RESEARCH PAPER

Comparative Outcomes of Lactated Ringer's Solution with Standard and Aggressive Hydration in Preventing Post-ERCP

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ABSTRACT

Background: Post-endoscopic retrograde cholangiopancreatography pancreatitis (PEP) is the most prevalent complication of ERCP with reported incidence of 3 to 15% globally and in some cases, it is higher in the high-risk groups. Prophylactic methods like pharmacological agent and procedural adjustments have been discussed, but the role of fluid therapy and especially aggressive hydration using lactated Ringer solution has become increasingly discussed because of its potential effects of improving the pancreatic microcirculation and reducing inflammation.

Aim: To compare the influence of aggressive versus standard hydration with lactated Ringer's solution on the incidence and clinical outcomes of post-ERCP pancreatitis.

Methods: It was a randomized controlled trial done at the Department of Medicine and Gastroenterology and Services Hospital Lahore (168 patients undergoing ERCPs) in aggressive and standard hydration groups (n=84 each). Aggressive hydration involved 6 ml/kg/hour during ERCP, then 40 ml/kg bolus, with continued infusion after the procedure whereas standard hydration adhered to traditional guidelines. A structured proforma was used to obtain data on demographic, clinical, laboratory, and procedural variables. The statistical analysis was conducted by means of SPSS version 28 with the use of independent t-tests and chi-square tests, where $p<0.05$ was used to assess the significance of test results.

Results: The incidence of PEP was significantly lower in the aggressive hydration group (4.8%) compared to the standard hydration group (16.7%) (p=0.01), with an odds ratio of 0.25 (95% CI: 0.08–0.78). Post-procedural enzyme levels were significantly reduced in the aggressive group, including amylase (145 ± 60 vs 210 ± 85 U/L at 12 hours, p=0.001) and lipase (180 ± 70 vs 260 ± 95 U/L, p=0.001). CRP levels at 48 hours were also lower (10.2 ± 4.8 vs 18.5 ± 6.2 mg/L, p=0.001). Hospital stay was significantly shorter (3.1 ± 1.2 vs 4.8 ± 1.9 days, p=0.001), and ICU admissions were reduced (1.2% vs 7.1%, p=0.04) in the aggressive hydration group.

Conclusion: Aggressive hydration with lactated Ringer solution is much more effective in reducing the rate and severity of post-ERCP pancreatitis, biochemical outcome and length of stay in the hospital than usual hydration. It is a valuable, inexpensive, and viable method to prevent PEP.

Keywords: Post-ERCP Pancreatitis, Aggressive Hydration, Lactated Ringer's Solution, ERCP Complications, Pancreatitis Prevention, Randomized Controlled Trial.

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INTRODUCTION

Endoscopic retrograde cholangiopancreatography (ERCP) is a vital therapeutic and diagnostic modality in biliary and pancreatic diseases, but with significant procedure-related complications, the most frequent being post-ERCP pancreatitis (PEP) (Cho et al., 2024). PEP is characterized as a new-onset abdominal pain, that has high levels of pancreatic enzymes and occurs following ERCP, commonly necessitating admission or extension of an existing one (Aljohani and Mirghani, 2021). The reported figures of PEP across the world are diverse between 3 and 15% on average risk patients and more than 20% on the high-risk groups (Shatsnimitkul et al., 2025). Less common, but severe forms of PEP lead to high morbidity, extended hospitalization, and health care expenses. There are several risk factors that are patient-related and procedure-related including sphincter of Oddi dysfunction, difficult cannulation, and pancreatic duct injection which predispose to PEP (Triki et al., 2024). The prevalence of PEP is still a clinically relevant burden in all parts of the world despite the innovations in the endoscopic procedures and prophylaxis. It has also led to thorough research on preventive measures that help to minimize the occurrence and severity of PEP (Cahyadi et al., 2022).

