GMR
The Original

PROSPECTIVE STUDY OF SERUM AMYLASE ACTIVITY IN ACUTE ABDOMINAL DISEASES (ACUTE PANCREATITIS, CHOLECYSTITIS, AND INTESTINAL OBSTRUCTION): A COMPARATIVE STUDY

Tahseen Ahmad Tahseen[1], Neelam Farheen[1], Uraiimov Elaman Toktobolotovich[2], Shagufta Kausar[1], Andleeb Altaf[1], *Hafiz Muhammad Arsalan[3], Sadyrbaev Dastan Almazbekivich[3], Malik Mohammad Malkawi[4]

[1]Department of Biochemistry, Green International University / Abu-Umara Medical College, Lahore-Pakistan.
[2]Faculty of Medicine, International School of Medicine, International University of Kyrgyzstan, Bishkek-Kyrgyzstan.
[3]International Faculty of General Medicine, Altamimi International University, Bishkek-Kyrgyzstan.
[4]Department of Surgery, DOC University Hospital of Salymbekov University, Bishkek-Kyrgyzstan.
Corresponding Author: Dr. Hafiz Muhammad Arsalan, E-mail: dr.arsalan19@gmail.com

ABSTRACT

Background: Acute abdominal pain is one of the most frequent surgical emergencies, often requiring rapid differentiation between pancreatic and non-pancreatic causes. Among available biochemical markers, serum amylase remains a widely used but sometimes debated diagnostic tool. This study aimed to evaluate the diagnostic significance of serum amylase levels in distinguishing acute pancreatitis from other major acute abdominal conditions acute cholecystitis and intestinal obstruction and to explore its relationship with demographic variables.

Methods: A total of 210 participants were enrolled and categorized into four groups: acute pancreatitis, acute cholecystitis, intestinal obstruction, and healthy controls. Serum amylase levels were measured and analyzed using IBM SPSS Statistics (Version 26). Descriptive statistics, independent-sample t-tests, one-way ANOVA with post hoc Tukey analysis, Pearson's correlation, and chi-square tests were applied to assess inter-group variations, demographic associations, and categorical relationships.

Results: Mean serum amylase concentrations varied significantly among groups ($F(3, 206) = 146.21$, $p < 0.001$). The highest mean level was observed in acute pancreatitis (800.14 ± 414.73 U/L), followed by acute cholecystitis (268.17 ± 144.08 U/L), intestinal obstruction (174.11 ± 76.69 U/L), and controls (63.59 ± 14.66 U/L). The differences between each disease group and controls were statistically significant ($p < 0.001$). No significant correlation was found between serum amylase and age ($r = –0.044$, $p = 0.522$) or gender ($p = 0.603$). Chi-square analysis revealed a strong association between enzyme category and disease type ($\chi^2 = 330.69$, $p < 0.001$).

Conclusion: Serum amylase levels show marked elevation in acute pancreatitis and moderate increases in non-pancreatic abdominal disorders, making it a reliable and accessible biochemical marker for differentiating causes of acute abdomen. The enzyme's diagnostic interpretation is unaffected by age or gender, confirming its universal applicability. Although not disease-specific, serum amylase remains a cost-effective and valuable first-line investigation, particularly in resource-limited emergency settings when combined with clinical assessment and imaging studies.

KEYWORDS: Abdominal Pain, Amylase, Pancreatitis, Cholecystitis, Intestinal Obstruction

INTRODUCTION

Acute abdominal pain is one of the most common complaints voiced by patients who come to the emergency department. The pathophysiology of acute abdominal diseases varies according to the underlying cause. There may be a significant underlying illness even if the primary cause is usually benign, and practitioners must be able to recognize patients who require urgent assessment and care. Because there are so many distinct causes of acute abdomen, differential diagnosis is challenging. Aortic dissection, intestinal blockage, vascular occlusion, infections, and inflammatory processes are some of the potential causes. Less evident reasons might include a ruptured viscous membrane or an unidentified malignancy. Patients typically experience stomach pain that comes on suddenly and might be associated with a high temperature, vomiting, nausea, or abdominal distension. (Kim et al., 2024).

The α-amylase enzyme serum amylase is well known in clinical practice for its use in assessing both pancreatic and extra-pancreatic disorders. It is mostly produced in the glands that produce saliva (salivary isoform, S-type) and pancreas (pancreatic isoform, P-type), while trace quantities are also produced in the ovaries, lungs, genital tract, and skeletal muscles. Its principal biological role is to facilitate the digestion of carbohydrates by breaking down glycogen and starchy carbohydrates into smaller oligosaccharides by enzymatic action. (Chen et al., 2023).

