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ORIGINAL ARTICLE

Case Control Study

Urgent one-stage endoscopic treatment for choledocholithiasis related moderate to severe acute cholangitis: A propensity score-matched analysis

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Abstract

BACKGROUND

During emergency endoscopic retrograde cholangiopancreatography (ERCP), the safety and feasibility of performing one-stage endoscopic treatment for patients with acute cholangitis (AC) due to choledocholithiasis are unclear.

AIM

To investigate the safety and feasibility of one-stage endoscopic treatment for moderate to severe AC.

METHODS

We enrolled all patients diagnosed with moderate to severe cholangitis due to common bile duct stones from January 2019 to July 2023. The outcomes were compared in this study between patients who underwent ERCP within 24 h and those who underwent ERCP 24 h later, employing a propensity score (PS) framework. Our primary outcomes were intensive care unit (ICU) admission rates, ICU length of stay, and duration of antibiotic use.

RESULTS

In total, we included 254 patients and categorized them into two groups based on the time elapsed between admission and intervention: The urgent group (≤ 24 h, n = 102) and the elective group (> 24 h, n = 152). Ninety-three pairs of patients with similar characteristics were selected by PS matching. The urgent ERCP group had more ICU admissions (34.4% *vs* 21.5%, P = 0.05), shorter ICU stays (3 d *vs* 9 d, P < 0.001), fewer antibiotic use (6 d *vs* 9 d, P < 0.001), and shorter hospital stays (9 d *vs*

18.5 d, $P < 0.001$). There were no significant differences observed in adverse events, in-hospital mortality, recurrent cholangitis occurrence, 30-d readmission rate or 30-d mortality.

CONCLUSION
Urgent one-stage ERCP provides the advantages of a shorter ICU stay, a shorter duration of antibiotic use, and a shorter hospital stay.

Key Words: Acute cholangitis; Endoscopic retrograde cholangiopancreatography; One-stage treatment; Optimal time

Core Tip: We investigated the safety and feasibility of one-stage endoscopic treatment for moderate to severe acute cholangitis. Our study found that patients who underwent endoscopic retrograde cholangiopancreatography within 24 h had a shorter intensive care unit stay, a shorter duration of antibiotic use, and a shorter hospital stay.

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INTRODUCTION

Acute cholangitis (AC) is a severe and life-threatening infection that affects the biliary tract. It is a significant digestive disorder characterized by rapid onset and is common. Approximately 10%-29% of people with AC develop sepsis[1,2], and approximately 5% of patients progress to septic shock[3]. In severe cases, AC can be fatal. Currently, the Tokyo Guideline 2018 (TG18) criteria are used to diagnose and categorize ACs as mild, moderate, or severe cholangitis[4]. The primary cause of AC is biliary obstruction, which is often caused by cholelithiasis. Approximately 53% of patients with severe AC (SAC) require admission to the intensive care unit (ICU)[5].

While treating SAC, fluid resuscitation and antibiotics need to be administered as initial therapy. In addition, emergent biliary decompression is necessary to improve clinical outcomes[4]. The primary treatment choice for AC is endoscopic retrograde cholangiopancreatography (ERCP), which benefits approximately 90% of patients[6-10]. It is essential to adhere to the principle of "the sooner, the better" when performing ERCP treatment for AC. However, emergency ERCP biliary drainage in patients with severe cholangitis is associated with a significantly high risk of morbidity and mortality. In cases of early ERCP for AC associated with choledocholithiasis, patients with severe cholangitis are frequently subjected to brief procedures such as endoscopic nasobiliary drainage (ENBD) or stenting[9,11,12]. Nevertheless, this additional ERCP procedure not only prolongs the duration of hospital stay but also increases associated risks[12-16]. It is unclear whether single-stage stone removal is feasible for individuals with AC. The optimal timing for ERCP is yet a matter of debate. Therefore, we retrospectively examined and evaluated patients who underwent ERCP for moderate to SAC with choledocholithiasis. The aim was to assess the feasibility and safety of urgent single-stage stone removal for moderate to SAC.

MATERIALS AND METHODS

The study was conducted at Zhongda Hospital Affiliated with Southeast University. The study was approved by the Ethics Committee (2019ZDSYLL094-P01). All methodologies employed in this study strictly adhered to the pertinent guidelines and regulations.

Inclusion criteria

We collected data from the endoscopic reporting system for all patients who underwent ERCP procedures following admission to the emergency department between January 2019 and July 2023. The inclusion criteria were as follows: (1) Diagnosed with AC in accordance with the TG13 or TG18[17,18]; (2) Aged > 18 years; and (3) Willing to undergo ERCP.

Exclusion criteria

The exclusion criteria were as follows: (1) Had mild AC; (2) Did not undergo endoscopic retrograde lithotomy; and (3) Had non-common bile duct (CBD) stones detected *via* cholangiopancreatography.