Pancreatic microcirculatory impairment that results in ischemia and the activation of an inflammatory cascade is one of the major pathogenic mechanisms involved in PEP (Easler and Fogel, 2021). It is an ischemic lesion caused by which premature activation of pancreatic enzymes is believed to occur, leading to autodigestion and inflammation. Fluid resuscitation is essential to avoid inflammatory injury progression as this involves pancreatic perfusion (Mirante et al., 2024). Lactated Ringer solution has been proposed to be better than normal saline because it can reduce the systemic inflammation and helps to maintain physiological pH (Paik et al., n.d.). Aggressive hydration plans are designed to address hypovolemia and pancreatic microcirculation in and out of ERCP. Conversely, the typical hydration plans entail the conservative fluid replacement which might not be adequate in patients at risk (Weiland et al., 2021). The hypothetical merit of aggressive hydration is the possibility to prevent the pancreatic ischemia and eliminate the inflammatory reaction as early as possible. Thus, hydration strategy has become a potentially manipulable variable in decreasing the occurrence of PEP (Kurita et al., 2023).

On top of the hydration interventions, nonsteroidal anti-inflammatory drugs (NSAIDs) have been commonly prescribed as a preventive measure of PEP because of their anti-inflammatory properties (Aziz et al., 2021). A number of clinical trials have explored the use of aggressive hydration using lactated Ringer's solution in the prevention of PEP with encouraging results. Randomized controlled trials also proved that aggressive hydration can greatly decrease the frequency of PEP in contrast to routine hydration interventions. An example that has been mentioned is that the rates of PEP decreased to about 5% in the aggressive hydration groups compared to about 17% in normal hydration groups (Park et al., 2023). Meta-analyses that indicate a pooling of risk reductions in favor of aggressive hydration strategies support these findings (Radadiya et al., 2022). Moreover, the most effective volume, time, and length of aggressive hydration are items of continuous research. Therefore, although there is evidence on aggressive hydration, the use of this method is subject to universal clinical attention (Chen et al., 2022).

In Pakistan, ERCP is increasingly performed for the management of biliary and pancreatic diseases, yet data on PEP prevention strategies remain limited (Hassan et al., 2025). PEP incidence rates locally have been reported to be similar to those in the rest of the world, with an incidence range of 5-12%, and varying with the characteristics of the patient population (Arham et al., 2026). The availability of resources and differences in clinical practice might affect the adoption of more advanced prophylactic interventions like NSAIDs or pancreatic stenting (Saleem et al., 2025). Aggressive hydration with lactated Ringer's solution offers a cost-effective

and feasible intervention in low- and middle-income settings. Yet, locally produced evidence assessing its effectiveness as opposed to conventional hydration measures is limited. Thus, the purpose of this study is to compare the effects of aggressive and normal hydration, and lactated Ringer solution, on the occurrence of PEP in a Pakistani clinical environment.

METHODS

Study Design and Setting

It is a randomized controlled trial study carried out in the Department of Medicine and Gastroenterology, Services Hospital in Lahore for the period from February 13, 2026 to May 12, 2026. This paper sought to compare the incidence of post-endoscopic retrograde cholangiopancreatography pancreatitis in aggressive and normal hydration groups. With a 5% level of significance and statistically 80% power, 168 patients were determined to be the total sample size. This was calculated using an expected frequency of PEP of 5% in the aggressive hydration group and 17% in the normal hydration group. A non-probability consecutive sampling method was applied in recruiting patients.

Study Population

Patients of both genders aged between 18- and 75-years undergoing ERCP were included in the study. They all had to have no previous cardiac or renal impairment history and be clinically fit to withstand aggressive hydration. The study excluded patients with renal impairment, which is the serum creatinine of 1.8 mg/dl and above or patients under dialysis conditions. Patients that had previous chronic pancreatitis were eliminated as well to prevent confounding of results. The study did not involve pregnant women and patients with diabetes mellitus. Patients with a high likelihood of fluid overload (CHF or chronic kidney disease), were excluded. Also patients having known allergy to Lactated Ringer solution or its constituents were excluded. Severely liver-diseased patients such as cirrhosis, or those that experience electrolyte imbalances before the procedure were also eliminated.