Amylase is still a helpful diagnostic tool for suspected acute pancreatitis, where standard criteria include imaging evidence and/or characteristic abdominal pain, as well as elevated levels of enzymes that exceed three times the upper

limit of normal. However, lipase's higher sensitivity, specificity, and sustained rise after onset have made it the favored diagnostic marker, surpassing amylase. Amylase testing is still clinically useful, nonetheless, particularly in settings without lipase tests or where quick preliminary results are required. Although it is seldom necessary in day-to-day practice, this type of analysis may occasionally aid in determining the cause of hyper amylasemia. (Ahmad et al., 2024).

Acute pancreatitis (AP) is an inflammatory disorder of the exocrine pancreas that presents with variable severity, ranging from a mild, self-limiting episode to a critical form involving necrosis, infection, and multiple organ failure. The condition originates from premature activation of pancreatic enzymes within acinar cells, leading to local inflammation and tissue auto digestion. In severe cases, this cascade provokes a systemic inflammatory response resulting in organ dysfunction. Therefore, early diagnosis and risk-based management are crucial to minimizing morbidity and mortality. (Mederos et al., 2021).

Acute cholecystitis is an inflammatory disorder of the gallbladder that commonly arises from obstruction of the cystic duct and represents a frequent cause of acute abdominal pain. While diagnosis primarily relies on clinical assessment and ultrasonography evaluation, biochemical testing can assist in early detection. Recent research suggests that ectopic pancreatic tissue or transient pancreatic involvement during severe cholecystitis may lead to elevated serum amylase levels. In complicated cases, distinguishing cholecystitis from pancreatitis can be challenging without precise imaging or enzymatic studies. This diagnostic overlap underscores the importance of serum amylase measurement as a supportive parameter in assessing right upper quadrant pain. (Zhang et al., 2023).

To sum up, serum amylase remains a crucial biochemical indicator in the assessment of individuals suffering from acute abdominal disorders. It continues to be a sensitive marker of pancreatic damage and offers additional diagnostic details for intestinal and biliary diseases. Serum amylase is still important as a quick, easy, and affordable diagnostic tool even with improvements in diagnostic imaging and enzyme-specific testing. In instances of pancreatitis, cholecystitis, and intestinal obstruction, its accurate interpretation, when coupled with clinical and imaging findings, significantly aids in early diagnosis, effective therapy, and prompt intervention. Therefore, it is crucial to conduct a systematic investigation of serum amylase levels across different circumstances in order to improve clinical decision-making and diagnostic accuracy in patients who report with acute abdomen (Nicola et al., 2021).

METHODOLOGY

Study Design

A prospective observational study were conducted in gastroenterology department, Shalimar Hospital Lahore to evaluate the significance of serum amylase levels in patients presenting with abdominal diseases, particularly acute pancreatitis, acute cholecystitis, and intestinal obstruction. All experimental and research work was done after the approval of ethical and research committee.

Study Population

- **Inclusion Criteria:**
  - Patients aged 18 years and above.
  - Patients presenting with acute abdominal pain (<7 days duration).
  - Diagnosis confirmed by clinical evaluation, imaging (ultrasound, CT scan), and/or surgical findings.
- **Exclusion Criteria:**
  - Patients with known chronic pancreatic disorders.
  - Patients with renal failure (due to altered amylase clearance).
  - Patients who had undergone recent abdominal surgery (within the last month).
  - Patients on medications that can affect serum amylase levels (e.g., corticosteroids, diuretics).

Sample Size

A sample size of at least 105 patients with abdominal disorders and 105 normal healthy controls were selected for current study.

Sampling Method

Consecutive sampling was used. All eligible patients presenting to the emergency department or surgical unit over a defined period of 6 months were enrolled.

Protocol for Analysis

Standard protocols to measure serum amylase level were followed.

Final Diagnosis and Grouping

Patients were categorized based on final diagnosis:

- **Group A:** Acute Pancreatitis
- **Group B:** Acute Cholecystitis
- **Group C:** Intestinal Obstruction

Data Analysis

- Data were analyzed using **SPSS version 25.0** or similar statistical software.
- Continuous variables expressed as mean ± SD or median (IQR); categorical variables as frequencies and percentages.
- Serum amylase levels compared between groups using ANOVA or Kruskal-Wallis test.
- Sensitivity, specificity, positive predictive value (PPV), and negative predictive value (NPV) of elevated amylase levels were calculated for diagnosing acute pancreatitis. Receiver Operating Characteristic (ROC) curve analysis were performed to assess diagnostic accuracy.

