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Impact of atrial fibrillation on in-hospital outcomes following endoscopic retrograde cholangiopancreatography: a propensity score-matched analysis of the National Inpatient Sample (2016-2020)

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Abstract

Background Endoscopic retrograde cholangiopancreatography (ERCP) is a critical tool in managing hepatobiliary and pancreatic diseases. Atrial fibrillation (AF) has been associated with greater morbidity in patients undergoing ERCP. This study compared in-hospital ERCP outcomes in patients with and without AF.

Methods This retrospective cohort study utilized data from the National Inpatient Sample (2016-2020). Patients who underwent ERCP during hospitalization were included. Patients with AF were matched 1:1 to those without AF, based on demographic and clinical variables. The primary outcome was all-cause in-hospital mortality. Secondary outcomes included procedure-related and non-procedure-related complications, hospitalization cost and length of stay.

Results The final matched sample consisted of 29,942 patients, with 14,971 in each group (AF and non-AF). Patients with AF demonstrated significantly higher in-hospital mortality compared to those without AF (3.6% vs. 1.9%; odds ratio [OR] 1.87, 95% confidence interval [CI] 1.62-2.17). The AF group had a significantly longer median length of stay (8.1 vs. 6.4 days; β 1.7; 95%CI 1.5-1.8) and incurred higher hospitalization costs ($111,000 vs. $87,255; β $23,745; 95%CI $20,783-26,708). In terms of complications, patients with AF had significantly higher rates of acute kidney injury (OR 1.33, 95%CI 1.27-1.40) and sepsis (OR 1.38, 95%CI 1.30-1.48). However, the rates of procedure-specific complications, including biliary perforation, post-ERCP pancreatitis and post-ERCP cholangitis, were similar between the 2 groups.

Conclusion Patients with AF undergoing ERCP have higher in-hospital mortality, longer stays, greater costs, and higher rates of acute kidney injury and sepsis, although procedure-specific complication rates remain unaffected.

Keywords Endoscopic retrograde cholangiopancreatography, atrial fibrillation, mortality, in-hospital outcome, national inpatient sample

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Conflict of Interest: None

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Introduction

Endoscopic retrograde cholangiopancreatography (ERCP) is an essential tool in managing hepatobiliary and pancreatic pathology. Since its development in the 1960s, ERCP has evolved from a purely diagnostic procedure into a primarily therapeutic intervention [1]. Today, it is considered the gold standard for managing these conditions, offering a high success rate with lower morbidity and mortality compared to surgical alternatives [2,3]. However, ERCP remains associated with significant procedural risks, including post-ERCP pancreatitis, bleeding and infections, making it one of the higher-risk endoscopic procedures [4,5]. Recent studies

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continue to highlight its complication rates, underscoring the need for careful patient selection and risk mitigation strategies [6,7].

The importance of understanding and mitigating the risks associated with ERCP cannot be overstated, especially given the complex nature of the conditions it treats. Preceding studies have highlighted various factors that can influence ERCP outcomes [8]. Comorbidities such as atrial fibrillation (AF) have been shown to increase adverse outcomes in patients undergoing ERCP, as presented in an analysis of the National Inpatient Sample (NIS) in 2016 [9]. Given the significant implications of AF for in-hospital patient outcomes, it is crucial to examine its impact on those undergoing ERCP.

To date, comprehensive studies employing robust methodologies have not been conducted to compare the in-hospital outcomes of ERCP in patients with and without AF. To address this gap, our study leveraged propensity score matching to minimize confounding variables and gain a more precise understanding of the risks associated with AF in this context. This study sought to elucidate the varying impact of AF on key outcomes, including all-cause in-hospital mortality, procedure-related and non-procedure-related complications, length of hospital stay, and total hospitalization costs.