Randomization and Intervention

Patients were randomly selected to either group of 84 patients and a total of 168 patients were eligible to take part in the study. Aggressive hydration was administered to one group whereas standard hydration was administered to the other group. Randomization was done to provide equality of distribution and reduce selection bias. The aggressive hydration solution was administered at the rate of 6 ml/kg/hour Lactated Ringer in the aggressive hydration group during ERCP procedure. A 40 ml/kg bolus of this was then given immediately after the procedure. This was then followed by hydration over 8 hours after the procedure at a rate of 6 ml/kg/hour. The group that was on the standard hydration is the group that had fluids administered as per the traditional institutional guideline. Close clinical monitoring was used to guarantee that all interventions were given in a safe environment.

Data Collection

Data on all participants was collected using a predesigned proforma in which detailed demographic, clinical, and procedural data were gathered. Data was captured in terms of age, gender, clinical history and procedural data of ERCP. The main outcome used was post-ERCP pancreatitis. Secondary outcomes were severity of pancreatitis and complications. All patients were followed up after the procedure to manifest clinical and biochemical signs of PEP. The systematic method was used to collect the data so as to be accurate and comprehensive.

Data Analysis

Statistical Package for Social Sciences (SPSS) version 28 was used to analyze the data. Demographic, clinical and outcome variables were summarized using descriptive statistics. Continuous variables (duration of hospital stay) were described using mean standard deviation. The frequencies and percentages of categorical variables, such as age groups, genders, and PEP incidence were represented. The chi-square test was used to compare the incidence of PEP in the two groups. The value of p below 0.05 was regarded as statistically significant in all the

analyses. The multivariate logistic regression analysis was conducted to eliminate the possible confounding factors. Subgroup analyses were also performed to examine trends in particular patient groups, and findings were represented in the form of tables and graphs.

Ethical Considerations

The study was ethically approved by the institutional review board of Services Hospital, Lahore. Informed written consent was given to all participants. The study strictly respected confidentiality of patient data. Before the inclusion, the participants received information about the purpose, the procedures, risks and the benefits of the study. The research was carried out in line with ethical considerations in the Declaration of Helsinki.

RESULTS

Baseline Demographic Characteristics

The mean age of the standard hydration group was 52.4 ± 12.6 years and aggression hydration group was 51.1 ± 11.9 years (p=0.48). In the standard group male patients represented 54.8% (n=46) and in the aggressive group 57.1% (n=48) (p=0.77). The mean weight was 71.8 ± 10.5 kg in the standard group compared to 72.6 ± 9.8 kg in the aggressive group (p=0.62). These results show that there is no significant difference between the groups, which proves baseline comparability.

Table 1

Baseline Demographic Characteristics

Variable	Standard Hydration (n=84)	Aggressive Hydration (n=84)	p-value
Age (years)	52.4 ± 12.6	51.1 ± 11.9	0.48
Gender (Male)	46 (54.8%)	48 (57.1%)	0.77
Gender (Female)	38 (45.2%)	36 (42.9%)	—
Weight (kg)	71.8 ± 10.5	72.6 ± 9.8	0.62

Baseline Clinical Characteristics

Clinical parameters were also similar between the two in the baseline. In the normal group, the systolic pressure of blood was 128.6 ± 14.2 mmHg, and in the aggressive group, it was 126.9 ± 13.8 mmHg (p=0.41). There were no statistically significant differences in Diastolic blood pressure, heart rate, oxygen saturation and body temperature (p>0.05). These findings imply that the two groups were alike and in a stable clinical state before the intervention.

Table 2

Baseline Clinical Characteristics

Variable	Standard Hydration	Aggressive Hydration	p-value
Systolic BP (mmHg)	128.6 ± 14.2	126.9 ± 13.8	0.41
Diastolic BP (mmHg)	79.3 ± 9.1	78.5 ± 8.7	0.55
Heart Rate (bpm)	82.7 ± 10.3	81.9 ± 9.8	0.63
Oxygen Saturation (%)	97.2 ± 1.4	97.4 ± 1.2	0.36
Body Temperature (°C)	36.8 ± 0.5	36.7 ± 0.4	0.29

Pre-Procedural Laboratory and Clinical Parameters

Laboratory and clinical parameters were similar in both groups, pre-procedural. Average amylase in the standard population was 88.5 ±22.4 U/L and in the aggressive population was 86.7 ±21.9 U/L (p=0.58), and lipase levels were not different (p=0.49). There was no significant (p>0.05) difference in liver functioning tests, renal parameters, electrolytes, and CBC indices. Also, there was an equal distribution of the size of CBD, prevalence of hyperlipidemia and history of previous pancreatitis. This validates no baseline biochemical bias of groups.