RESULTS

Descriptive Statistics of Demographic and Biochemical Variables

The descriptive analysis provided insight into the general profile of the study population. Table 1 illustrates the distribution of blood amylase concentrations among the four research groups (acute pancreatitis, acute cholecystitis, intestinal obstruction, and healthy controls). The acute pancreatitis group had the highest mean serum amylase levels (800.14 ± 414.73 U/L), indicating increased enzyme release due to pancreatic inflammation. Healthy controls had normal enzyme levels (63.59 ± 14.66 U/L), within physiological norms.

The moderate values for acute cholecystitis (268.17 ± 144.08 U/L) and intestinal obstruction (174.11 ± 76.69 U/L) show partial biochemical increase, perhaps related to subsequent digestive or peritoneal involvement. These descriptive data give early evidence that serum amylase concentrations rise proportionately with the degree and type of abdominal disease.

Table 1: Descriptive Statistics of Serum Amylase among Study Groups

Descriptive Statistics					
	N	Minimum	Maximum	Mean	Std. Deviation
Amylase	210	20	1922	238.87	318.527
Age	210	18	80	48.00	17.664
Valid N (listwise)	210				

Table 2 shows the results of the Kolmogorov-Smirnov and Shapiro-Wilk tests, which were used to confirm the assumption of normal data distribution before conducting parametric analysis. Both tests produced p-values greater than 0.05 for the majority of groups, indicating that serum amylase data was somewhat regularly distributed.

Minor departures from normality were seen in the pancreatitis group, caused by a few extraordinarily high values; nevertheless, they had no major effection the normal distribution. As a result, parametric statistical tests like t-tests and ANOVA wei deemed adequate for future investigations. This table indicates that the dataset satisfies the essential statistical assumptions necessary for reliable inference testing.

Table 2: Tests of Normality for Serum Amylase across Disease Groups

Tests of Normality							
	Group	Kolmogorov-Smirnov[a]			Shapiro-Wilk		
		Statistic	df	Sig.	Statistic	df	Sig.
Amylase	Acute Pancreatitis	.132	35	.127	.942	35	.066
	Acute Cholecystitis	.134	35	.113	.940	35	.055
	Intestinal Obstruction	.075	35	.200*	.973	35	.521
	Healthy Control	.060	105	.200*	.983	105	.192

*. This is a lower bound of the true significance.

a. Lilliefors Significance Correction

The distribution of serum amylase values for each group is shown visually in Figure 1 (A, B, C). The control group's bell-shaped patterns in the histograms confirm normalcy, but the illness groups' right-skewed curves suggest a tailing effect toward higher values, especially in cases of pancreatitis