Data records

We retrieved data for all emergency ERCP procedures performed from January 2019 to July 2023 from the endoscopy reporting system, all patients were diagnosed with moderate to severe cholangitis due to CBD stones. The flowchart of this study is listed as Figure 1. The patients in the study were categorized into two groups based on the time between admission and intervention. These patients were classified into urgent (≤ 24 h, n = 102) and elective (> 24 h, n = 152) ERCP groups. The time span from admission to intervention was considered the time between registration in the emergency room and ERCP. We then sorted and reviewed patient demographic data, presenting symptoms, and ERCP outcomes. These data included the date, time between symptom onset and ERCP, admission and ERCP procedures, as well as laboratory data upon admission, such as the white blood cell (WBC) count, platelets (PLT), total bilirubin (TB), international normalized ratio (INR), creatinine (Cr), serum albumin, C-reactive protein (CRP), and neutrophil/lymphocyte ratio. The time span for biliary drainage was calculated as the duration between admission and the ERCP procedure. Furthermore, postoperative follow-up data were acquired through outpatient examinations or postoperative telephone follow-ups conducted after discharge. Disease severity was graded using the TG18 severity scale[18].

Procedure

Prior to ERCP, we monitored the patients' vital signs, established intravenous access, and administered empiric antibiotic therapy with third-generation cephalosporins. In instances where patients exhibited postshock symptoms, the execution of ERCP was postponed until their condition improved. Urgent ERCP was considered the primary treatment for patients who did not respond to drug therapy or who had moderate to severe disease. Prior to commencing the procedure, all participants provided informed consent. ERCP procedures were performed under general anesthesia and supervised by an anesthesiologist. During ERCP, the maternal endoscope used in this procedure was a therapeutic duodenoscope (Olympus TJF-260, Tokyo, Japan).

In the initial step, we established biliary access. Conventional biliary cannulation was attempted by using a sphincterotome (Microtech, Nanjing, China) and a 0.035-inch guidewire (Microtech, Nanjing, China). Successful biliary access was confirmed by observing visible bile aspiration, and bile samples were extracted for bacterial cultivation upon the manifestation of turbid bile flow. Subsequently, a 3-mm endoscopic sphincterotomy (EST) combined with endoscopic papillary balloon dilation was performed to establish a proper biliary orifice. The balloon was gradually inflated with 0.9% saline solution to the proposed pressure or until the biliary wall could be seen. For the extraction of stones, we employed either a basket or a balloon; for larger stones, mechanical lithotripsy was employed at the discretion of the endoscopist. In cases of cannulation failure, percutaneous transhepatic biliary drainage was explored as an alternative therapeutic option. Subsequently, a nasal biliary drainage tube was placed, and bile acid samples were collected for bacterial culture on postoperative days 1 and 2. The decision to drain the nasal biliary tube was contingent upon the patient's clinical condition. Adverse reactions after drainage were classified according to the ASGE dictionary[19] and included post-ERCP pancreatitis (PEP), bleeding, and infection, among others.

Statistical analysis

The quantitative parameters are reported as either the mean (with range) or median (with interquartile range), depending on the distribution. Categorical variables are presented as the frequency and percentage. The propensity score (PS) framework was used to compare the clinical endpoints of ERCP within 24 h of onset and 24 h after onset. The PS method was used to create a new dataset in which the probability of ERCP occurring within 24 h of or after its occurrence was equal (as in a purely randomized trial) to balance the baseline characteristics of patients. First, multivariate logistic regression was used to predict the probability of ERCP within 24 h (*i.e.*, estimated PS), controlling for the following prespecified covariates: Sex, age, Charlson Comorbidity Index (CCI) score, previous discharge ERCP, history of gallbladder surgery, TB, albumin, Cr, the INR, the PLT, the WBC, and the Tokyo score. The 1:1 nearest neighbor matching algorithm was used to match the two groups (urgent group and elective group) without substitution, and the caliper was 0.2[20] of the PS standard deviation of the logit score. The clinical endpoints were subsequently compared between the two groups in the matched datasets. Statistical analysis, including the χ^2 test, one-way analysis of variance (ANOVA) and multivariate linear regression, was performed using the Statistical Package for Social Sciences (SPSS, Inc., version 27.0 for Windows, Chicago, IL, United States). A P value of < 0.05 was considered to indicate statistical significance.