Materials and methods

Data source

Data for this retrospective cohort study were collected from the NIS database provided by the Healthcare Cost and Utilization Project (HCUP) from January 1, 2016, to December 31, 2020. NIS is the largest, all-payer, inpatient care database publicly available in the United States and represents approximately 20% of all discharges from United States (US) hospitals [10]. It stores de-identified information about individual hospitalizations, including demographic characteristics, diagnoses and procedures, in the form of International Classification of Diseases (ICD)-10 codes [11]. The internal validity of the database is maintained by annual quality assessments, and its external validity is assessed and ensured by comparison with the National Hospital Discharge Survey from the National Center for Health Statistics, the American Hospital Association Annual Survey Database, and the Medicare Provider Analysis and Review inpatient data from the Centers for Medicare and Medicaid Services [12].

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Study population

Using the NIS data, patients 18 years and above who had undergone ERCP during their hospital stay between January 1st, 2016, and December 31st, 2020, were included in this study. The identification of ERCP was made based on ICD-10 PCS codes (Supplementary Table 1). ICD-10 codes were used to identify patients with atrial fibrillation (Supplementary Table 1). Discharge weights in the NIS were used to compute national estimates. Employing 1:1 propensity score matching, 14,971 patients with atrial fibrillation were matched with an equivalent number of patients without atrial fibrillation. The matching variables were age, sex, race, region, location and teaching status of the hospital, payer, Charlson comorbidity index, body mass index (BMI), immunosuppressive medications (chemotherapy or steroids), anticoagulant and antiplatelet use before admission, pacemaker and implantable defibrillator cardioverter implant history before admission, the presence or absence of hyperlipidemia, diabetes or hypertension, alcohol or nicotine dependence history, as well as heart failure, malignancy, chronic kidney disease (CKD), chronic liver disease (CLD), chronic obstructive pulmonary disease (COPD), asthma, pulmonary arterial hypertension (PAH), indication for ERCP (acute cholangitis, acute gallstone pancreatitis, choledocholithiasis, pancreaticobiliary mass, obstructive jaundice with no clear cause, and miscellaneous), and procedure performed during the ERCP (biliary and pancreatic stenting).

Study objective

The primary objective of this study was to elucidate the impact of atrial fibrillation on in-hospital outcomes among patients undergoing ERCP during their hospitalization. The primary outcome assessed was all-cause in-hospital mortality during the index hospitalization. Secondary outcomes encompassed the length of stay, the total cost of hospitalization, and procedure-related and non-procedure-related complications during the same hospitalization.

Study variables

Demographic variables such as age, sex and race/ethnicity were directly extracted from the NIS data. Age was categorized into 4 ranges: 18-44, 45-64, 65-84 and 85+ years. BMI categories were defined using ICD-10-CM diagnostic codes for overweight (BMI 25-29.9 kg/m^2), class I and II obesity (BMI 30-39.9 kg/m^2), and Class III obesity (BMI >40 kg/m^2). Patients who did not fall into these 3 categories were classified as having a BMI <25 kg/m^2. AF was identified using ICD-10-CM diagnosis codes (Supplementary Table 1). The presence or absence of hyperlipidemia, diabetes, hypertension, alcohol dependence history, nicotine dependence history, heart failure, malignancy, CKD, COPD, CLD, asthma and PAH was determined using corresponding ICD-10-CM diagnosis codes (Supplementary Table 1). The indication for the ERCP was evaluated based on the presence of 1 or more of the following conditions: acute cholangitis, acute gallstone pancreatitis, choledocholithiasis, pancreaticobiliary mass, obstructive jaundice with no clear cause; all these were coded using the corresponding ICD-10 CM codes. When none of these conditions were present during the index hospitalization, the indication for the ERCP was labeled as miscellaneous. Pancreatic and biliary stenting during the ERCP were coded using corresponding ICD-10 PCS codes. Antiplatelet or anticoagulant use, and pacemaker and implantable cardioverter-defibrillator implants before admission were also coded using corresponding ICD 10 codes. A literature review guided the identification of potential procedure-related and non-procedure-related complications following ERCP, and new variables were created based on the corresponding ICD-10-CM diagnostic codes (Supplementary Table 1). For acute post-ERCP pancreatitis, since no specific ICD-10 code was available, a previously well-validated combination of existing ICD-10 codes was used [13-15]. Inpatient mortality and length of stay data were extracted directly from the NIS dataset.