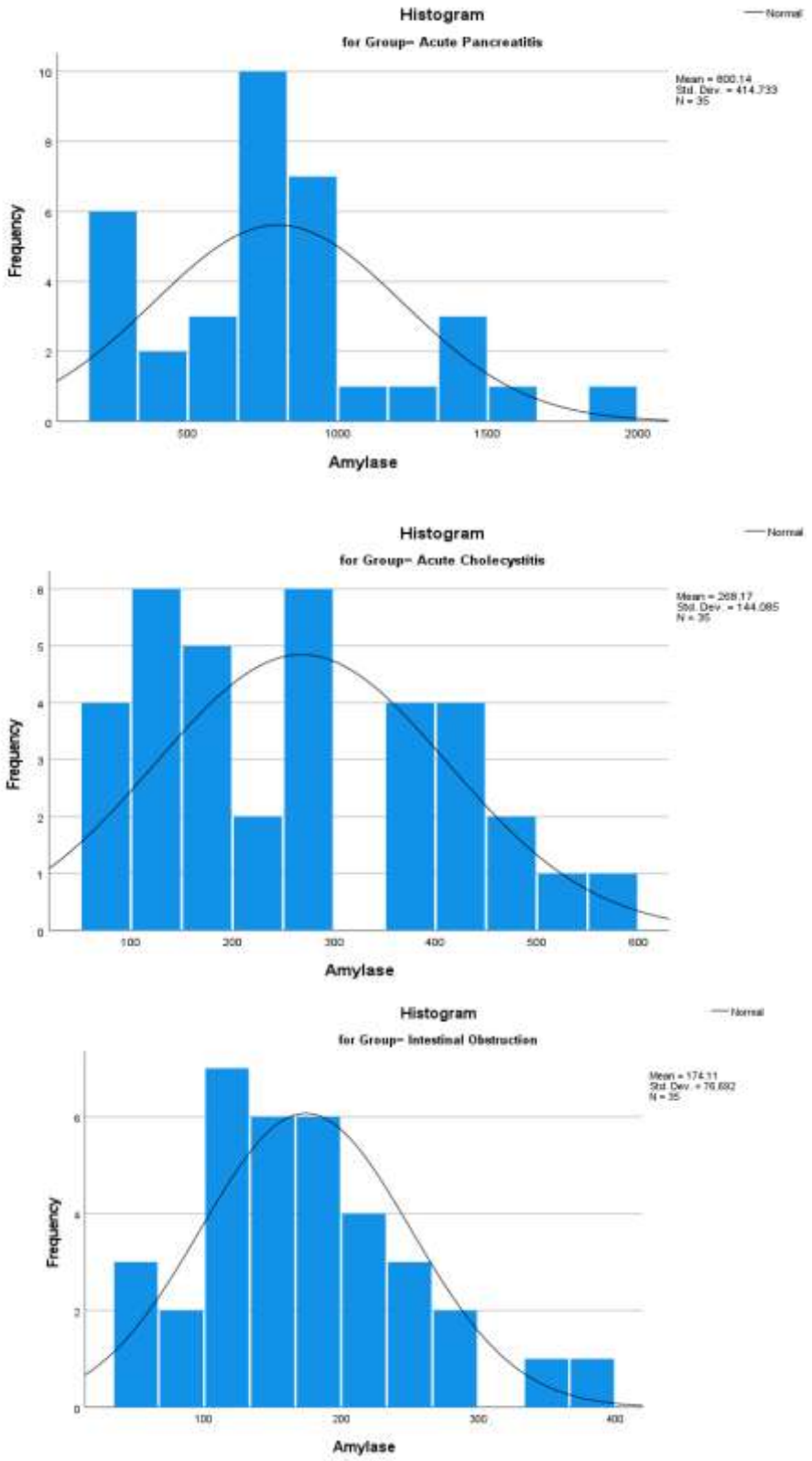
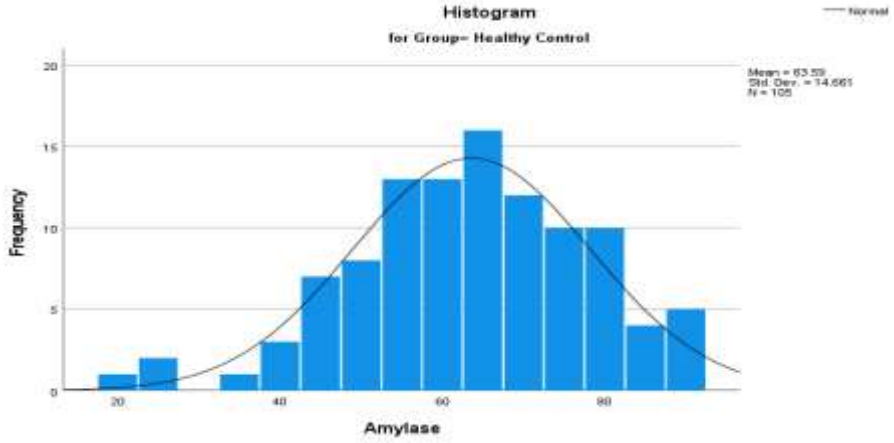
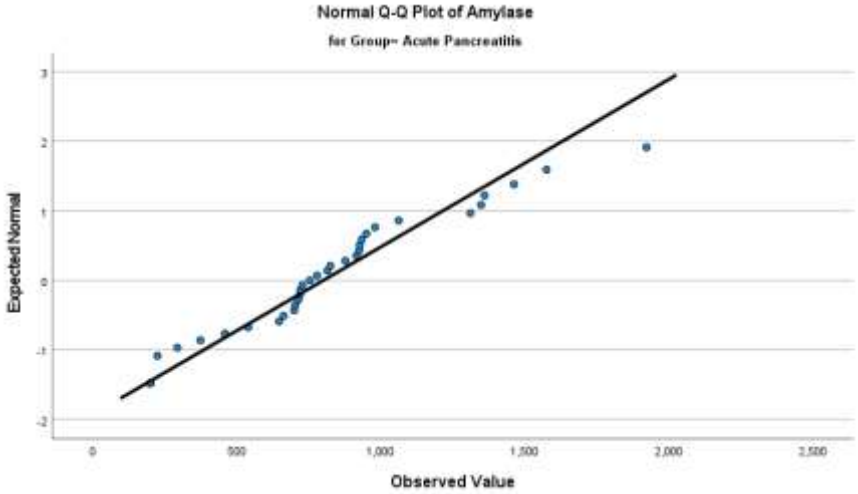
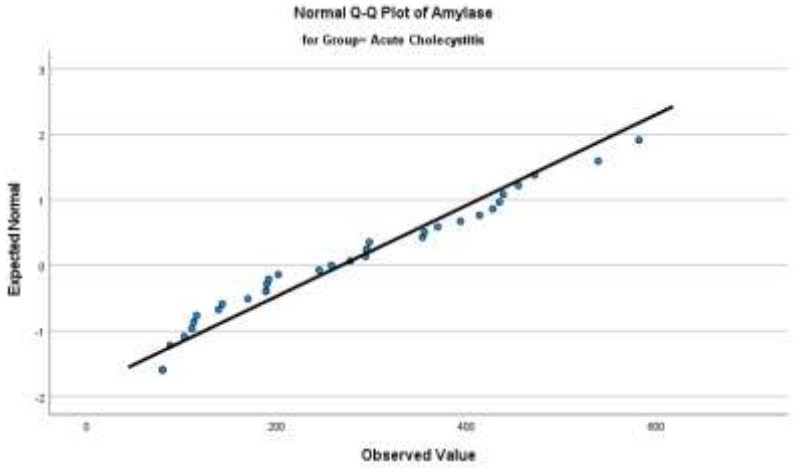
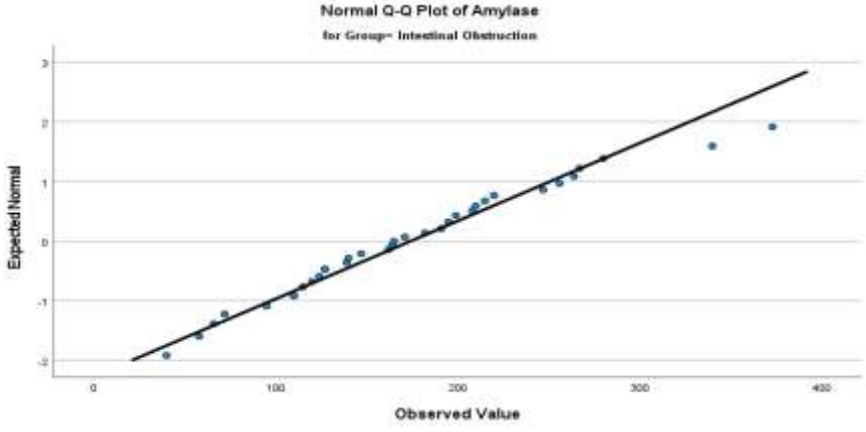