RESULTS

Population characteristics

From January 2019 to July 2023, a total of 456 patients with acute cholangitis were screened. Among these, 74, 16, 19 and 16 patients were excluded due to mild acute cholangitis, refusal of endoscopic treatment, upper gastrointestinal anatomy changes, and preference of PTBD or PTGBD, respectively. Additionally, 19, 20, 12 and 26 patients were excluded due to intrahepatic stone, acute acalculous cholecystitis, dysfunction of previous biliary stents and malignant obstructions, respectively. Consequently, 254 patients were included, 102 (40.2%) of whom underwent ERCP within 24 h of presentation and 152 (59.8%) after 24 h. The mean age was 69.47 (± 15.81) years, 47.6% were male, and 100% had choledocholithiasis-related cholangitis. The mean CCI score was 1 (0-7), and ERCP was performed for a mean time span of 48 (1-312) h. Cholangitis severity was categorized per Tokyo guidelines: Score 1 = 0%, score 2 = 72%, and score 3 = 28%. Table 1 shows the baseline patient characteristics before and after PS matching. After PS matching, 93 pairs of patients with similar traits were selected (Algorithm 1, Table 1). The proportion of patients who underwent one-step stone

Table 1 Characteristics of the study population and endoscopic retrograde cholangiopancreatography procedures

	Before matching				After matching			
	Total, *n* = 254	ERCP ≤ 24 h, *n* = 102	ERCP > 24 h, *n* = 152	*P* value	Total, *n* = 186	ERCP ≤ 24 h, *n* = 93	ERCP > 24 h, *n* = 93	*P* value
Age, yr	69.47 ± 15.81	70.73 ± 15.24	68.63 ± 16.18	0.362	70.32 ± 15.39	71.05 ± 15.26	69.58 ± 15.56	0.515
Male sex, *n* (%)	121 (47.6)	58 (56.9)	63 (41.4)	0.016	94 (50.5)	54 (58.1)	40 (43)	0.04
CCI	1 (0-7)	1 (0-5)	1 (0-7)	0.108	1 (0-7)	1 (0-3)	1 (0-7)	0.187
Past medical history								
ERCP, *n* (%)	30 (11.8)	13 (12.7)	17 (11.2)	0.706	22 (11.8)	13 (14)	9 (9.7)	0.364
Cholecystectomy, *n* (%)	67 (26.4)	27 (26.5)	40 (26.3)	0.978	44 (23.7)	22 (23.7)	22 (23.7)	1
Lab values								
WBC count as/μL	10.32 ± 6.71	12.57 ± 6.61	8.81 ± 6.37	< 0.001	10.58 ± 7.03	12.11 ± 6.44	9.06 ± 7.3	0.003
Platelet count as/μL	173.96 ± 71.08	164.21 ± 73.35	180.5 ± 68.99	0.594	168.11 ± 71.33	164.85 ± 74.65	171.38 ± 68.09	0.534