Table 3

Pre-Procedural Laboratory and Clinical Parameters

Variable	Standard	Aggressive	p-value
Amylase (U/L)	88.5 ± 22.4	86.7 ± 21.9	0.58
Lipase (U/L)	52.6 ± 18.3	50.9 ± 17.7	0.49
ALT (U/L)	64.2 ± 28.5	62.8 ± 27.1	0.72
AST (U/L)	59.1 ± 25.3	57.6 ± 24.7	0.68
ALP (U/L)	212.5 ± 65.4	208.7 ± 62.9	0.70
Bilirubin (mg/dL)	2.4 ± 1.1	2.3 ± 1.0	0.66
GGT (U/L)	180.2 ± 72.5	176.9 ± 70.1	0.75
PT (sec)	13.5 ± 1.8	13.3 ± 1.7	0.47
Creatinine (mg/dL)	1.02 ± 0.21	1.01 ± 0.19	0.82
eGFR (ml/min)	88.6 ± 12.4	89.1 ± 11.8	0.79
Sodium (mEq/L)	138.2 ± 3.4	138.5 ± 3.2	0.61
Potassium (mEq/L)	4.2 ± 0.5	4.1 ± 0.4	0.38
Hemoglobin (g/dL)	12.9 ± 1.7	13.1 ± 1.6	0.45
CBD Size (mm)	10.8 ± 3.2	10.5 ± 3.0	0.53

Hyperlipidemia (Yes)	21 (25.0%)	19 (22.6%)	0.71
Previous Pancreatitis (Yes)	15 (17.9%)	14 (16.7%)	0.84

Intra-Procedural Characteristics

There were no differences in the intra-procedural characteristics. The average time taken per procedure was found to be 38.5 ± 12.2 minutes in the standard group and 37.9 ± 11.8 in the aggressive group (p=0.74). There were no significant differences in the rates of difficult cannulation, pancreatic duct injection and sphincterotomy (p>0.05). Such findings imply that there is uniformity in the procedures and that procedural bias is reduced.

Table 4

Intra-Procedural Characteristics

Variable	Standard	Aggressive	p-value
Procedure Duration (min)	38.5 ± 12.2	37.9 ± 11.8	0.74
Difficult Cannulation	19 (22.6%)	17 (20.2%)	0.70
Pancreatic Duct Injection	14 (16.7%)	13 (15.5%)	0.84
Sphincterotomy	51 (60.7%)	54 (64.3%)	0.63

The incidence of post-ERCP pancreatitis was significantly higher in the standard hydration group (16.7%) compared to the aggressive hydration group (4.8%) (p=0.01). PEP, mild and moderate, were more common in the standard group and severe PEP was only present in one patient in the standard group. Such results prove a statistically and clinically significant decrease of PEP using aggressive hydration.

Table 5

Post-Procedural Outcomes (PEP Incidence and Severity)

Outcome	Standard	Aggressive	p-value
PEP Incidence	14 (16.7%)	4 (4.8%)	0.01
Mild PEP	8 (9.5%)	3 (3.6%)	—
Moderate PEP	5 (6.0%)	1 (1.2%)	—
Severe PEP	1 (1.2%)	0 (0%)	—

Laboratory Trends at Follow-up

The trend of post-procedural laboratory results indicated that the aggressive hydration group had significantly reduced levels of inflammatory markers. At 12, 24 and 48 hours, the level of amylase and lipase was always lower (p≤0.02). CRP levels at 48 hours were markedly reduced in the aggressive group (10.2 ± 4.8 vs 18.5 ± 6.2, p=0.001). These results favor enhanced inflammatory management using vigorous hydration.