Statistical analysis

In light of potential dissimilarities between patients with atrial fibrillation and those without, we implemented a propensity score matching technique to address potential confounding factors [16]. The propensity score was computed using a non-parsimonious logistic regression model incorporating the relevant matching variables reported above. Employing a 1:1 matching scheme without replacement, nearest-neighbor matching, and a caliper width of 0.001 on the probability scale, we sought to ensure the robustness of the matching process. The standardized mean differences (SMD) in the sample population pre- and post-matching are shown in Table 1. Instances of hospitalizations that fell beyond the specified caliper width were excluded to minimize bias, as their comorbidities were disproportionate to the remainder of the cohort. Continuous variables were succinctly summarized using means and standard deviations, with inter-group comparisons conducted through *t*-tests. Categorical variables, on the other hand, were summarized using proportions and subjected to inter-group comparisons utilizing the chi-square test. The odds ratios (OR) of atrial fibrillation for each procedure-related and non-procedure-related complication were assessed using the Cochrane-Mantel-Haenszel test. Simple linear regression models were used to evaluate differences in length of stay and cost of hospitalization. The output of all tests was reported with a 95% confidence interval at a 0.05 level of significance. All data cleaning and analysis were performed using R statistical software version 4.1.3 (2023) [17]. Propensity score matching was performed using the "MatchIt" package in R [18].

Results

A total of 29,942 patients underwent ERCP from 2016-2020; of these, 14,971 patients had AF, and they were matched with the same number of patients without AF. The mean age was 76.8±11 years and 54% of patients were male. The majority of patients were White (80%). There was no significant difference between the groups as regards the baseline characteristics, including comorbidities, Charlson comorbidity index, indications for ERCP, hospital setting where ERCP was performed, and long-term anticoagulation or antiplatelet use.

The most common indication for ERCP was choledocholithiasis (50%), followed by pancreaticobiliary mass (15.7%), acute gallstone pancreatitis (14.8%), obstructive jaundice (11%), acute cholangitis (5%), and other (3%). Biliary stents were placed in 47% of the patients, while pancreatic duct stents were placed in 6.6% (Table 1). The most common procedure-related complication was gastrointestinal/hepatobiliary bleeding (1.2%), followed by post-ERCP pancreatitis (0.6%), biliary perforation (0.5%) and post-ERCP cholangitis (0.2%) (Table 2).

Outcomes

A total of 827 patients (2.8%) died during their hospital stay (1.9% in the non-AF group vs. 3.6% in the AF group). Mortality was significantly higher among the AF cohort in comparison to the non-AF cohort (OR 1.87, 95% confidence interval [CI] 1.62-2.17). The overall cohort's median length of stay was 7.3 days. Mean hospital stay was slightly longer in the AF group (8.1 vs. 6.4 days; β 1.7; 95%CI 1.5-1.8). The median cost of hospitalization in the entire cohort was $99,134. The AF group had a higher cost of hospitalization ($111,000 vs. $87,255; β $23,745; 95%CI $20,783-26,708).

There was a greater risk of periprocedural gastrointestinal or hepatobiliary bleeding in the AF group (1.3% vs. 1%; OR 1.33, 95%CI 1.08-1.65; P=0.008). The incidence of acute kidney injury (OR 1.33, 95%CI 1.27-1.40; P<0.001) and sepsis (OR 1.38, 95%CI 1.3-1.48; P<0.001) was also significantly higher in the AF group. In addition, patients in the AF group received more blood transfusions than the non-AF group (OR 1.35, 95%CI 1.21-1.5; P<0.001). Notably, the 2 groups had no significant discrepancies in the occurrence rates of biliary perforation, post-ERCP pancreatitis, or post-ERCP cholangitis. Moreover, the incidence of deep vein thrombosis (DVT), pulmonary embolism (PE), and periprocedural cardiac arrest was comparable across both groups (Table 3).