CRP in mg/L	75.17 ± 76.03	94.9 ± 79.32	61.75 ± 70.95	< 0.001	78.53 ± 76.6	89.66 ± 76.37	76.37 ± 75.75	0.079
NLR (%)	7.94 (0.81-106.31)	15.67 (1.36-106.31)	6.9 (0.805-64.13)	< 0.001	18.545 (2.55-64.13)	19.87 (11.2)	16.42 (2.55-64.13)	< 0.001
INR	1.2 ± 0.22	1.23 ± 0.97	1.14 ± 0.92	< 0.001	1.21 ± 0.23	1.25 ± 0.27	1.17 ± 0.17	0.012
D2 polymers	657 (0.21-26652)	1567 (76-26652)	504 (0.38-15502)	< 0.001	1193.5 (479-15502)	1455 (479-4811)	832 (504-15502)	0.005
Creatinine in mg/dL	0.826 (0.34-8.32)	1.01 (0.34-5.86)	0.76 (0.44-8.32)	< 0.001	1.10 (0.77-5.86)	1.15 (0.77-5.86)	1.02 (0.79-3.1)	0.013
TB in mg/dL	2.61 (0.28-22.52)	3.7 (0.29-15.02)	2.14 (0.28-22.52)	0.021	3.58 ± 2.98	3.78 ± 2.8	3.38 ± 3.14	0.363
AST in U/L	108.5 (13-4051)	128.5 (13-744)	104 (15-4051)	0.168	118 (40-539)	131 (40-497)	116 (46-539)	0.53
ALT in U/L	201.68 ± 206.61	196.67 ± 173.10	205.03 ± 226.84	0.652	222 (68-512)	259 (68-512)	209 (88-479)	0.55
γ-GT in U/L	406.66 ± 354.98	425.8 ± 376.89	393.82 ± 340.16	0.463	383.61 ± 332.61	405.97 ± 347.74	361.25 ± 361.25	0.361
Albumin in g/dL	35.8 (15.9-46.6)	35.9 (15.9-48.7)	37.8 (25.1-49.1)	0.033	33.7 (24.3-36.1)	32.6 (24.3-35.7)	33.8 (25.4-36.1)	0.163
Tokyo Score								
3	48 (28)	39 (38.2)	32 (21.1)	0.003	58 (31.2)	35 (37.6)	23 (24.7)	0.058
2	206 (72)	63 (61.8)	120 (78.9)		128 (68.8)	58 (62.4)	70 (75.3)	
ERCP procedure								
Door to ERCP time in h	48 (1-312)	8.5 (1-24)	120 (27-312)	< 0.001	25.5 (1-312)	9 (1-24)	120 (27-312)	< 0.001
ERCP procedure time (min)	60 (25-780)	60 (30-200)	60 (30-335)	0.714	60 (26-780)	60 (30-200)	60 (30-335)	0.52
One-stage ERCP, *n* (%)	254 (100)	102 (100)	152 (100)	1	186 (100)	93 (100)	93 (100)	1
CBD, *n* (%)	254 (100)	102 (100)	152 (100)	1	186 (100)	93 (100)	93 (100)	1
Stones size (mm)	8 (2-25)	9 (2-25)	8 (2-25)	0.222	8 (2-25)	9 (2-25)	8 (2-25)	0.368
Multiple stones, *n* (%)	109 (42.9)	35 (34.3)	74 (48.7)	0.023	79 (42.5)	32 (34.4)	47 (50.5)	0.026
Common bile duct width (mm)	13 (4-33)	14 (4-33)	14 (5-33)	0.016	13 (4-33)	13 (4-33)	12.1 (5-25)	0.038
EST, *n* (%)	177 (69.7)	75 (73.5)	102 (67.1)	0.275	128 (68.8)	69 (74.2)	59 (63.4)	0.113
EPBD, *n* (%)	204 (80.3)	90 (88.2)	114 (75)	0.009	149 (80.1)	83 (89.2)	66 (71)	0.002
Pancreatic stent placement, *n* (%)	21 (8.3)	5 (4.9)	16 (10.5)	0.111	15 (8.1)	5 (5.4)	10 (10.8)	0.178