Table 6

Laboratory Trends at Follow-up

Parameter	Time	Standard	Aggressive	p-value
Amylase	12h	210 ± 85	145 ± 60	0.001
Amylase	24h	180 ± 70	120 ± 50	0.001
Amylase	48h	120 ± 50	90 ± 40	0.02
Lipase	12h	260 ± 95	180 ± 70	0.001
Lipase	24h	220 ± 80	150 ± 60	0.001
CRP	48h	18.5 ± 6.2	10.2 ± 4.8	0.001
Sodium	48h	137.5 ± 3.6	138.9 ± 3.1	0.03

Patients in the aggressive hydration group had significantly shorter hospital stays (3.1 ± 1.2 days) compared to the standard group (4.8 ± 1.9 days) (p=0.001). ICU admissions were also significantly lower in the aggressive group (1.2% vs 7.1%, p=0.04). These results indicate better clinical recovery and reduced healthcare burden with aggressive hydration.

Table 7

Hospital Stay and ICU Admission

Outcome	Standard	Aggressive	p-value
Hospital Stay (days)	4.8 ± 1.9	3.1 ± 1.2	0.001
ICU Admission	6 (7.1%)	1 (1.2%)	0.04

Normality and Comparative Analysis Outcomes

Age, weight, blood pressure, heart rate, baseline levels of amylase and lipase, and most of these variables showed normal distribution (p>0.05). But there was a slight deviation of hospital stay among both groups (p<0.05) though the deviation was very small and acceptable considering the number of samples. On the basis of these results, the parametric tests (independent samples t-test) were deemed suitable to most of the continuous variables. This is why independent t-tests were used to compare continuous variables and chi-square tests were utilized to compare categorical variables, and the level of statistical significance was set at p<0.05.

Table 8

Tests of Normality for Continuous Variables (Shapiro–Wilk Test)

Variable	Group	Statistic (W)	p-value
Age	Standard	0.976	0.182
	Aggressive	0.981	0.264

Weight	Standard	0.972	0.121
	Aggressive	0.978	0.198
Systolic BP	Standard	0.969	0.094
	Aggressive	0.975	0.156
Diastolic BP	Standard	0.974	0.139
	Aggressive	0.979	0.221
Heart Rate	Standard	0.971	0.113
	Aggressive	0.977	0.176
Amylase (Pre)	Standard	0.965	0.061
	Aggressive	0.970	0.088
Lipase (Pre)	Standard	0.962	0.052
	Aggressive	0.968	0.079
Hospital Stay	Standard	0.958	0.041
	Aggressive	0.961	0.048

Group comparability was established by comparison analysis which showed no statistically significant difference in baseline continuous variables: age (p=0.48), weight (p=0.62), systolic blood pressure (p=0.41), or heart rate (p=0.63). On the same note, baseline biochemical levels such as amylase and lipase did not exhibit any significant differences (p>0.05). Nonetheless, statistically significant decrease in PEP incidence was found in aggressive hydration group (4.8%) relative to the standard group (16.7%) (p=0.01) with odds ratio of 0.25 (95% CI: 0.08-0.78) implying reduction in risk by 75%. The aggressive group also showed a significantly reduced length of stay in the hospital (3.1 ± 1.2 vs 4.8 ± 1.9 days, p=0.001). The aggressive group had fewer ICU admissions, though with a wide confidence interval (OR=0.16, 95% CI: 0.02-1.34) that indicates the scarcity of events.

Table 9

Comparative Analysis Between Standard and Aggressive Hydration Groups

Variable	Standard	Aggressive	p-value	OR (95% CI)
Age (years)	52.4 ± 12.6	51.1 ± 11.9	0.48	—
Weight (kg)	71.8 ± 10.5	72.6 ± 9.8	0.62	—
Systolic BP	128.6 ± 14.2	126.9 ± 13.8	0.41	—
Heart Rate	82.7 ± 10.3	81.9 ± 9.8	0.63	—
Pre-Amylase	88.5 ± 22.4	86.7 ± 21.9	0.58	—
Pre-Lipase	52.6 ± 18.3	50.9 ± 17.7	0.49	—
PEP Incidence	14 (16.7%)	4 (4.8%)	0.01	0.25 (0.08–0.78)
Hyperlipidemia	21 (25.0%)	19 (22.6%)	0.71	0.87 (0.43–1.74)
Previous Pancreatitis	15 (17.9%)	14 (16.7%)	0.84	0.92 (0.41–2.05)
Difficult Cannulation	19 (22.6%)	17 (20.2%)	0.70	0.87 (0.42–1.81)
Hospital Stay (days)	4.8 ± 1.9	3.1 ± 1.2	0.001	—
ICU Admission	6 (7.1%)	1 (1.2%)	0.04	0.16 (0.02–1.34)

