall bile duct clearance rate was high at 96.7%. Interestingly, hemorrhagic adverse events occurred only after EST in the present study and not after EPBD (EST 16.7%. EST with EPBD 37.5%, EPBD 0%;  $P=0.02$ ) indicating the suitability of ERCP for stone removal in HD patients. On the other hand, our results advise against the use of EST because of a high associated hemorrhage rate.

In the present study, ERCP produced satisfactory results with respect to the efficacy of stone removal. The overall success rate of complete stone retrieval by ERCP was 96.7% in patients with ESRD on HD, which is comparable with the 90% successful stone removal rate that was

**Table 4.** The clinical outcomes and adverse events in the \*EST and EPBD groups.

	EST (n=38)	EPBD (n=23)	p
Clinical outcomes, n (%)			
Overall success in stone removal	36 (94.7)	23 (100)	0.52
Mechanical lithotripsy	3 (7.9)	2 (8.7)	0.63
Sessions required for complete clearance			0.69
First	32 (84.2)	21 (91.3)	
More than twice	6 (15.8)	2 (8.7)	
Adverse events			
Hemorrhage	8 (21.1%)	0 (0%)	0.02
Pancreatitis	2 (5.3%)	1 (4.3%)	0.55
Cholangitis	2 (5.3%)	2 (8.7%)	0.63
Perforation	0 (0%)	0 (0%)	

EST: Endoscopic sphincterotomy; EPBD: Endoscopic papillary balloon dilation

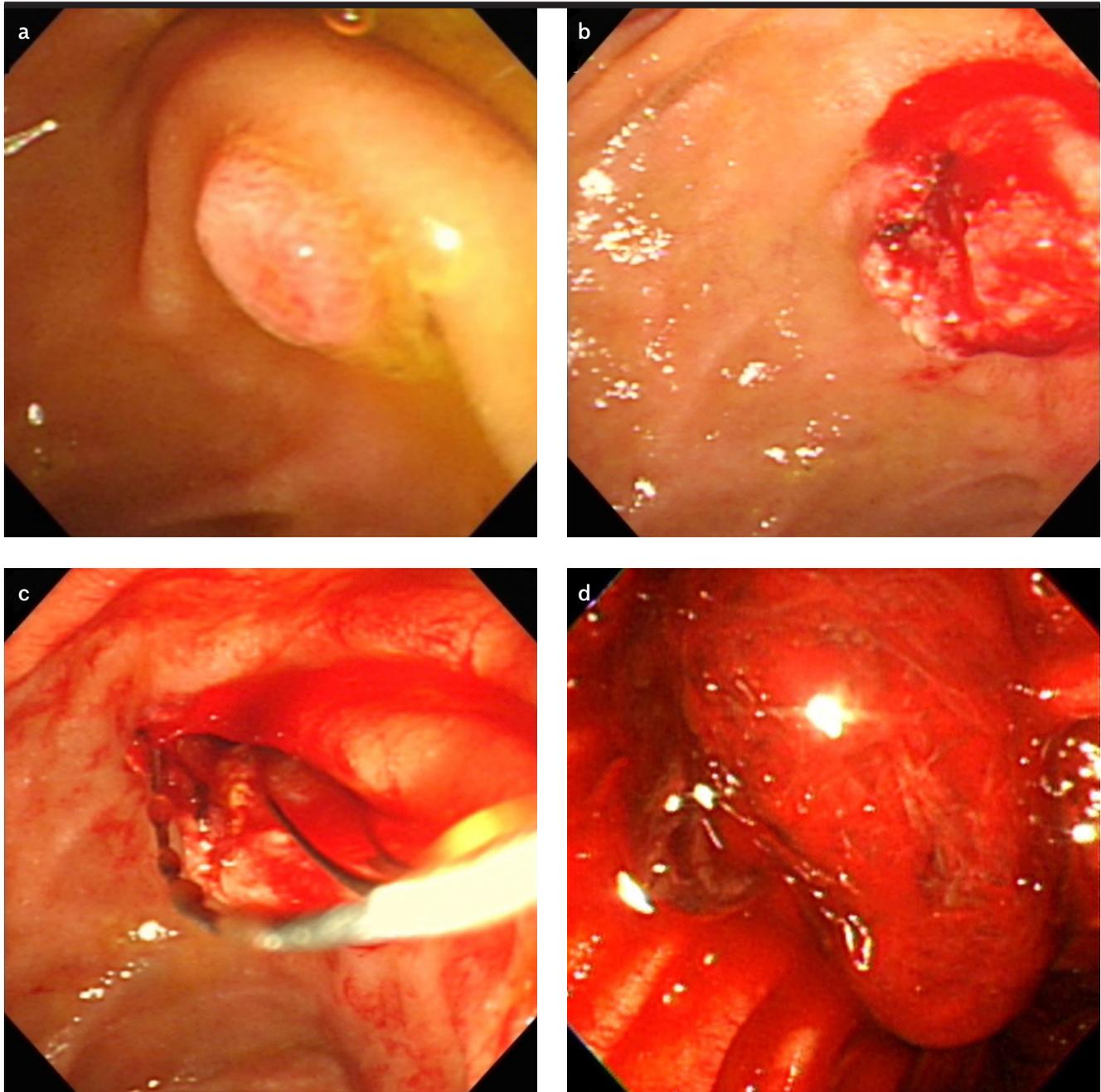
\*EST group includes EST alone and EST plus EPBD cases