Nasal Biliary Drainage Catheter placement, *n* (%)	251 (98.8)	100 (98)	151 (99.3)	0.346	183 (98.4)	91 (97.8)	92 (98.9)	0.561
HLL, *n* (%)	21 (8.3)	11 (10.8)	10 (6.6)	0.233	16 (8.6)	11 (11.8)	5 (5.4)	0.117

SMD: Standardized mean difference; CCI: Charlson Comorbidity Index; ERCP: Endoscopic retrograde cholangiopancreatography; WBC: White blood cell; CRP: C-reactive protein; NLR: Neutrophil-lymphocyte ratio; INR: International normalized ratio; TB: Total bilirubin; AST: Aspartate transaminase; ALT: Alanine transaminase; γ-GT: γ-glutamyl transpeptidase; CBD: Common bile duct stones; LC-IntraERCP: Laparoscopic cholecystectomy combined with intraoperative endoscopic retrograde cholangiopancreatography; EST: Endoscopic sphincterotomy; EPBD: Endoscopic papillary balloon dilatation; HLL: Holmium Laser Lithotripsy.

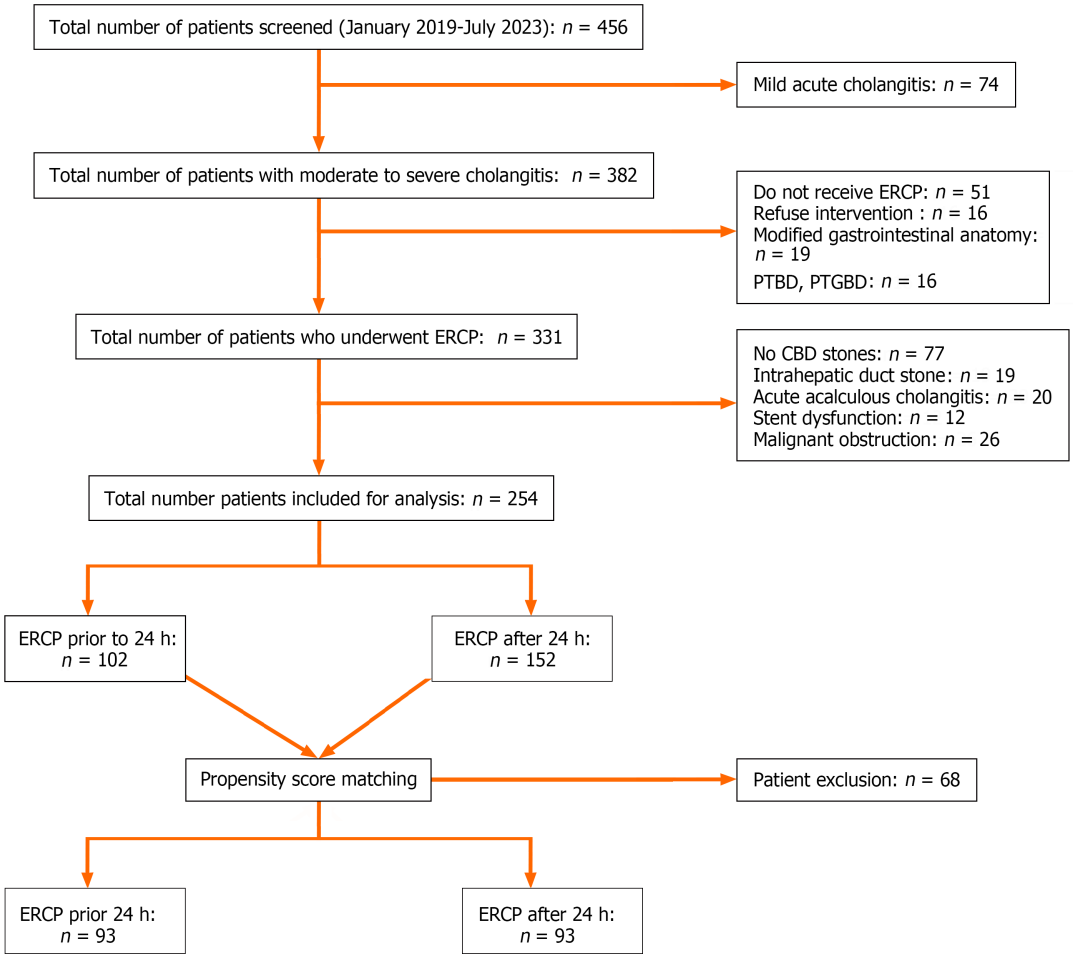

Figure 1 Flow diagram of patients' selection. ERCP: Endoscopic retrograde cholangiopancreatography; PTBD: Percutaneous transhepatic biliary drainage; PTGBD: Percutaneous transhepatic gallbladder drainage; CBD: Common bile duct.

extraction after matching was consistent (100% *vs* 100%, $P = 1$) (Table 1).

Primary clinical outcomes

Our primary outcome was ICU admission rate, ICU length of stay, and duration of antibiotic use (Table 2). The results derived from our analysis of a PS-matched population indicated a significant difference in ICU admission rates between the urgent ERCP group and the elective ERCP group (34.4% *vs* 21.5%, $P = 0.05$). Importantly, there was a significant difference in ICU stay length between the urgent ERCP and elective ERCP groups, with the urgent group having a shorter stay (3 d *vs* 9 d, $P < 0.001$). Additionally, compared with those in the elective group, the patients in the urgent ERCP group had a shorter duration of antibiotic use (6 d *vs* 9 d, $P < 0.001$). Univariate linear regression analysis of ICU stay length revealed independent correlations with variables, including WBC [95% confidence interval (CI): 0.18-0.82, $P = 0.003$], CRP (95%CI: 0.01-0.08, $P = 0.015$), Cr (95%CI: 4.22-8.28, $P < 0.001$), age (95%CI: -0.66 to -0.07, $P = 0.016$), and the time span of ERCP (hours) (95%CI: 0.04-0.06, $P < 0.001$). Additionally, ICU stay length was not significantly correlated with one-stage endoscopic treatment, EST, ENBD, adverse events, 30-d readmission, or recurrent cholangitis (Table 3). Multivariate linear regression analysis of the matched data revealed significant correlations between ERCP delay time (95%CI: 0.03-0.06, $P < 0.001$), Cr level (95%CI: 0.07-3.56, $P = 0.041$), and ICU stay length.