Discussion

To the best of our knowledge, this is the first propensity score-matched study to compare the outcome of patients with and without AF undergoing ERCP. According to our study, those with AF had longer mean hospital stays, a higher

Table 1 Baseline patient characteristics in the study population

Variables	Categories	Overall	No AF	AF	SMD
n		29942	14971	14971	
Age (mean (SD))		76.8 (11.0)	76.6 (11.1)	76.9 (10.8)	0.032
Age categories (%)	<45 years	264 (0.9)	124 (0.8)	140 (0.9)	0.016
	>85 years	8486 (28.3)	4253 (28.4)	4233 (28.3)	
	45-64 years	3514 (11.7)	1732 (11.6)	1782 (11.9)	
	65-74 years	7475 (25.0)	3740 (25.0)	3735 (24.9)	
	75-84 years	10203 (34.1)	5122 (34.2)	5081 (33.9)	
Sex (%)	Female	13717 (45.8)	6804 (45.4)	6913 (46.2)	0.015
	Male	16225 (54.2)	8167 (54.6)	8058 (53.8)	
Race (%)	Asian or Pacific Islander	1109 (3.7)	528 (3.5)	581 (3.9)	0.025
	Black	1612 (5.4)	801 (5.4)	811 (5.4)	
	Hispanic	2177 (7.3)	1059 (7.1)	1118 (7.5)	
	Native American	136 (0.5)	69 (0.5)	67 (0.4)	
	Other	753 (2.5)	378 (2.5)	375 (2.5)	
	White	24155 (80.7)	12136 (81.1)	12019 (80.3)	
Region (%)	Midwest	6720 (22.4)	3344 (22.3)	3376 (22.6)	0.010
	Northeast	6315 (21.1)	3152 (21.1)	3163 (21.1)	
	South	10412 (34.8)	5241 (35.0)	5171 (34.5)	
	West	6495 (21.7)	3234 (21.6)	3261 (21.8)	
Location and teaching status of the hospital (%)	Rural	1038 (3.5)	529 (3.5)	509 (3.4)	0.016
	Urban nonteaching	5680 (19.0)	2795 (18.7)	2885 (19.3)	
	Urban teaching	23224 (77.6)	11647 (77.8)	11577 (77.3)	
Charlson Comorbidity Index (%)	Mild	14863 (49.6)	7472 (49.9)	7391 (49.4)	0.059
	Moderate	7244 (24.2)	3450 (23.0)	3794 (25.3)	
	Severe	7835 (26.2)	4049 (27.0)	3786 (25.3)	
BMI (kg/m^2) (%)	BMI (< 25)	24766 (82.7)	12418 (82.9)	12348 (82.5)	0.014
	BMI (>40)	2111 (7.1)	1052 (7.0)	1059 (7.1)	
	BMI (25-29.9)	131 (0.4)	63 (0.4)	68 (0.5)	
	BMI (30-39.9)	2934 (9.8)	1438 (9.6)	1496 (10.0)	
Dyslipidemia (%)		15237 (50.9)	7631 (51.0)	7606 (50.8)	0.003
Diabetes (%)		10603 (35.4)	5288 (35.3)	5315 (35.5)	0.004
Hypertension (%)		24537 (81.9)	12312 (82.2)	12225 (81.7)	0.015
Alcohol abuse (%)		1065 (3.6)	536 (3.6)	529 (3.5)	0.003
Smoking (%)		10353 (34.6)	5192 (34.7)	5161 (34.5)	0.004
CLD (%)		3070 (10.3)	1534 (10.2)	1536 (10.3)	<0.001
Malignancy (%)		4827 (16.1)	2450 (16.4)	2377 (15.9)	0.013
Heart failure	HFrEF (%)	2269 (7.6)	1137 (7.6)	1132 (7.6)	0.001
	HFpEF (%)	3473 (11.6)	1758 (11.7)	1715 (11.5)	0.009
CKD	No CKD	28571 (95.4)	14295 (95.5)	14276 (95.4)	0.013
	Stage 1	48 (0.2)	24 (0.2)	24 (0.2)	
	Stage 2	377 (1.3)	185 (1.2)	192 (1.3)	
	Stage 3A	22 (0.1)	13 (0.1)	9 (0.1)	
	Stage 3B	15 (0.1)	8 (0.1)	7 (0.0)	
	Stage 4	854 (2.9)	419 (2.8)	435 (2.9)	
	ESRD	55 (0.2)	27 (0.2)	28 (0.2)	

