

# Association Between the Pancreatic Enzyme Level and Organ Failure in Trauma Patients

Arulselvi Subramanian,<sup>1\*</sup> Venencia Albert,<sup>1</sup> Biplab Mishra,<sup>2</sup> Shilpi Sanoria,<sup>1</sup> and Ravindra Mohan Pandey<sup>3</sup>

<sup>1</sup>Department of Laboratory Medicine, Jai Prakash Narayan Apex Trauma Center, All India Institute of Medical Sciences (AIIMS), New Delhi, India

<sup>2</sup>Department of Surgery, Jai Prakash Narayan Apex Trauma Center, All India Institute of Medical Sciences (AIIMS), New Delhi, India

<sup>3</sup>Department of Biostatistics, All India Institute of Medical Sciences (AIIMS), New Delhi, India

\*Corresponding author: Arulselvi Subramanian, Department of Laboratory Medicine, Jai Prakash Narayan Apex Trauma Center, All India Institute of Medical Sciences (AIIMS), New Delhi, India. Tel: +98-10644033, Fax: +91-1126106826, E-mail: arulselvi.jpnatc@gmail.com

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## Abstract

**Background:** The literature suggests an association of pancreatic enzymes with systemic inflammation resulting in secondary organ injury and dysfunction following trauma. Elevation in serum enzymes may not always be predictive of pancreatic disease, and can reflect extra pancreatic production.

**Objectives:** This study was conducted to evaluate the rise in serum pancreatic enzyme levels with the incidence of organ failure following trauma.

**Patients and Methods:** A retrospective review was performed on critically injured patients from December 2009 to March 2010. Patient's clinical demographics, routine laboratory investigations along with amylase and lipase levels were also extracted from the patients' records. Patients with pancreatic or duodenal injuries were excluded from the study.

**Results:** From a total of 296 patients (mean age, 31 years), 85% were males. Blunt injury was seen in 91.6% of the cases and 8.4% had penetrating injury. One hundred and fifty-three patients had single organ failure, 96 had multiple organ failure and 47 had no organ failure. There was a significant difference in lipase levels ( $P = 0.04$ ), potassium levels ( $P = 0.05$ ) and hemoglobin levels ( $P = -0.004$ ), among the three patient groups. There was no significant difference in amylase levels among the three patient groups. The observed independent predictors of mortality included coagulopathy (OR = 1.7), Glasgow coma scale (OR = 1.1, 4.7), pulmonary failure (OR = 0.0004), hepatic failure (OR = 0.048), renal failure (OR = 5.5), organ failure (OR = 149.8), lipase levels (OR = 1.3), and infection (OR = 3.0).

**Conclusions:** There was a significant correlation between elevated lipase levels and the incidence of multiple organ failure. Moreover, No significant association was found between the elevated amylase levels and organ failure. However, on admission, measurement of these enzymes coupled with routine laboratory investigations can be a powerful tool in the early detection of patients progressing towards organ failure.

**Keywords:** Amylase, Lipase, Organ Failure, Trauma

## 1. Background

Multiple organ failure (MOF) is the leading cause of posttrauma morbidity and mortality. It is thought to be caused by the systemic inflammatory response syndrome (SIRS) that follows severe trauma and hemorrhagic shock. Multiple organ failure has been defined as progressive dysfunction of two or more organ systems following an acute threat to systemic homeostasis (1,2). Review of earlier studies depicts an incidence of 5% to 25%. Several organ dysfunction scoring systems have been developed to describe and quantify organ dysfunction/ failure in ICU patients (3-5). There is no gold standard for quantification of the degree of organ damage; however, several scores like multiple organ dysfunctions (MOD) score, and Denver postin-

jury MOF scores (6) are being utilized.

Available literature suggests that intraluminal pancreatic enzymes stimulate the production of inflammatory mediators by the gut causing uncontrolled systemic inflammation leading to secondary organ injury and dysfunction (7-11).

Increased serum enzyme levels in pancreatic inflammation are not always predictive of pancreatic disease and they may also reflect non-pancreatic or extra-pancreatic production (12-16). This effect is uncertain to predict, whether their direct secretion into the circulation from the pancreas is a part of normal physiology, ischemic pancreatitis, or absorption into the bloodstream through an ischemic intestinal mucosal barrier (17). Detailed information about the prognosis of trauma patients is crucial to

improve survival in the intensive care unit (ICU).