Table 2 Outcomes of endoscopic retrograde cholangiopancreatography

	Before matching				After matching			
	Total, *n* = 254	ERCP ≤ 24 h, *n* = 102	ERCP > 24 h, *n* = 152	*P* value	Total, *n* = 186	ERCP ≤ 24 h, *n* = 93	ERCP > 24 h, *n* = 93	*P* value
ERCP intervention type, *n* (%)								
Complete stone removal	250 (98.4)	101 (99)	149 (98)	0.533	184 (98.9)	92 (98.9)	92 (98.9)	1
Biliary stent insertion	4 (1.6)	1 (1)	3 (2)	0.533	2 (1.1)	1 (1.1)	1 (1.1)	1
Technical success rate, *n* (%)	250 (98.4)	101(99)	149 (98)	0.533	183 (98.4)	92 (98.9)	91 (98)	0.561
ERCP failure, *n* (%)	4 (1.6)	1 (1)	3 (2)	0.533	3 (1.6)	1 (1.1)	2 (2.2)	1
Duration of antibiotic use (d)	7 (1-28)	6 (2-15)	8 (2-26)	< 0.001	7 (2-28)	6 (2-18)	9 (2-28)	< 0.001
In-hospital mortality, *n* (%)	3 (1.2)	0	3 (2)	0.153	2 (1.1)	0	2 (2.2)	0.155
30-d mortality, *n* (%)	7 (2.8)	2 (2)	5 (3.3)	0.526	5 (2.7)	2 (2.2)	3 (3.2)	0.65
Recurrent cholangitis, *n* (%)	7 (2.8)	3 (2.9)	4 (2.6)	0.883	6 (3.2)	3 (3.2)	3 (3.2)	1
LOHS, (d)	10 (3-71)	9 (3-39)	18 (5-71)	< 0.001	9 (3-71)	9 (3-39)	18.5 (7-71)	< 0.001
Required ICU stay, *n* (%)	61 (24)	33 (32.4)	28 (18.4)	0.011	52 (28)	32 (34.4)	20 (21.5)	0.05
ICU stay length, (d)	9 (1-71)	3 (1-15)	8 (1-71)	0.003	4.5 (1-71)	3 (1-15)	9 (1-71)	< 0.001
30 d readmission, *n* (%)	33 (13)	15 (14.7)	18 (11.8)	0.506	29 (15.6)	14 (15.1)	15 (16.1)	0.84
ERCP-related complications, *n* (%)	42 (16.5)	18 (17.7)	24 (15.8)	0.696	29 (15.6)	16 (17.2)	13 (14)	0.544
PEP	23 (9.1)	9 (8.8)	14 (9.2)	0.916	17 (9.1)	9 (9.7)	8 (8.6)	0.799
Cholangitis	9 (3.5)	6 (5.9)	3 (2)	0.099	7 (3.8)	5 (5.4)	2 (2.2)	0.248
Bleeding	6 (2.4)	4 (3.9)	2 (1.3)	0.18	4 (2.2)	3 (3.2)	1 (1.1)	0.312
Others	2 (0.8)	2 (2)	0	0.083	2 (1.1)	2 (2.2)	0	0.155

ERCP: Endoscopic retrograde cholangiopancreatography; LOHS: Length of hospital stay; PEP: Post-endoscopic retrograde cholangiopancreatography pancreatitis; ICU: Intensive care unit.

Secondary clinical outcomes

According to our analysis of the PS-matched population (Table 2), the length of hospital stay (LOHS) in the urgent group was significantly shorter than that in the elective group (9 d *vs* 18.5 d, $P < 0.001$). The two groups exhibited no significant differences in 30-d readmission (15.1% *vs* 16.1%, $P = 0.84$), recurrent cholangitis (2.9% *vs* 2.6%, $P = 0.883$), in-hospital mortality (0% *vs* 2.2%, $P = 0.155$), 30-d mortality (2.2% *vs* 3.2%, $P = 0.65$), adverse events after ERCP (17.65% *vs* 15.79%, $P = 0.696$), PEP (8.82% *vs* 9.21%, $P = 0.916$), bleeding (3.9% *vs* 1.3%, $P = 0.180$), biliary tract infection (5.9% *vs* 1.97%, $P = 0.099$), or other ERCP-related adverse events (1.96% *vs* 0, $P = 0.083$).

Subgroup analysis of patients with SAC

After PS matching (Table 4), 58 patients in the cohort presented with severe biliary tract infection according to a Tokyo score of 3. Among these patients, 60.3% underwent ERCP within 24 h of onset, while 39.7% underwent ERCP after 24 h. Subsequently, we compared outcomes between the urgent ERCP group and the elective ERCP group within the subset of patients who experienced severe cholangitis. No significant difference in ICU admission rates was observed between the two groups (60% *vs* 47.8%, $P = 0.362$). The urgent group had a significantly shorter ICU stay than did the elective group (4 d *vs* 11 d, $P = 0.014$), a significantly shorter duration of antibiotic use (17.1% *vs* 17.4%, $P = 0.98$), and a markedly shorter LOHS (9 d *vs* 20 d, $P < 0.001$). Additionally, within 30 d, there were no significant differences between the two subgroups in terms of readmission (17.1% *vs* 17.4%, $P = 0.98$), in-hospital mortality (0% *vs* 4.3%, $P = 0.213$), 30-d mortality (5.7% *vs* 8.7%, $P = 0.661$), occurrence of adverse events after ERCP (22.86% *vs* 13.04%, $P = 0.351$), PEP (8.57% *vs* 4.35%, $P = 0.535$), bleeding (2.86% *vs* 4.35%, $P = 0.761$), biliary tract infection (8.57% *vs* 0%, $P = 0.149$), or occurrence of other ERCP-related adverse events (2.86% *vs* 0, $P = 0.414$).