(*Contd...*)

Table 1 (*Continued*)

Variables	Categories	Overall	No AF	AF	SMD
COPD (%)		38 (0.1)	16 (0.1)	22 (0.1)	0.011
Asthma (%)		1468 (4.9)	734 (4.9)	734 (4.9)	<0.001
Pulmonary hypertension (%)		1792 (6.0)	876 (5.9)	916 (6.1)	0.011
Indication for the ERCP (%)	Acute cholangitis	1630 (5.4)	842 (5.6)	788 (5.3)	0.002
	Acute gallstone Pancreatitis	4430 (14.8)	2175 (14.5)	2255 (15.1)	
	Choledocholithiasis	14968 (50.0)	7446 (49.7)	7522 (50.2)	
	Miscellaneous	871 (2.9)	420 (2.8)	451 (3.0)	
	Obstructive jaundice NOS	3353 (11.2)	1688 (11.3)	1665 (11.1)	
	Pancreaticobiliary mass	4690 (15.7)	2400 (16.0)	2290 (15.3)	
Procedures	Biliary stent (%)	14071 (47.0)	7068 (47.2)	7003 (46.8)	0.009
	Pancreatic duct stent (%)	1964 (6.6)	961 (6.4)	1003 (6.7)	0.011
Medication use prior to admission	Anticoagulant use (%)	6008 (20.1)	2879 (19.2)	3129 (20.9)	0.042
	Antiplatelet use (%)	1325 (4.4)	667 (4.5)	658 (4.4)	0.003
	Chemotherapy (%)	123 (0.4)	60 (0.4)	63 (0.4)	<0.001
	Corticosteroids (%)	469 (1.6)	233 (1.6)	236 (1.6)	<0.001
Device implant history	Pacemaker (%)	1931 (6.4)	948 (6.3)	983 (6.6)	0.010
	ICD (%)	728 (2.4)	364 (2.4)	364 (2.4)	<0.001

AF, atrial fibrillation; SMD, standardized mean difference; SD, standard deviation; BMI, body mass index; CLD, chronic liver disease; HFpEF, heart failure with preserved ejection fraction; HFrEF, heart failure with reduced ejection fraction; CKD, chronic kidney disease; COPD, chronic obstructive pulmonary disease; ERCP, endoscopic retrograde cholangiopancreatography; NOS, not otherwise specified; ICD, implantable cardioverter-defibrillator