previously reported for CBD stone removal in general adult patients (15, 16). This result suggests that ongoing HD does not affect the success rate of stone removal by ERCP. Although the outcomes of ERCP for CBD stone removal in HD patients have not been sufficiently evaluated, one previous study on the clinical outcomes of EPBD in HD patients reported a similar result. Takahara et al. conducted study on 37 patients with bile duct stones who were undergoing HD and were treated by EPBD, and reported an overall stone removal success rate of 100% and a first session success rate of 76% in patients with small stones. (17)

The incidence of ERCP-related adverse events in dialysis patients is expected to be substantially higher than in nondialysis patients because of tissue vulnerability and a tendency to bleed. However, the incidence of adverse events after ERCP for stone removal in patients with ESRD on HD has not been previously evaluated. Our results show an overall adverse event rate of 21.3%, which is much higher than the rates reported for the general adult population (5 to 9.8%), (12, 13) which may have been caused by vulnerability to hemorrhage. In the general adult population, serious hemorrhage-related EST has been reported to occur in up to 2% of ERCP cases (13, 18). On the other hand, the rate of serious ERCP-related hemorrhages (13.1%) in patients with ESRD on HD was significantly higher than in the general adult population,

and this result concurs with previously reported rates (19, 20). Furthermore, it appears that bleeding tended to be more severe in these patients than in the normal CBD stone cases, and despite successful treatment, blood transfusions were needed.

The mechanism responsible for excessive hemorrhage in patients with ESRD is unclear and may be multifactorial. Platelet dysfunctions in the form of impaired platelet adhesiveness or altered platelet-vessel-wall interactions are believed to play an important role (21). Williams et al. found that the rate of severe hemorrhage after ESCP was significantly greater in patients undergoing HD (50%) than in the normal adult population (1.1%,  $p < 0.001$ ), (19), which is consistent with the findings of Nelson et al., (20), who suggested a relative risk of hemorrhage of 8.4 among hemodialysis patients. However, these studies lack sufficient evidence to demonstrate the nature of any correlation between ERCP-related bleeding risk and ongoing HD because the studies had a low number of HD patients. In the current study, we analyzed the medical records of 61 patients with ESRD undergoing HD with CBD stones and estimated that this was sufficient to determine the risk of post-ERCP hemorrhage in patients with ESRD on HD. In addition, we tried to find risk factors of post-ERCP hemorrhage in patients with ESRD on HD. Interestingly, post-ERCP hemorrhage occurred only after EST and not after EPBD (EST group, 21.1% vs. EPBD group, 0%;



**Figure 1. a-d.** a) Normal appearance of duodenal ampulla before procedure. b) Minor bleeding after EST. c) Extraction of a brown pigment stone after EST. d) Duodenal ampulla at one day after EST, showing copious amounts of blood clots with oozing blood at the duodenal papilla.