## 2. Objectives

The purpose of this study was to evaluate the prognostic significance of the elevation in serum pancreatic enzyme levels on admission in trauma patients with MOF. We hypothesized that serum amylase and lipase can serve as predictors for the development of MOF in traumatic injury patients.

## 3. Patients and Methods

A retrospective review was performed on 296 trauma patients presented to the red area of a level-1 trauma center, from December 2009 to March 2010. Data of all the critically injured patients presented during the period of the study, including their demographics, clinical and transfusion data such as age, sex, Glasgow coma score, injury severity score, SOFA score, indication for blood product transfusion, injuries, sepsis, organ failure, coagulopathy and mortality was collected from the computerized patient record system maintained by the institute, or from the individual patient file.

Laboratory investigations namely, complete hemogram (Hb, TLC, and DLC) and coagulation profile (PT, aPTT) were routinely performed on the Sysmex XE-2100 hematology analyzer and STA compact coagulation analyzer, respectively. Biochemistry analysis (liver function test, renal function test, electrolytes) along with amylase and lipase was also routinely performed on the Synchron Cx9 Pro Biochemistry analyzer. Patients with pancreatic or duodenal injuries were excluded from the study group, to ensure that the elevations are due to other intra-abdominal injuries.

The presence of coagulopathy was diagnosed if any of the prothrombin time (PT) or activated partial prothrombin time (aPTT) was  $> 1.5$  times normal and the INR value was  $> 1.6$ . Immediate outcome was assessed in terms of hospital length of stay and mortality during the course of the study.

Serum amylase and lipase levels of all traumatic injury patients, who required admission at the trauma care center were assessed and recorded in the emergency department. Trauma scores such as injury severity score (ISS) and Glasgow coma score (GCS) were calculated to assess the severity of injury for the study patients. Elevation in the amylase and lipase levels in the admission day were defined as being  $> 2$  times the upper limit of normal. Normal range for amylase in our laboratory is 30 u/L to 100 u/L, and a value  $> 200$  u/L was considered elevated. The normal range for lipase is 13 u/L to 60 u/L and a value  $> 120$  u/L

was considered elevated. The sequential organ failure assessment (SOFA) score was calculated, that quantifies and describes the evolution of organ dysfunction/failure over time, and has been validated in trauma patients. The SOFA score assesses the function of six different organ systems: respiratory [ $\text{PaO}_2/\text{FiO}_2$  ratio], cardiovascular (blood pressure, vasoactive drugs), renal (creatinine), hepatic (bilirubin), neurological (Glasgow coma score) and hematological (platelet count) (18).

Multiple organ failure is defined as the occurrence of severe organ failure in two or more organ systems during the ICU stay, either on the same day or on different days.

Statistical analysis was performed using a chi-square test, and two-way ANOVA tests with STATA 11.0 statistical software (USA). Analytical study was done on three different groups of patients namely MOF, single organ failure and no organ failure. The correlation between serum pancreatic enzyme levels and the progression of organ failure was analyzed by comparing the incidence of any one of the following organ system failures in the elevated and non elevated enzyme groups: cardiac (a requirement for vasopressors, despite adequate volume resuscitation, to maintain adequate organ perfusion), pulmonary ( $\text{pao}_2$ :  $\text{fio}_2 <$ , central venous pressure  $> 18$  mmHg, and bilateral infiltrates on chest radiograph), hepatic (serum total bilirubin  $> 3$  mg/dL and aspartate aminotransferase  $> 80$  IU/L [two times the upper limit of normal]), or renal (serum creatinine  $> 2$  and creatinine clearance  $< 100$  mg/dL), central nervous system (GCS  $< 8$ ) and hematologic dysfunction (presence of coagulopathy) in the body (19). In this study  $P < 0.05$  has been considered statistically significant.

## 4. Results

A total of 296 trauma patients from the ICU were enrolled in the study, with the mean age of 31 years, 85% were males and 15% females. Blunt injury was seen in 270 cases (91.6%) and 45 (8.4%) had penetrating injury. (Figure 1) depicts the site of injury. From a total of 296 patients, 153 cases (51.6%) had single organ failure, 96 (32.4%) had MOF and 47 (15.8%) had no organ failure. Of the patients with single organ failure, 1.9% had cardiac failure, 89.5% had pulmonary failure, 7.8% had hepatic failure and 0.6% had renal failure.