DISCUSSION

This study was planned to compare the effect of aggressive and standard hydration with lactated Ringer solution on the incidence and clinical outcomes of post- ERP pancreatitis. The results showed that the PEP occurred much less often in the aggressive hydration group (4.8%) than in the standard hydration group (16.7%), which was statistically at a significant difference (p=0.01). This translates to odds ratio of 0.25 (95% CI 0.08-0.78) which suggests a 75% risk reduction in case of aggressive hydration. Such findings align with the retrospective comparative study by Ko et al., (2026) in 1194 patients whose findings reflected that PEP rates in aggressive and standard groups were 5.3% and 17.0% respectively (Ko et al., 2026). The scale of the risk decrease in the current research corresponds in close relation to pooled estimates of meta-analyses that indicate a relative risk decrease of about 60-70% (Wu et al., 2021). The clinical significance of fluid resuscitation as a preventive approach, which can be altered, is also shown by the statistically significant difference. In addition, the confidence interval is very small, which supports the accuracy of the calculated treatment effect. Hence, aggressive hydration seems to be a very useful intervention to prevent the occurrence of PEP among this population.

Baseline demographic and clinical variables were similar across groups with no significant differences in mean age (52.4 ± 12.6 years vs 51.1 ± 11.9 years, p=0.48), and weight (71.8 ± 10.5 kg vs 72.6 ± 9.8 kg, p=0.62). Similarly,

baseline hemodynamic parameters such as systolic blood pressure (128.6 ± 14.2 vs 126.9 ± 13.8 mmHg, p=0.41) and heart rate (82.7 ± 10.3 vs 81.9 ± 9.8 bpm, p=0.63) were statistically comparable. These findings are important as they eliminate confounding bias and strengthen the internal validity of the study. Similar baseline features have been observed in a past RCT in United States among that assessed hydration interventions in 136 ERCP patients (Patel et al., 2022). Effective randomization is indicated by the absence of statistically significant differences (p>0.05). This is to ensure that the reduction in PEP was as a result of the intervention and not baseline imbalance. Equivalent methodological rigor has been highlighted in multicenter trials to determine the effectiveness of PEP prevention strategies (Wang et al., 2021). Thus, the comparability of groups increases outcome interpretation reliability.

Pre-procedural biochemical parameters, including amylase (88.5 ± 22.4 vs 86.7 ± 21.9 U/L, p=0.58) and lipase (52.6 ± 18.3 vs 50.9 ± 17.7 U/L, p=0.49), showed no statistically significant differences. There was also homogeneity in the baseline physiological status with liver function tests and renal indices being similar across groups (p>0.05). This is paramount because high baseline enzyme or liver dysfunction reported to be a factor contributing towards PEP risk in a recent RCT of 144 patients of PEP (Sharma et al., 2023). The similarity in CBD size (10.8 ± 3.2 vs 10.5 ± 3.0 mm, p=0.53) and prevalence of hyperlipidemia (25.0% vs 22.6%, p=0.71) further supports baseline equivalence. It has been previously shown in An Algerian RCT among 210 patients that baseline levels of enzymes do not predict PEP when procedural factors are confounded (Amalou et al., 2026). The lack of meaningful differences assures the fact that changes, which occur after the procedure, can be ascribed to hydration strategy. This enhances the cause-and-effect relationship between aggressive hydration and better results. In this way, uniformity of biochemical baselines supports the research results.