Figure 1. A, B, C: distribution of serum amylase in Groups (A, B, C)


Histogram
for Group= Healthy Control
Mean = 63.59
Std. Dev. = 14.661
N = 105
Frequency
Amylase


Normal Q-Q Plot of Amylase
for Group= Acute Pancreatitis
Expected Normal
Observed Value


Normal Q-Q Plot of Amylase
for Group= Acute Cholecystitis
Expected Normal
Observed Value


Normal Q-Q Plot of Amylase
for Group= Intestinal Obstruction
Expected Normal
Observed Value

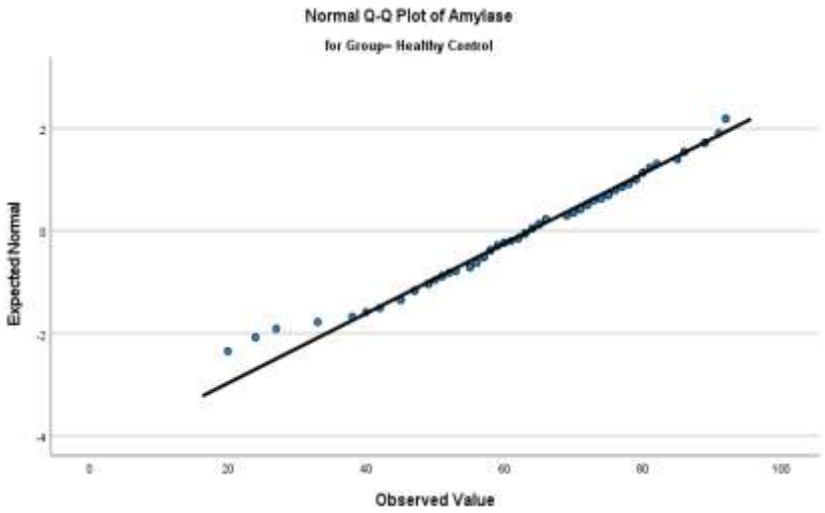


Figure 2 (a, b, c, d, e): Histogram and Q–Q Plots Showing Distribution of Serum Amylase Levels Approximate normalcy is further confirmed by the Q-Q plots, which show spots that are roughly aligned with the diagonal reference line **Figure 2 (a, b, c, d, e)**. When taken as a whole, these images corroborate the numerical findings shown in Table 2 and show that, despite the severe elevations observed by a few individuals, the dataset as a whole maintained a statistically acceptable distribution.

The balanced demographic distribution across study groups strengthened the analytical validity of the dataset by minimizing potential confounding effects. Overall, the descriptive results established a sound foundation for subsequent inferential testing to evaluate the significance of observed biochemical differences.