Univariate analysis of all the laboratory parameters amongst the three patient groups showed varied and significant difference in the lipase level ( $P = 0.04$ ), prothrombin time ( $P < 0.001$ ),  $\text{PaO}_2$  ( $P < 0.001$ ),  $\text{PCo}_2$  ( $P = 0.04$ ), potassium levels ( $P = 0.05$ ), bilirubin level ( $P = 0.008$ ) and hemoglobin level ( $P = 0.004$ ) (Table 1). However, the amylase levels were not found to be significant (Table 1).

The prevalence of coagulopathy was observed to be significantly higher in patients with MOF (22.9%), 7.1% in pa-

**Table 1.** Patients' Characteristics in Different Groups of Organ Failure

Parameters	Patient Group			P Value	SOF vs. No Organ Failure, P Value	No Organ Failure vs. MOF, P Value	SOF vs. MOF, P Value
	No Organ Failure, n = 47	Single Organ Failure, n = 153	Multiple Organ Failure, n = 96				
Age, y	29.3 ± 13.7	33.8 ± 17.1	30.1 ± 16.1	0.11	0.29	1.00	<b>0.25</b>
Sex <sup>a</sup>				0.26	-	-	-
Male	38 (80.8)	136 (88.8)	80 (83.3)		-	-	-
Female	9 (19.1)	17 (11.1)	16 (16.6)				
Prothrombin time, sec <sup>b</sup>	15.6 ± 2.6	16.4 ± 3.8	18.6 ± 6.5	< 0.001	0.97	< 0.001	< 0.001
Activated partial Thrombin time, sec <sup>b</sup>	27.5 ± 7.3	26.5 ± 6.1	31.0 ± 13.6	< 0.001	1.00	0.11	< 0.001
Coagulopathy <sup>a</sup>				< 0.001	-	-	-
No	45 (95.7)	142 (92.8)	74 (77.0)				
Yes	2 (4.26)	1 (7.1)	22 (22.9)				
Blunt injury <sup>a</sup>	42 (89.3)	139 (90.8)	90 (93.7)	0.61	-	-	-
Penetrating injury <sup>a</sup>	5 (10.6)	4 (9.10)	6 (6.2)				
Glasgow coma scale <sup>b</sup>	11.8 ± 4.0	11.9 ± 4.3	11.0 ± 4.9	0.37	1.00	1.00	0.52
Heart rate, /min <sup>b</sup>	90.9 ± 13.5	92.3 ± 17.2	97.9 ± 21.6	0.03	1.00	0.09	0.06
Injury <sup>a</sup> severity score				0.54		-	-
< 24	143 (93.6)	143 (93.5)	89 (93.7)				
> 24	16 (6.4)	10 (6.5)	6 (6.3)				
Systolic BP, mmHg <sup>b</sup>	116.3 ± 12.7	120.9 ± 23.2	115.6 ± 16.7	0.09	0.50	1.00	0.13
PRBC, units <sup>b</sup>	1.08 ± 2.1	0.9 ± 1.5	1.78 ± 2.1	0.002	1.00	0.11	0.002
Pao <sub>2</sub> , mmHg <sup>b</sup>	251.7 ± 38.9	140.2 ± 57.4	133.2 ± 65.1	< 0.001	< 0.001	< 0.001	1.000
Pco <sub>2</sub> , mmHg <sup>b</sup>	34.7 ± 6.08	37.0 ± 6.3	43.8 ± 44.6	0.065	1.00	0.14	0.13
Hco <sub>3</sub> , mEq/L <sup>b</sup>	21.5 ± 4.2	22.7 ± 3.4	22.5 ± 4.8	0.20	0.23	0.56	1.000
pH <sup>b</sup>	7.3 ± 0.1	7.3 ± 0.1	7.2 ± 0.5	0.49	1.00	1.00	0.78
Sodium, meq/L <sup>b</sup>	138.6 ± 5.7	138.8 ± 5.2	138.5 ± 4.9	0.89	1.00	1.00	1.000
Potassium, meq/L <sup>b</sup>	3.8 ± 0.5	3.9 ± 0.76	4.1 ± 0.8	0.02	0.95	0.03	0.08
SOFA score <sup>b</sup>	4.1 ± 1.2	5.5 ± 1.4	6.2 ± 1.6	< 0.001	< 0.001	< 0.001	< 0.002
Bilirubin, mg % <sup>b</sup>	0.6 ± 0.3	0.7 ± 0.4	0.9 ± 0.6	< 0.001	1.00	0.02	0.01
AST, u/L <sup>b</sup>	61.5 ± 102.8	62.4 ± 71.2	212.4 ± 237.4	< 0.001	1.00	< 0.001	< 0.001
Creatinine, meq/L <sup>b</sup>	0.6 ± 0.2	0.7 ± 0.32	0.8 ± 0.6	0.01	0.83	0.01	0.05
Urea, meq/L <sup>b</sup>	26.4 ± 10.3	29.8 ± 14.9	37.1 ± 37.4	0.01	1.00	0.04	0.06
Hemoglobin, gms/dl <sup>b</sup>	11.9 ± 2.2	11.6 ± 2.2	10.6 ± 2.6	< 0.001	1.00	0.005	0.003
Hematocrit, % <sup>b</sup>	35.7 ± 6.2	35.0 ± 6.4	32.1 ± 7.8	< 0.001	1.00	0.01	0.004
Total leukocyte count, x/cu mm <sup>b</sup>	14376.5 ± 5865.5	14950.3 ± 6627.5	16301.0 ± 6789.7	0.1	1.00	1.00	1.00
Platelet, /cu mm <sup>b</sup>	240.4 ± 118.3	233 ± 95.5	200.6 ± 84.3	0.01	1.00	0.06	0.02
Amylase, U/L <sup>b</sup>	93 (31-309)	89 (9-645)	89.5 (30 -1759)	0.08	1.00	0.3	0.10
Lipase U/L <sup>b</sup>	31 (17-190)	31.5 (4-350)	33.5 (9 -526)	0.05	1.00	0.16	0.09
Length of stay, days <sup>b</sup>	5.8 ± 7.4	8.4 ± 10.0	10.1 ± 11.2	0.63	0.38	0.05	0.63
Infection <sup>a</sup>				0.15		-	-
Yes	40 (85.1)	122 (79.7)	69 (71.8)				
No	7 (14.89)	31 (20.2)	27 (28.1)				
Outcome <sup>a</sup>				< 0.001		-	-
Dead	45 (95.74)	146 (95.4)	35 (36.4)				
Alive	2 (4.26)	7 (4.5)	61 (63.5)				