Intra-procedural outcomes, such as procedure time (38.5 ± 12.2 vs 37.9 ± 11.8 minutes, p=0.74) and challenging cannulation (22.6% vs 20.2%, p=0.70) were similar in the two groups. Pancreatic duct injection (16.7% vs 15.5%, p=0.84) and sphincterotomy rates (60.7% vs 64.3%, p=0.63) also did not differ significantly. These procedural variables have been proven risk factors of PEP and should be monitored when conducting a prevention plan (Abdullah, 2021). The absence of significant differences can be interpreted as uniformity of procedures in both groups. These results have also been observed in an open-label RCT on 521 patients of ERCP (Guha et al., 2023). This ensures that the results were not affected by procedural bias. Thus, the decrease in PEP that was observed can be assumed with certainty to be because of aggressive hydration and not due to variation in the procedures.

The post-procedural trend in lab showed a significant decrease in the inflammatory indicator in the aggressive hydration group, with amylase values (12 hours) of (145 ± 60 vs 210 ± 85 U/L, p=0.001) and lipase (180 ± 70 vs 260 ± 95 U/L, p=0.001). There was also a significant reduction in CRP at 48 hours (10.2 ± 4.8 vs 18.5 ± 6.2 mg/L, p=0.001), which showed a decreased systemic inflammatory state. These results confirm the assumption of aggressive hydration enhancing microcirculation in the pancreas and inflammatory response. Another Indian RCT of 57 patients demonstrated similar decreases in inflammatory markers in previous trials assessing lactated Ringer's solution (Thanage et al., 2021). The biological plausibility of the intervention is enhanced by the statistically significant differences at several time points. The decrease in enzymes is associated with less pancreatic damage and better clinical outcome. These results are in line with pathophysiological theories of PEP that entail inflammation due to ischemia (Chang et al., 2022). Thus, aggressive hydration is shown to have biochemical and clinical advantages.

The clinical outcomes also showed the superiority of the aggressive hydration, with reduced hospital stay (3.1 ± 1.2 vs 4.8 ± 1.9 days,

p=0.001) and reduced ICU admission rates (1.2% vs 7.1%, OR=0.16, p=0.04). What these results demonstrate is a lower incidence, as well as, a lower severity of PEP. Similar decreases in hospital days have been documented in meta-analyses of five trials including 299 patients with mean differences of 1.5-2 days in favor of aggressive hydration (Mosquera et al., 2025). The decreased rate of ICU admissions indicates less healthcare burden and complications. The findings are especially applicable in resource-restricted environments where the availability of ICUs is limited. The statistically significant differences indicate the cost-effectiveness of aggressive hydration. Decreased rates of comorbidity and lowered hospitalization lead to enhanced patient outcomes, and healthcare efficiency. Thus, aggressive hydration is a clinically effective and cost-saving approach to prevent PEP.

Although this study has a number of strengths, it has some limitations that can be recognized. To begin with, the research was carried out at only one center, which can hamper the extrapolation of the results to the wider populations. Second, the non-probability consecutive sampling can be used, which implies a selection bias even with random allocation. Third, a small sample size led to a relatively wide confidence interval of some outcomes even though this sample size was sufficiently powered. Fourth, there was no explicit protocol on blinding and it could bring about performance or observer bias. Besides, no long-term follow-up (beyond 48 hours) was done to evaluate delayed complications.

CONCLUSION

The aggressive hydration using lactated Ringer solution compared to a standard hydration, reduced the occurrence of post-ERCP pancreatitis by 4.8% versus 16.7% (p=0.001). The risk reduction of 75% related to the intervention was estimated by odds ratio of 0.25 (95% CI: 0.08-0.78). Besides a reduction in PEP incidence, aggressive hydration led to better biochemical outcomes, such as much lower amylase, lipase, and CRP at various post-procedural sampling times. Aggressive hydration in patients also exhibited a reduced length of stay (3.1 ± 1.2 vs 4.8 ± 1.9 days, p=0.001) and ICU hospitalizations (1.2% vs 7.1%, p=0.04). These findings are valid as they are strengthened by the comparability of baseline demographic, clinical, and procedural characteristics. These findings indicate the effectiveness of aggressive hydration as a safe, practical and effective intervention to prevent PEP. Since it is not very expensive and it is easy to apply, it can be especially useful in the health care environment that is constrained by resources. Thus, aggressive hydration can be regarded as a routine preventive intervention in ERP patients.

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