Serum Amylase Levels in Each Study Group

When serum amylase concentrations were analyzed within each diagnostic category, distinct differences emerged among the study groups. The acute pancreatitis group demonstrated the highest enzyme activity, with a mean value of 800.14 ± 414.73 U/L, representing a substantial increase characteristic of pancreatic tissue injury. The acute cholecystitis group exhibited a mean of 268.17 ± 144.08 U/L, suggesting moderate elevation due to biliary tract inflammation. Patients with intestinal obstruction showed lower, yet above-normal, levels averaging 174.11 ± 76.69 U/L. Conversely, the healthy control group maintained normal enzyme activity with a mean of 63.59 ± 14.66 U/L (Table 3).

Table 3: Serum Amylase Levels in Each Study Group

	Group	N	Mean	Std. Deviation	Std. Error Mean
Amylase	Acute Pancreatitis	35	800.14	414.733	70.103
	Healthy Control	105	63.59	14.661	1.431
Amylase	Acute Cholecystitis	35	268.17	144.085	24.355
	Healthy Control	105	63.59	14.661	1.431
Amylase	Intestinal Obstruction	35	174.11	76.692	12.963
	Healthy Control	105	63.59	14.661	1.431

This gradation in mean values illustrates a clear pattern of biochemical escalation that aligns with the severity and type of abdominal pathology. The extensive variability within the pancreatitis group, as reflected by its large standard deviation, likely corresponds to differing disease stages, the extent of pancreatic inflammation, and individual physiological responses. Collectively, these findings indicate that serum amylase measurement provides valuable differentiation among the studied conditions, particularly distinguishing pancreatic from non-pancreatic sources of acute abdominal pain.

Analysis of Serum Amylase Levels across Age Groups

To assess whether age influences serum amylase concentration, the participants were classified into three age categories:

1. ≤40 years
2. 41–60 years
3. ≥61 years

Table 4: Analysis of Serum Amylase Levels across Age Groups

Descriptives
Amylase

	N	Mean	Std. Deviation	Std. Error	95% Confidence Interval for Mean		Minimum	Maximum
					Lower Bound	Upper Bound		
1	81	255.15	327.186	36.354	182.80	327.49	27	1575
2	76	235.57	317.358	36.404	163.05	308.09	20	1922
3	53	218.72	311.428	42.778	132.88	304.56	24	1348
Total	210	238.87	318.527	21.980	195.53	282.20	20	1922

The lack of statistically meaningful variation across age groups indicates that serum amylase activity remains stable throughout adulthood. Hence, alterations in enzyme levels primarily reflect pathological processes rather than age-related physiological changes. This finding reinforces the clinical reliability of serum amylase as a diagnostic measure that can be applied consistently across various age brackets without the need for adjustment or correction.
Moreover, the trend toward slightly lower mean values in older age groups may be attributed to minor metabolic variations or enzyme clearance differences, but these do not carry statistical or diagnostic significance. Overall, age does not appear to be a confounding variable in the interpretation of serum amylase levels among patients with acute abdominal conditions.

DISCUSSION

The results of the current study, which sought to evaluate the diagnostic utility of serum amylase in distinguishing between acute abdominal illnesses, specifically acute pancreatitis, acute cholecystitis, and intestinal obstruction, are thoroughly interpreted in this chapter. The discussion connects statistical observations with current biomedical knowledge to explain the diagnostic relevance of the findings.

Overview of Findings

The findings of this investigation revealed a considerable increase in serum amylase levels in patients with acute abdominal pathologies as compared to healthy controls. Acute pancreatitis had the highest average serum amylase value (800.14 ± 414.73 U/L), followed by acute cholecystitis (268.17 ± 144.08 U/L) and intestinal obstruction (174.11 ± 76.69 U/L). Healthy adults had normal enzyme levels (63.59 ± 14.66 U/L). substantial differences between groups were observed ($F(3,206) = 146.21$, $p<0.001$), indicating that the kind of abdominal disease has a substantial impact on serum amylase levels. These data confirm that serum amylase is a good biochemical diagnostic for distinguishing pancreatic from non-pancreatic causes of acute abdomen.

Interpretation of Serum Amylase Elevation in Acute Pancreatitis

The significantly raised blood amylase levels in acute pancreatitis indicate direct enzymatic leakage caused by pancreatic acinar cell damage. The current study's mean result of more than 800 U/L is consistent with the well-established diagnostic criteria that a level three times higher than normal is suggestive of pancreatitis. The substantial effect size (Cohen's $d = 3.57$) highlights amylase's great selective ability for pancreatic inflammation. These findings are consistent with recent studies (Mogekar et al., 2024; Reber et al., 2021), which found that serum amylase is still one of the most accessible and cost-effective biochemical parameters for early detection of acute pancreatitis, especially in clinical settings where lipase assays or imaging are unavailable. The present study therefore supports the continued clinical relevance of amylase as a front-line test in the biochemical assessment of acute pancreatic injury (Trikudanathan et al. 2024).