<sup>a</sup> Values expressed as f (%) compared between the different organ failure groups using the chi-square test.

<sup>b</sup> Values expressed as mean ± SD, compared between the different organ failure groups using analysis of variance-one way ANOVA.

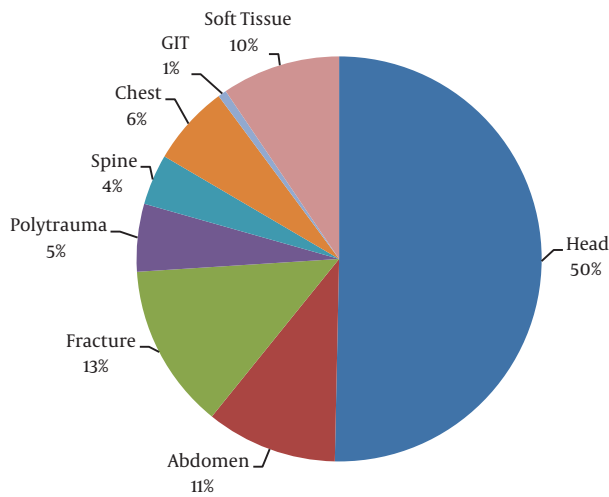


Figure 1. Site of Injury

tients with single organ failure and 4.2% in patients with no organ failure ( $P < 0.001$ ) (Table 1).

Incidence of organ failure was also found to be significantly correlated with immediate outcome (dead/alive), ( $P < 0.001$ ). The mortality rate in case of MOF was 36.4%, 4.5% in patients with single organ failure and 4.2% in patients with no organ failure (Table 1).