Table 2 Frequency of in-hospital complications and outcomes

Complication	Categories	Overall	No AF	AF	P-value
n		29942	14971	14971	
Periprocedural cardiac arrest (%)		29 (0.1)	12 (0.1)	17 (0.1)	0.457
Acute kidney injury (%)		8530 (28.5)	3830 (25.6)	4700 (31.4)	<0.001
Pulmonary embolism (%)		282 (0.9)	158 (1.1)	124 (0.8)	0.048
Deep vein thrombosis (%)		570 (1.9)	297 (2.0)	273 (1.8)	0.331
Sepsis (%)		4434 (14.8)	1912 (12.8)	2522 (16.8)	<0.001
Number of packed red blood cell transfusions (%)	1-2 units	1372 (4.6)	589 (3.9)	783 (5.2)	<0.001
	3-4 units	7 (0.0)	3 (0.0)	4 (0.0)	
	More than 4 units	2 (0.0)	1 (0.0)	1 (0.0)	
	No transfusion	28561 (95.4)	14378 (96.0)	14183 (94.7)	
Periprocedural gastrointestinal and Hepatobiliary bleeding (%)		348 (1.2)	150 (1.0)	198 (1.3)	0.008
Biliary perforation (%)		145 (0.5)	67 (0.4)	78 (0.5)	0.405
Post ERCP cholangitis (%)		63 (0.2)	30 (0.2)	33 (0.2)	0.706
Post ERCP pancreatitis (%)		184 (0.6)	88 (0.6)	96 (0.6)	0.555
In-hospital mortality (%)		827 (2.8)	291 (1.9)	536 (3.6)	<0.001
Length of stay (days) (median (IQR))		7.3 (7.4)	6.4 (6.5)	8.1 (8.2)	<0.001
Total cost of hospitalization (US$) (Median (IQR))		99,134.8 (130,884.2)	87,255.3 (111,099.1)	111,000.8 (147,079.0)	<0.001

AF, atrial fibrillation; ERCP, endoscopic retrograde cholangiopancreatography; IQR, interquartile range

Table 3 Odds ratio for in-hospital complications in the AF group compared to the non-AF group

In-hospital complications	OR	95%CI	P-value
Periprocedural cardiac arrest	1.42	0.68-3.04	0.356
Acute kidney injury	1.33	1.27-1.4	<0.001
Pulmonary embolism	0.78	0.62-1.09	0.062
Deep vein thrombosis	0.92	0.78-1.08	0.309
Sepsis	1.38	1.3-1.48	<0.001
Periprocedural GI and hepatobiliary bleeding	1.33	1.08-1.65	0.008
Need for packed red blood cell transfusion	1.35	1.21-1.5	<0.001
Biliary perforation	1.15	0.83-1.6	0.405
Post ERCP cholangitis	1.10	0.67-1.81	0.706
Post ERCP pancreatitis	1.09	0.82-1.46	0.555
In-hospital mortality	1.87	1.62-2.17	<0.001

CI, confidence interval; GI, gastrointestinal; ERCP, endoscopic retrograde cholangiopancreatography

incidence of in-hospital mortality, AKI, sepsis, periprocedural gastrointestinal and hepatobiliary bleeding, and need for blood transfusion, whereas rates of various periprocedural complications, such as cardiac arrest, pancreatitis, biliary perforation, cholangitis and DVT, were similar between the 2 groups.

AF has been established as a risk factor for greater in-hospital mortality in various patient groups, including patients with known cardiovascular disease, critically ill Intensive Care Unit patients, elderly patients, patients with pulmonary hypertension, and hospitalized COVID-19 patients [19-22]. However, whether AF affects inpatient outcomes in patients undergoing ERCP is largely unexplored. The overall in-hospital mortality following ERCP ranges from 0.1-3.3% in various studies, depending on the study population, procedural indications and patient comorbidities [23-25]. The 2.8% overall mortality rate observed in our study falls within this range, but is on the higher end compared to some earlier reports. One major factor contributing to this discrepancy is the inclusion of an older patient population with significant comorbidities, as our study specifically focused on patients with and without AF, a population inherently at higher risk for adverse outcomes. Studies reporting lower mortality rates often include a broader ERCP population, including elective outpatient cases with lower acuity, which may underestimate the true mortality risk in hospitalized patients undergoing the procedure. Notably, the higher mortality rate in patients with AF observed in our study aligns with the findings of Sharma *et al*, who analyzed NIS data from 2016 and found a greater risk of adverse outcomes in AF patients undergoing ERCP [9]. Our study expands on these findings by utilizing a multi-year dataset and propensity score matching to provide a more robust comparison. The similar incidence of periprocedural cardiac arrest between groups suggests that immediate procedural complications are unlikely to be the primary driver of higher mortality in the AF cohort. Instead, the significantly higher rates of sepsis and acute kidney injury in the AF group suggest that late postprocedural complications play a crucial role in driving mortality differences.