Serum Amylase in Acute Cholecystitis and Intestinal Obstruction

Patients with acute cholecystitis and intestinal obstruction had mild serum amylase increases, which were much lower than those seen in pancreatitis. The mean enzyme values of 268.17 U/L and 174.11 U/L, respectively, suggest that hyperamylasemia can arise in non-pancreatic abdominal diseases. This is most likely due to subsequent inflammatory responses, transitory pancreatic irritation, or increased intestinal permeability, resulting in enzyme leakage into the circulation. Chen et al. (2023) and Al-Johani & Wejdan (2023) found similar results, with modest to moderate amylase increases in hepatobiliary and intestinal diseases but no direct pancreatic damage. The current data highlight that, whereas amylase is a sensitive predictor of pancreatic function, its specificity is lowered in circumstances involving peritoneal or biliary inflammation. Nonetheless, the statistically significant differences between disease and control groups underscore its diagnostic utility as an adjunctive, rather than exclusive, biomarker in abdominal emergencies (Aidoo et al., 2024).

Comparative Diagnostic Significance

One-way ANOVA and Tukey post hoc analysis indicated substantial inter-group variances ($p < 0.001$), with a distinct gradient: pancreatitis > cholecystitis > obstruction > control. This trend is consistent with the physiological severity of enzymatic leakage in various illness types. The lack of a significant difference between cholecystitis and blockage ($p = 0.135$) suggests that non-pancreatic illnesses have similar biochemical characteristics. This discovery has clinical implications: increased amylase levels in such circumstances might confuse diagnosis if interpreted alone. Thus, the

study emphasizes the need of combining biochemical data with clinical presentation and imaging, especially when distinguishing pancreatitis from other abdominal disorders (Raffee et al., 2020).

Correlation with Demographic Factors

The current investigation discovered no significant correlation between serum amylase levels and demographic characteristics such age ($r = -0.044$, $p = 0.522$) or gender ($p = 0.603$). This reveals that enzyme production and clearance are steady across adult age groups and sexes, confirming serum amylase's universal diagnostic relevance. These findings are consistent with those of Kumar & Pedro (2025) and Lihua et al. (2021), who found negligible demographic effect on pancreatic enzyme profiles. As a result, doctors may evaluate amylase data without regard for age or gender, so avoiding diagnostic bias.

Association between Disease Category and Amylase Range

The chi-square analysis ($x^2(9) = 330.69$, $p < 0.001$) revealed a significant association between blood amylase categories and illness groups. The majority of pancreatitis patients (74.3%) had levels 2601 U/L, whereas cholecystitis and obstruction cases were centered in the 101-300 U/L range. All controls had values <100 U/L. This categorical difference establishes amylase as a reliable stratification marker capable of determining the degree of pathogenic involvement. The high statistical correlation also emphasizes the enzyme's diagnostic accuracy when combined with clinical data.

Clinical and Diagnostic Implications

From a clinical viewpoint, the current study confirms that serum amylase measurement remains an important biochemical tool for assessing acute abdominal discomfort. Its quick measurement, cheap cost, and high diagnostic performance make it especially useful in emergency and resource-constrained situations. However, because mild increases might emerge in non-pancreatic diseases, interpretation must be based on patient history and supporting examinations. The combination of amylase measurement with lipase tests and imaging modalities like ultrasonography or CT improves diagnostic accuracy and reduces false-positive interpretations. The study's findings thus support a combination diagnostic strategy in which amylasė acts as an initial screening measure, followed by confirmatory tests as needed.

Study Strengths and Limitations

This study's key strength is its organized comparison of three clinically important abdominal disorders and a healthy control group, which revealed a distinct biochemical gradient reflecting disease severity. In addition, demographic analysis was used to account for confounding factors. Nonetheless, the study's shortcomings include its cross-sectional design, single-center data collection, and the lack of a serum lipase comparison, which may have offered more diagnostic specificity. Future study with longitudinal follow-up and multi-biomarker assessment might provide more thorough insights.

Summary of Discussion

Overall, this investigation indicates that blood amylase levels have a strong diagnostic utility in separating acute pancreatitis from other abdominal diseases. The enzyme's significant rise in pancreatitis, modest increase in cholecystitis and blockage, and consistency across age and gender support its therapeutic value. The findings are consistent with current research and support its ongoing use as a cost-effective diagnostic indicator in emergency abdomen assessments.