To determine if differences exist among three patient groups, one-way analysis of variance (ANOVA) was performed using the mean values of all the laboratory parameters (Table 1). A significant difference was observed in the mean values of  $\text{PaO}_2$  ( $P < 0.001$ ) and SOFA score ( $P < 0.001$ ) for the patients who developed single organ failure when compared to the patients with no organ failure. On comparison of the no organ failure patient group with the patients with MOF, mean values were as follows: for PT ( $P < 0.001$ ),  $\text{PaO}_2$  ( $P < 0.001$ ), SOFA score ( $P < 0.001$ ), potassium ( $P = 0.03$ ), bilirubin ( $P = 0.02$ ), AST ( $P < 0.001$ ), creatinine ( $P = 0.01$ ), urea ( $P = 0.04$ ), Hb ( $P = 0.005$ ), Hct ( $P = 0.01$ ), length of stay ( $P = 0.05$ ).

The analysis of variance for the single vs. MOF group showed a significant difference in the mean values of PT ( $P < 0.001$ ), aPTT ( $P < 0.001$ ), PRBC transfusion ( $P = 0.002$ ), SOFA score ( $P = 0.002$ ), bilirubin ( $P = 0.01$ ), AST ( $P < 0.001$ ), creatinine ( $P = 0.05$ ), Hb ( $P = 0.003$ ), Hct ( $P = 0.004$ ) and platelets ( $P = 0.02$ ) (Tables 2 and 3).

To compare the lipase and amylase levels within the normal range, and above and beyond the normal range in serum samples, the chi-square test was performed in correlation with the different laboratory parameters. Serum lipase levels were observed to be significantly associated with the platelet count ( $P = 0.005$ ) of acutely injured pa-

tients. Lipase levels were also significantly correlated with coagulopathy ( $P = 0.02$ ), infection ( $P = 0.01$ ), immediate outcome (dead/alive) ( $P = 0.04$ ), and organ failure ( $P = 0.02$ ). Both amylase and lipase levels were found to be significant in patients with renal failure ( $P = 0.03$ , and  $P = 0.005$ , respectively) (Table 2).

To determine the comparison between patients with and without organ failure, the univariate logistic regression analysis of the categorical data was performed. Variables that were determined to have statistically significant association with the occurrence of organ failure were evaluated using multivariate regression analysis to determine the independent association of the variable with organ failure (Tables 4 and 5). It was concluded that independent predictors of organ failure were  $\text{PCO}_2$  (OR = 0.5) and potassium (OR = 4.1).

The immediate outcome (dead/alive) of the study group was correlated with the clinical and laboratory parameters, and the univariate analysis was performed, followed by multivariate regression analysis of the variables that were determined to be statistically significant (Tables 6 and 7). The observed independent predictors of mortality were coagulopathy (OR = 1.7), Glasgow coma scale (OR = 1.1, 4.7), sodium (OR = 18.2, 3.4), potassium (OR = 5.7, 0.3), bilirubin (OR = 0.4), Hb (OR = 1.5), pulmonary failure (OR = 0.0004), hepatic failure (OR = 0.048), renal failure (OR = 5.5), organ failure (OR = 149.8), lipase (OR = 1.3) and infection (OR = 3.0).

## 5. Discussion

Serum amylase and lipase levels are markers of pancreatic inflammation and are standard tests to diagnose acute pancreatitis; however, neither amylase nor lipase is specific for acute pancreatitis (13). Rise of the enzyme is detected in patients with trauma, tumors or intracranial hemorrhage, patients with abdominal trauma and those submitted to cardiac surgery (20). Malinoski et al. (19) reported that elevation in pancreatic enzymes in trauma patients in the absence of a pancreatic injury have an increased risk of morbidity and mortality. The results of our study suggest that elevated serum levels of pancreatic enzymes are independent predictors of organ failure and post trauma mortality. It is often difficult to predict whether enzyme elevations are due to ischemic pancreatitis or the translocation of intraluminal enteric pancreatic enzymes. It is unlikely that circulating pancreatic enzymes are direct cause of organ failure because of abundant protease inhibitors in the blood that bind and limit their activity but they may serve as tools to detect progression to organ failure in trauma patient (17, 21).