With regard to the utilization of hospital resources, patients with AF had a longer hospital stay and higher costs of hospitalization, a finding that is in line with the study by Sharma *et al* [9]. Both length of stay and hospital charges are directly related to the presence and severity of in-hospital complications, as more time and resources are needed to manage them. The higher incidence of several inpatient complications observed in the AF cohort could partially explain the longer length of stay and increased hospital charges observed in the same group. In addition, the level of anticoagulation has to be monitored and necessary adjustments made in patients with AF, further lengthening their hospital stay.

While the overall incidence of periprocedural pancreatitis was remarkably lower than reports from prior studies, the rate of periprocedural bleeding was similar to previous reports [26-31]. Most previously identified risk factors for post-ERCP pancreatitis are procedure-related factors, such as difficult and repeated cannulation of the main pancreatic duct, multiple contrast material injections into the main pancreatic duct, pancreatic sphincterotomy, endoscopic snare papillectomy, and balloon dilation of an intact biliary sphincter [32-36]. The presence of these factors is largely influenced by the indication for the procedure, and it is not expected to be affected by the concomitant presence of AF. Other patient-related factors, such as age and sex, were also similar between the 2 groups following propensity score matching, mitigating their increased risk of post-ERCP pancreatitis observed in prior studies [37-39]. A statistically significant higher incidence of periprocedural gastrointestinal and hepatobiliary bleeding in the AF group is an expected finding, as these patients tend to be on chronic anticoagulation before undergoing ERCP.

Concerning the thrombotic events, the risk of developing PE was significantly lower in patients with AF. Similarly, although it did not reach statistical significance, there was a trend toward a lesser risk of DVT in this group. This is despite patients with AF having a longer mean hospital stay (8.2 vs. 6.1 days), a well-established risk factor for the development of DVT and PE. A possible explanation for this finding is the fact that after undergoing ERCP, AF patients would be put on therapeutic anticoagulation as soon as feasible, while those without AF would be kept on prophylactic anticoagulation for the duration of their hospitalization.

Our study had several strengths, including a large sample size, which provides a robust and comprehensive overview of in-hospital outcomes across a wide variety of US hospital institutions. Moreover, the use of propensity matching mitigates confounding variables and allows for a more balanced comparison between groups. However, several limitations should be acknowledged. First, the retrospective design limits inference, and causation cannot be established. Additionally, while propensity score matching helps reduce confounding, residual confounding may persist despite our best efforts to account for relevant factors. Second, the reliance on administrative data coded via ICD-10 introduces the potential for misclassification bias and limits the granularity of certain variables, particularly when assessing complications and comorbidities. Furthermore, the ICD-10 codes used to identify atrial fibrillation and procedural complications, such as biliary perforation, post-ERCP pancreatitis, and gastrointestinal or hepatobiliary bleeding, may not fully capture the clinical complexity or severity of these conditions. Additionally, administrative databases like the National Inpatient Sample do not capture data regarding the cause of death or prolonged hospital stay, limiting the interpretation of some of our findings. These limitations should be considered when interpreting our findings, highlighting the need for prospective studies with more precise data collection to validate and expand upon these results.

In summary, our study highlights that AF significantly impacts hospital outcomes in patients undergoing ERCP. Greater mortality, longer hospital stays, and higher complication rates were seen in patients with AF. Vigilant perioperative monitoring and careful management of anticoagulation are crucial in mitigating these risks. Future prospective studies should attempt to confirm the associations observed, and to explore the underlying mechanisms contributing to the increased risk of in-hospital mortality and complications in patients with AF undergoing ERCP. Moreover, studies should investigate the optimal management strategies for anticoagulation in these patients, attempting to balance the risk of bleeding and thrombotic events.