p=0.02), which shows EPBD significantly reduced the risk of procedure-related hemorrhage (odds ratio 1.27, 95% confidence interval 1.075-1.493, p=0.02). This finding is in-line with those of a previous study, (17) in which no hemorrhage developed in any of the 33 patients on HD who underwent EPBD. The authors concluded that EPBD

appeared to be safe and effective for bile duct stone extraction in HD patients. In the current study, our analysis of other factors related to hemorrhage identified only EST and no contribution from age, gender, antiplatelet agent and/or anticoagulant use, hemodialysis factors (including heparin use), endoscopic factors or hematologic

factors. We suppose the impact of EST in HD patients is caused by predisposition to or an exacerbation of hemorrhage related to associated platelet dysfunctions and the activation of fibrinolysis (21, 22). Therefore, we believed that EPBD would be a safer procedure than EST for patients with HD.

Pancreatitis is the most serious adverse event after ERCP. In previous randomized controlled trials in a non-HD setting, the incidence of pancreatitis was reported to be 1.6-15.7%, (23, 24) and in the present study, the incidence of ERCP-related pancreatitis was similar at 4.9% (3/61). Therefore, we believe ERCP is a feasible procedure in HD patients as well as in non-HD patients in terms of the risk of ERCP-related pancreatitis.

The usefulness of EPBD for CBD stone removal is a matter of considerable debate (25). EPBD is the preferred procedure for stone removal in Asia, and has been shown to have adverse event rates equivalent to or less than those of EST (26, 27). On the other hand, EPBD is rarely performed in the United States because of concerns of EPBD-related pancreatitis. However, in the present study, ERCP-related pancreatitis was detected in only one patient after EPBD, and pancreatitis rates were similar for the EST (5.3%) and EPBD (4.3%) groups ( $p=0.55$ ). Therefore, we recommend that EPBD be considered the first endoscopic option for patients with ESRD on HD because of its low hemorrhage and similar pancreatitis risks.

This study has certain limitations. First, it is limited by its retrospective design and a limited number of cases. Patients with unsuccessful cholangiography were excluded from the current study due to the lack of medical records of these patients. Thus, it is possible that the results of the current study did not reflect the real clinical conditions of the HD patients who underwent ERCP. In addition, the occurrence of cholangitis related to ERCP was defined on the basis of the Charcot triad. However, this triad is not able to differentiate between cholangitis and cholecystitis in a retrospective setting. Therefore, the incidence of cholangitis related to ERCP in current study has the risk of overestimation. With regard to the risk of bleeding, ERCPs were conducted without the discontinuation of antiplatelet and anticoagulation agents, and the risk factors that might be associated with bleeding, such as severity of cholangitis, presence of periaampullary diverticulum, precut sphincterotomy, uncontrolled cutting during sphincterotomy, and stone impaction were not evaluated in the current study. Therefore, there is a risk that the factors associated with bleeding were not well

evaluated. Further investigation in a prospective setting is needed to confirm the safety of ERCP for patients with ESRD undergoing HD. Second, we did not perform long-term follow-up to determine stone recurrence rates. We suggest that an accumulation of cases and long-term analysis are needed to confirm the safety and efficacy of ERCP in patients with ESRD on HD. Last, there is a risk of bias because the selection of patients with EST or EPBD was determined by each researcher's preference. In addition, the characteristics of stones including size, number, and the location of stones were not clear in the current study, and the study did not evaluate if these factors affected the clinical outcomes of EST and EPBD. Therefore, there is a possibility that our results do not sufficiently represent the clinical outcomes of EST and EPBD.

In conclusion, the present study shows that ERCP is feasible for the treatment of CBD stones in patients with ESRD on HD and the rate of adverse event is acceptable. Furthermore, we found that EST was significantly related to hemorrhagic events and that EPBD significantly reduced the risk of hemorrhage and was as effective as EST in terms of successful stone removal. Therefore, we recommend that EPBD be substituted for EST in patients with ESRD on HD.

**Ethics Committee Approval:** Ethics committee approval was received for this study from the Ethics Committee of Inha University Hospital Institutional Review Board (Decision date: 2018.12.3; Decision number: 2018-11-021).

**Informed Consent:** Informed consent is not necessary due to the retrospective nature of this study.

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**Conflict of Interest:** The authors have no conflicts of interest to declare.

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