**Table 2. [Part 1]** Comparison Between Abnormal and Normal Levels of Lipase and Amylase in Trauma Patients

Parameters	Lipase		P Value	Amylase		P Value
	Normal	Abnormal		Normal	Abnormal	
<b>Sex</b>			0.06			0.67
Male	197 (83.8)	56 (93.3)		192 (85.3)	62 (87.3)	
Female	38 (16.1)	4 (06.6)		33 (14.6)	9 (12.6)	
<b>Activated partial Thrombin time</b>			0.6			0.08
Normal ( $\leq$ 49.2)	229 (97.4)	58 (96.6)		221 (98.2)	67 (94.3)	
Abnormal ( $>$ 49.2)	6 (02.5)	2 (03.3)		4 (1.70)	4 (05.6)	
<b>Coagulopathy</b>			0.02			0.12
No	212 (90.2)	48 (80)		202 (89.7)	59 (83.1)	
Yes	23 (09.7)	12 (20)		23 (10.2)	12 (16.9)	
<b>Mode of injury</b>			0.12			0.62
Blunt injury	212 (90.2)	23 (09.7)		207 (92)	64 (90.1)	
Penetrating injury	58 (96.6)	2 (03.3)		18 (08)	7 (09.8)	
<b>Glasgow coma scale</b>			0.56			0.50
Mild (13 -15)	144 (61.2)	38 (63.3)		140 (62.2)	43 (60.5)	
Moderate (9 -12)	23 (09.7)	8 (13.3)		21 (09.3)	10 (14.0)	
Severe (1 -8)	68 (28.9)	14 (33.3)		64 (28.4)	18 (25.3)	
<b>Injury Severity Score</b>			0.06			0.25
< 24	225 (80.9)	10 (58.8)		214 (76.7)	11 (64.7)	
> 24	53 (19.1)	7 (41.2)		65 (23.3)	6 (35.3)	
<b>Systolic BP, mmHg</b>			0.06			0.94
Normal ( $\leq$ 130)	207 (88.0)	47 (78.3)		194 (86.2)	61 (85.9)	
Abnormal ( $>$ 130)	28 (11.9)	13 (21.6)		31 (13.7)	10 (14.0)	
<b>PaO<sub>2</sub>, mmHg</b>			0.24			0.62
Normal (80 -100)	35 (14.8)	7 (11.6)		33 (14.6)	9 (12.6)	
Abnormal low (< 80)	31 (13.1)	13 (21.6)		31 (13.7)	13 (18.3)	
Abnormal high (> 100)	169 (71.9)	40 (66.6)		161 (71.5)	49 (69.0)	
<b>PCO<sub>2</sub>, mmHg</b>			0.4			0.92
Normal (35 -45)	118 (50.2)	35 (58.3)		115 (51.1)	38 (53.5)	
Abnormal low (> 45)	25 (10.6)	7 (11.6)		25 (11.1)	8 (11.2)	
Abnormal high (< 35)	92 (39.1)	18 (30.0)		85 (37.7)	25 (35.2)	
<b>HCO<sub>3</sub>, mEq/L</b>			0.63			0.6
Normal (24 -29)	78 (33.3)	24 (40.0)		76 (33.7)	26 (37.1)	
Abnormal high (> 29)	8 (03.4)	1 (01.6)		8 (03.5)	1 (01.4)	
Abnormal-low (< 24)	148 (63.2)	35 (58.3)		141 (62.6)	43 (61.4)	
<b>pH</b>			0.69			0.1
Normal (7.35 -7.45)	93 (39.5)	20 (33.9)		87 (38.6)	26 (37.1)	
Abnormal low (< 7.35)	105 (44.6)	28 (47.4)		107 (47.5)	27 (38.5)	
Abnormal high (> 7.45)	37 (15.7)	11 (18.6)		31 (13.7)	17 (24.2)	
<b>Sodium, mEq/L</b>			0.3			0.26
Normal (135 -145)	201 (85.9)	47 (78.3)		185 (82.5)	63 (88.7)	
Abnormal high (> 145)	11 (04.7)	4 (06.6)		11 (04.9)	4 (05.6)	
Abnormal low (< 135)	22 (09.4)	9 (15.0)		28 (12.5)	4 (05.6)	
<b>Potassium, mEq/L</b>			0.1			0.14
Normal (3.5 - 5)	181 (77.0)	39 (65.0)		170 (75.5)	57 (71.8)	
Abnormal-high (> 5)	17 (07.2)	5 (08.3)		13 (05.7)	9 (12.6)	
Abnormal-low (< 3.5)	37 (15.7)	16 (26.6)		42 (18.6)	11 (16.4)	

Elevation of the serum lipase and amylase is a common problem in clinical practice of an ICU and is not ex-

clusive of pancreatic inflammation (22, 23). Liu et al. (12) reported that 15% of a group of patients admitted because