Summary Box

What is already known:

- Endoscopic retrograde cholangiopancreatography (ERCP) is the gold standard for treating hepatobiliary and pancreatic conditions but has high morbidity
- Atrial fibrillation (AF) is linked to worse outcomes, including in-hospital mortality and complications
- The impact of AF on ERCP outcomes remains unclear
- Periprocedural complications in ERCP are influenced by multiple factors, but the role of AF has not been well studied

What the new findings are:

- AF patients undergoing ERCP had higher in-hospital mortality (3.6% vs. 1.9%) and longer stays (8.1 vs. 6.4 days)
- AF was associated with higher hospitalization costs ($111,000 vs. $87,255) and more complications, including bleeding and acute kidney injury
- No significant differences were observed in post-ERCP pancreatitis, biliary perforation, or cardiac events

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Supplementary material

Supplementary Table 1 ICD -10 CM and ICD -10 PCS codes used for variables

Condition	ICD-10 CM/PCS Codes
Endoscopic retrograde cholangiopancreatography (ERCP)	0FJB8ZZ, 0FJD8ZZ, 0F9C8ZZ, 0F758DZ, 0F768DZ, 0F788DZ, 0F798DZ, 0F7C8DZ, 0F9580Z, 0F9680Z, 0F9880Z, 0F9980Z, 0F9C80Z, 0FC58ZZ, 0FC68ZZ, 0FC88ZZ, 0FC98ZZ, 0FCC8ZZ, 0FF58ZZ, 0FF68ZZ, 0FF88ZZ, 0FF98ZZ, 0FFC8ZZ, 0FJD8ZZ, 0F7D8DZ, 0F7F8DZ, 0F9D80Z, 0F9F80Z, 0FCD8ZZ, 0FCF8ZZ, 0FFD8ZZ, 0FFF8ZZ
Biliary duct stenting	0F758DZ, 0F768DZ, 0F788DZ, 0F798DZ, 0F7C8DZ, 0F9580Z, 0F9680Z, 0F9880Z, 0F9980Z, 0F9C80Z
Pancreatic duct stenting	0F7D8DZ, 0F7F8DZ, 0F9D80Z, 0F9F80Z
Cardiogenic shock	R57.0
Liver cirrhosis	K74*, K70.2*, K70.3*
Anticoagulant use history	Z79.01
Antiplatelet use history	Z79.02
Dyslipidemia	E78
Diabetes	E09, E10, E11, E12, E13
Pulmonary hypertension	I27*
Chronic kidney disease	N181*, N182*, N1831*, N1832*, N184*, N185*
Chronic obstructive pulmonary disease	J40*, J41*, J42*, J43*, J44*
Asthma	J45*
Heart failure with preserved ejection fraction	I50.3*
Heart failure with reduced ejection fraction	I50.2*
Alcohol use	F10*
Tobacco use history	F1721*, F1722*, F1720*, F1729*, Z87891*, Z720*
Hypertension	I10*, I11*, I12*, I13*, I15*, I16*, I1A*
Overweight (BMI 25-29.99 Kg/m^2)	E66.3*
Obesity class I & II (BMI 30-39.9 Kg/m2)	E66.09*, E66.1*, E66.8*, E66.9*
Obesity class III (BMI >40 Kg/m^2)	E66.01*, E66.2*
Blood transfusion	30233N0, 30233N1, 30243N1
Periprocedural GI and hepatobiliary bleeding	K91.61, K91.840, K91.870
Biliary perforation	K91.71, K83.2
Post ERCP cholangitis	K83.0, K83.08
Pulmonary embolism	I26
Acute deep venous thrombosis	I82.210, I82.220, I82.290, I82.3, I82.40, I82.41, I82.42, I82.43, I82.44, I82.45, I82.46, I82.49, I82.4Y, I82.4Z, I82.62, I82.B1, I82.C1, I82.890, I82.90
Acute kidney injury	N17
Intracranial hemorrhage	I60*, I61*, I62*
Bacteremia	R78.81
Sepsis	A40, A41, T81.44
Cardiac arrest	I97.12, I97.71

BMI, body mass index; GI, gastrointestinal; ERCP, endoscopic retrograde cholangiopancreatography