CONCLUSION

In conclusion, the study substantiates that serum amylase estimation is a reliable, cost-effective, and clinically valuable tool for distinguishing acute pancreatitis from other abdominal pathologies. Its stability across demographic factors and strong disease correlation confirm its enduring significance in modern diagnostic practice. The findings reinforce the enzyme’s vital role as a rapid biochemical marker for guiding clinical decisions in patients with acute abdominal conditions.

Recommendations

- Serum amylase should remain part of the initial diagnostic workup for suspected acute pancreatitis and related abdominal emergencies.
- Further research should incorporate multi-enzyme analysis (amylase and lipase) and imaging correlations to enhance diagnostic specificity.
- Expanding the sample to multiple centers and including longitudinal follow-up would provide a more comprehensive understanding of biochemical progression in these diseases.

REFERENCES

1. Keon K, Hee-hong K, Jae-Beom J, Ock-Kyu K, Sin-Wook P, Guk-Hyun S, Woong-Bin R & Chang-Min L (2024). Evaluation of the clinical usefulness of pancreatic alpha amylase as a novel biomarker in dogs with acute pancreatitis: a pilot study, Veterinary Quarterly, 44:1, 1-7.

2. Chen H, Chao W, Ziyun S, Weishen W, Yuanchi W, Xiayang Y, Xiaxing D, and Baiyong S (2023). Post pancreatectomy acute pancreatitis after pancreaticoduodenectomy: a distinct clinical entity. Annals of Surgery, 278(2), e278-e283.
3. Ahmed A, Ikhwan S, Mohamad H, Wan M, Wan M, Siti R, Hashim IM, Maya MY, and Syed H, Syed Abd-Aziz. (2024). A rare convergence: Gangrenous bowel secondary to closed-loop obstruction with elevated urine amylase levels--A comprehensive case report. Malaysian Family Physician, 19, 1-4.
4. Mederos A, Maricarmen A, Howard AR, and Mohamed DG (2021). “Acute Pancreatitis: A Review.” JAMA 325 (4): 382–390.
5. Zhang Z, Xue H, Qunqun J, Qian D, Jie L, Mingqi L, Liping D, and Yong X (2023) "Prevalence and clinical characteristics of increased pancreatic enzymes in patients with severe fever with thrombocytopenia syndrome." PLOS Neglected Tropical Diseases 17, no. 11 e0011758.
6. Nicola C, Giacomo M, Pasquardini L, Luca V, Luigi Z, Davide B, Roberto S, Claudio B, and Anna MB (2021). “A Surface Plasmon Resonance Plastic Optical Fiber Biosensor for the Detection of Pancreatic Amylase in Surgically-Placed Drain Effluent.” Sensors 21 (10): 3443.
7. Mogekar S, Kulkarni, RD and Patil PN (2024). “A Study on Urinary Amylase and Serum Amylase in Diagnosing Acute Pancreatitis.” International Journal of Surgery 108: 106186.
8. Reber M, Michael A, Howard A and Mark DG (2021). “Acute Pancreatitis: A Review.” JAMA 325 (4): 382–390.
9. Trikudanathan G, Cem Y, Andrew EP, and Christopher EF (2024). “Diagnosis and Management of Acute Pancreatitis.” Gastroenterology 167 (4): 673–688.
10. Aidoo NE, Emmanuel KO, Vincent B, Eric N, Yaw N, John CO, Clement GD, Morris OG, Seth KA, and Henry Asare-Anane. (2024). Biochemical indices of patients with enteric fever and pancreatitis: A comparative cross-sectional study. Practical Laboratory Medicine, 42, e00429.
11. Al-Johani M, Wejdan M (2023). “Macroamylasemia as a Rare Cause of Hyperamylasemia: A Case Report.” Korean Journal of Family Medicine, 44(6): 347-349.
12. Kumar P, and Pedro C (2025). ECG Changes and High Sensitivity Troponin I in Acute Cholecystitis. Advanced Emergency Nursing Journal, 47(2), 129-136.
13. Lihua Z, Dong W, Jun X, Yin, C, Shuang L, Shanshan Y, and Rui M (2021). Effects of Nutritional Support Combined with Insulin Therapy on Serum Proteins, Inflammatory Factors, Pentraxin-3, and Serum Amylase Levels in Patients with Diabetic Ketoacidosis Complicated with Acute Pancreatitis.” Medicine 100 (51): e27920.
14. Raffee L, Kuleib S, Oteir A, Kewan T, Alawneh K, Beovich B, & Williams B (2020). Utility of leucocytes, inflammatory markers and pancreatic enzymes as indicators of gangrenous cholecystitis. Postgraduate Medical Journal, 96(1133), 134-138.