**Table 3. [Part 2]** Comparison Between Abnormal and Normal Levels of Lipase and Amylase in Trauma Patients

Parameters	Lipase		P Value	Amylase		P Value
	Normal	Abnormal		Normal	Abnormal	
<b>Bilirubin, mg %</b>			0.16			0.22
Normal (up to 1)	188 (80.0)	43 (71.6)		180 (80)	52 (73.2)	
Abnormal (> 1)	47 (20.0)	17 (28.3)		45 (20)	90 (26.7)	
<b>Cardiac Failure</b>			0.15			0.71
No	208 (88.5)	49 (81.6)		197 (87.5)	61 (85.9)	
Yes	27 (11.4)	11 (18.3)		28 (12.4)	10 (14.0)	
<b>Pulmonary failure</b>			0.6			0.34
No	58 (24.6)	13 (21.6)		51 (22.6)	20 (28.1)	
Yes	177 (75.3)	47 (78.3)		174 (77.3)	51 (71.8)	
<b>Hepatic failure</b>			0.3			0.90
No	166 (70.6)	39 (65.0)		68 (30.2)	22 (30.9)	
Yes	69 (29.3)	21 (35.0)				
<b>Renal failure</b>			0.005			0.03
No	233 (99.1)	55 (91.6)		222 (98.6)	67 (94.3)	
Yes	2 (08.0)	5 (08.3)		3 (01.3)	4 (05.6)	
<b>Hemoglobin, gms/DL</b>			0.91			0.90
Normal ( $\geq 9$ )	201 (85.5)	51 (85.0)		192 (85.3)	61 (85.9)	
Abnormal (< 9)	34 (14.4)	9 (15.0)		33 (14.6)	10 (14.0)	
<b>Total leukocyte Count, <math>\times 10^3</math>/cumm</b>			0.6			0.68
Normal (4000 - 10000)	48 (20.4)	15 (25.0)		48 (21.3)	15 (21.1)	
Abnormal high (> 10000)	185 (78.7)	45 (75.0)		176 (78.2)	55 (71.4)	
Abnormal low (< 4000)	2 (0.8)	0 (0.0)		1 (00.4)	1 (01.4)	
<b>Platelet/(cu mm)</b>			0.005			0.51
Normal (1 - 4 lakh)	224 (95.3)	51 (85.0)		211 (93.7)	65 (91.5)	
Abnormal (< 1 lakh)	11 (04.6)	9 (15.0)		14 (06.2)	6 (08.4)	
<b>Infection<sup>a</sup></b>			0.01			0.26
Yes	191 (81.2)	40 (66.6)		179 (79.5)	52 (73.2)	
No	44 (18.7)	20 (33.3)		46 (20.4)	19 (26.7)	
<b>Outcome<sup>a</sup></b>			0.04			0.34
Dead	205 (87.2)	46 (76.6)		194 (86.2)	58 (81.6)	
Alive	30 (12.7)	14 (23.3)		31 (13.7)	13 (18.3)	
<b>Organ Failure</b>			0.02			0.28
No Organ Failure	38 (16.1)	9 (15.0)		33 (14.6)	14 (19.7)	
Single Organ Failure	129 (54.8)	23 (38.3)		122 (54.2)	31 (43.6)	
Multiple Organ Failure	68 (28.9)	28 (46.6)		70 (31.1)	26 (36.6)	

<sup>a</sup>Values expressed as F (%), compared between the normal abnormal levels using  $\chi^2$  test.

of trauma, infection, tumor or other intracranial injuries showed elevated amylase and lipase levels without any evi-

dence of pancreatitis, and recommend a routine monitoring of these enzymes. Lee et al. (14) reported an associa-