Table 3 Linear regression analyses to assess intensive care unit length of stay

	Univariate analysis		Multivariate analysis	
	OR (95%CI)	*P* value	OR (95%CI)	*P* value
WBC count	0.503 (0.185 to 0.821)	0.003	-0.092 (-0.305 to 0.12)	0.387
Platelet count	-0.031 (-0.069 to 0.007)	0.105		
CRP	0.046 (0.009 to 0.082)	0.015	0.002 (0.021 to 0.024)	0.877
NLR	-0.006 (-0.181 to 0.169)	0.945		
INR	-4.986 (-15.932 to 5.961)	0.365		
TB	-0.101 (-1.26 to 1.058)	0.862		
Cr	6.248 (4.216 to 8.281)	< 0.001	1.818 (0.073 to 3.564)	0.042
Albumin	0.569 (0.043 to 1.095)	0.035	0.02 (-0.308 to 0.347)	0.905
ALT	-0.005 (-0.017 to 0.007)	0.375		
AST	-0.001 (-0.007 to 0.005)	0.789		
Multiple stones	-3.31 (-9.87 to 3.249)	0.316		
CCI	1.466 (-0.713 to 3.644)	0.183		
Age	-0.367 (-0.663 to -0.072)	0.016	-0.086 (-0.256 to 0.083)	0.312
Severity of AC	3.188 (-3.434 to 9.809)	0.338		
Time to ERCP	0.051 (0.340 to 0.059)	< 0.001	0.044 (0.033 to 0.056)	< 0.001
Common bile duct width	-0.002 (-0.34 to 0.335)	0.988		

OR: Odds ratio; CI: Confidence interval; CCI: Charlson Comorbidity Index; ERCP: Endoscopic retrograde cholangiopancreatography; WBC: White blood cell; CRP: C-reactive protein; NLR: Neutrophil-lymphocyte ratio; INR: International normalized ratio; TB: Total bilirubin; Cr: Creatinine; AST: Aspartate transaminase; ALT: Alanine transaminase; AC: Acute cholangitis.

Table 4 Outcomes of endoscopic retrograde cholangiopancreatography in the propensity matched population (Tokyo score 3 subgroup)

Patients with Grade III AC	Total, *n* = 58	ERCP ≤ 24 h, *n* = 35	ERCP > 24 h, *n* = 23	*P* value
Duration of antibiotic use (d)	8 (3-28)	7 (3-15)	11 (3-28)	0.004
In-hospital mortality, *n* (%)	1 (1.7)	0	1 (4.3)	0.213
30-d mortality, *n* (%)	4 (6.9)	2 (5.7)	2 (8.7)	0.661
Recurrent cholangitis, *n* (%)	4 (6.9)	2 (5.7)	2 (8.7)	0.661
LOHS, (d)	13 (6-71)	9 (6-17)	20 (14-71)	< 0.001
Required ICU stay, *n* (%)	32 (55.2)	21 (60)	11 (47.8)	0.362
ICU stay length, (d)	6 (1-71)	4 (1-15)	11 (1-71)	0.014
30 d readmission, *n* (%)	10 (17.2)	6 (17.1)	4 (17.4)	0.98
ERCP-related complications, *n* (%)	11 (19)	8 (22.9)	3 (13)	0.351
PEP	4 (6.9)	3 (8.6)	1 (4.3)	0.535
Cholangitis	3 (5.2)	3 (8.6)	0	0.149
Bleeding	2 (3.4)	1 (2.9)	1 (4.3)	0.761
Others	1 (1.7)	1 (2.9)	0	0.414

AC: Acute cholangitis; ERCP: Endoscopic retrograde cholangiopancreatography; LOHS: Length of hospital stay; PEP: Post-endoscopic retrograde cholangiopancreatography pancreatitis; ICU: Intensive care unit.

DISCUSSION

Numerous studies have been conducted to determine the best timing for biliary decompression in patients with AC. However, the advantages of urgent one-stage endoscopic procedures *via* ERCP for treating moderate to severe cholangitis associated with CBD stones still need further clarification[20-23]. We comprehensively analyzed the characteristics and diagnostic findings of 254 patients diagnosed with AC who were admitted to Zhongda Hospital of Southeast University over the past four years. Within our PS-matched population, multivariate regression analysis was used to identify independent predictors of ICU stay length, including preoperative Cr levels and delay in performing ERCP. Notably, elective ERCP was associated with a longer duration of ICU stay (3 d *vs* 8 d, $P < 0.001$) and a prolonged course of antibiotic treatment (6 d *vs* 9 d, $P < 0.001$). Additionally, elective ERCP resulted in an increased LOHS (9 d *vs* 18.5 d, $P < 0.001$). Similar findings were observed in the unadjusted cohort analysis: ICU stay length (3 d *vs* 8 d, $P = 0.003$), antibiotic duration (6 d *vs* 8 d, $P < 0.001$), and LOHS (9 d *vs* 18 d, $P < 0.001$).

Our investigation concentrated on patients who underwent single-stage endoscopic procedures for AC. In our PS-matched population, the mortality rate was 2.7%. This figure aligns with the findings reported by Park *et al*[12] and Zhang *et al*[14]. Notably, our observation rate was lower than the 5%-11% range documented in other studies[11,21]. One plausible rationale for this variance may stem from the fact that all subjects in our study exclusively underwent single-stage endoscopic procedures, potentially contributing to the observed lower mortality rate. Notably, single-stage endoscopic procedures exhibit both safety and efficacy in addressing biliary drainage and CBD stone clearance in individuals with AC. Previous studies have revealed that one-stage endoscopic treatment has a high cure rate and low complication rate in patients with mild to moderate cholangitis. In a multicenter retrospective study conducted by our team in 2019, the safety and efficacy of this approach were reaffirmed, particularly in patients with severe complications [14]. Eto *et al*[24] also reported a cure rate of 90% within 4 d of single-stage treatment for AC (45 out of 50 patients), as well as complete stone clearance achieved in all patients and a complication rate of only 10% (5 out of 50 individuals). This approach effectively reduces the risks associated with two-stage ERCP procedures. Our study included 254 patients who underwent urgent single-stage endoscopic procedures, all of which resulted in complete stone clearance and a low complication rate of 16.5%. These results suggested that single-stage treatment can be an effective and safe method for treating moderate to SAC associated with stone removal.

In 2023, Hedjoudje *et al*[22] conducted an analytical study based on a substantial database that included 85 patients with severe cholangitis. These patients underwent drainage within 24 h, while the remaining 51 patients underwent drainage 24 h later. The study revealed that the elective ERCP procedure was linked to higher mortality rates (13.0% *vs* 45.5%, $P < 0.001$), prolonged length of ICU stays (4.61 d *vs* 7.41 d, $P = 0.004$), and increased LOHS. In a retrospective study conducted by Muangkaew *et al*[25], a cohort of patients diagnosed with acute biliary pancreatitis associated with cholangitis was analyzed. Of these, 67 out of 95 patients underwent drainage within 72 h. The study revealed no statistically significant differences in mortality, ERCP-related complications, or disease-related complications between the early and elective ERCP groups. However, the early ERCP (< 72 h) group had a shorter LOHS (6.3 ± 4.4 d) than did the elective ERCP group (9.8 ± 6.1 d; $P = 0.002$). The difference in mortality outcomes between the two studies may be attributed to the study of Hedjoudje *et al*[22], patients specifically with severe cholangitis were enrolled, which potentially resulted in significantly greater mortality rates than those in the study of Muangkaew *et al*[25]. This discrepancy may partially explain the differences in mortality outcomes between the two studies.

Given the relatively low mortality rate observed among cholangitis patients in our study, our primary outcome measures included the ICU admission rate, ICU length of stay, and duration of antibiotic use. After analyzing multiple factors within our matched cohort, we found that for every hour of delay in ERCP, patients' ICU stay increased by 0.033 d. Such a prolonged ICU stay not only contributes to increased hospital expenses but also amplifies the risks of hospital-acquired infections and associated adverse events. Our research underscores the imperative for urgent ERCP in patients experiencing moderate to SAC. The delay in receiving ERCP correlates with extended hospital and ICU stays, aligning with findings from prior investigations[11,21,22,25,26]. Nevertheless, we observed a heightened ICU admission rate in the urgent ERCP group, potentially attributed to the greater prevalence of severe cases in that cohort (34.4% *vs* 21.5%, $P = 0.05$). After surgery, medical practitioners typically move patients with severe biliary tract inflammation to the ICU for stabilization. Contrary to this norm, our study demonstrated that patients receiving urgent ERCP exhibited a shorter ICU stay (3 d *vs* 8 d, $P < 0.001$), with no discernible differences in post-ERCP prognostic indicators between the two groups. Despite a higher percentage of severe patients in the urgent group, patients in this subset recovered faster post surgery. Additionally, we assessed the duration of antibiotic usage among patients who underwent ERCP. Patients in the urgent group had a significantly shorter duration of antibiotic usage than did those in the nonurgent group (7 d *vs* 16 d, $P < 0.001$). Simultaneously, our results indicate a reduction in overall hospitalization within the urgent group. These findings collectively affirm the quicker postoperative recovery observed in the urgent group. Furthermore, our multifactorial linear analysis of ICU stay length revealed that Cr levels had a significant impact on ICU stay.

There are several limitations to our research. First, there may be inherent selection bias present, and the results of our research may only reflect the clinical situation within our facility because this was a retrospective single-center study. Second, we implemented strict inclusion and exclusion criteria, which led to a relatively small sample size. To address these issues, further large-scale clinical studies are necessary to confirm our findings.

CONCLUSION

To summarize, urgent one-stage endoscopic treatment is feasible and safe for patients with moderate to SAC. Our

research also showed that if ERCP is performed more than 24 h after admission for moderate to SAC, it may lead to longer stays in the ICU and hospital.

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