**Table 4. [Part 1]** Analysis of Organ Failure (Univariate and Multivariate Analysis)<sup>a</sup>

Parameters	Organ Failure		P Value	Odds Ratio (95% CI)	Adjusted Odds Ratio (95% CI)
	No	Yes			
<b>Sex</b>			0.29		
Male	38 (80.8)	216 (86.7)		1.0	-
Female	9 (19.1)	33 (13.2)		0.6 (0.2-1.4)	
<b>Activated partial Thrombin time</b>			0.48	1.0	-
Normal ( $\leq 49.2$ )	45 (95.7)	243 (75.0)		0.5 (0.1-2.8)	
Abnormal ( $> 49.2$ )	2 (4.26)	6 (02.4)		1.0	-
<b>Mode of injury</b>			0.55	0.7 (0.2-2)	
Blunt	42 (89.3)	229 (91.9)			
Penetrating	5 (10.6)	20 (08.0)			
<b>Glasgow coma scale</b>			0.62	1.0	-
Mild (13-15)	30 (63.8)	153 (61.4)		1.3 (0.4-4.0)	
Moderate (9-12)	4 (08.5)	27 (10.8)			
Severe (1-8)	13 (27.6)	69 (27.7)		1 (0.5-2.1)	
<b>Injury Severity Score</b>			0.28	1.0	-
< 24	45 (97.8)	143 (93.6)		3.1 (0.4-23.8)	
> 24	1 (2.2)	16 (6.4)			
<b>PCO<sub>2</sub>, mmHg</b>			0.04	1.0	1.0
Normal (35-45)	20 (42.5)	133 (53.4)		2.3 (0.5-11.1)	2.2 (0.4-10.2)
Abnormal-high (>45)	2 (04.2)	31 (12.4)		0.5 (0.2-1.0)	0.4 (0.2-0.90)
Abnormal-low (<35)	25 (53.1)	85 (34.1)			
<b>Hco<sub>3</sub>, mEq/L</b>			0.98	1.0	-
Normal (24-29)	16 (34.0)	86 (34.6)			
Abnormal high (> 29)	2 (04.2)	7 (02.8)		0.6(0.1-3.4)	
Abnormal-low (< 24)	29 (61.7)	155 (62.5)		0.9 (0.5-1.9)	

<sup>a</sup>Values expressed as f (%).

tion of elevated pancreatic enzymes with various neurosurgery events and diagnoses and a higher mortality rate in patients admitted to the neurosurgery ICU.

The gut has been considered as one of the major sources of the inflammatory response following trauma and has the potential to lead to MOF (14, 24, 25), after traumatic injury intraluminal pancreatic enzymes have been postulated to enter the gut submucosa, activating local inflammatory mediators which then enter the systemic circulation through the mesenteric lymph and might play an important role in the pathogenesis of MOF (9). Several studies have demonstrated that inhibition of intraluminal pancreatic enzymes during the resuscitation minimizes the acute inflammatory response as well as histological organ injury (9, 26, 27). In addition, on ligating the

pancreatic duct several weeks before hemorrhage, delayed mucosal injury and prolonged survival has been observed (11, 13).

Low levels of pancreatic enzymes are present in the healthy individual's circulation in addition to residing in the lumen of intestinal tract (28). Serum pancreatic enzyme levels have been found to be elevated in 36% to 67% of critically ill patients (29, 30). Although some studies suggest that the hyperamylasemia of critical illness is from nonpancreatic sources (16), others depict an increase in either pancreatic lipase or amylase, both of which are specific indicators of pancreatic origin (29, 30). Regardless of which pancreatic enzyme is being measured, all the studies indicate that greater severity of organ failure and illness are correlated with elevated serum enzyme levels. Kumar

**Table 5. [Part 2]** Analysis of Organ Failure (Univariate and Multivariate Analysis)<sup>a</sup>

Parameters	Organ Failure		P Value	Odds Ratio (95% CI)	Adjusted Odds Ratio(95% CI)
	No	Yes			
<b>pH</b>			0.40	1.0	-
Normal (7.35 - 7.45)	15 (31.9)	98 (31.5)		0.7(0.3-1.4)	
Abnormal low (< 7.35)	23 (48.9)	111 (44.7)			
Abnormal high (> 7.45)	9 (19.1)	39 (15.7)		0.6 (0.2-1.6)	
<b>Sodium, mEq/L</b>			0.33	1.0	-
Normal (135 - 145)	41 (87.2)	207 (83.4)		2.7 (0.3-21.6)	
Abnormal high (> 145)	1 (2.1)	14 (05.6)			
Abnormal low (< 135)	5 (10.6)	27 (10.8)		1.0 (0.3-2.90)	
<b>Potassium, mEq/L</b>			0.02	1.0	1.0
Normal (3.5 - 5)	43 (91.4)	178 (71.4)		4.4(0.5-11.1)	4.2(0.5 - 33.4)
Abnormal-high (> 5)	1 (2.10)	21 (08.4)			
Abnormal-low (< 3.5)	3 (6.30)	50 (20.0)		4.1 (1.2-14.0)	4.0 (1.1 - 14.0)
<b>Bilirubin, mg %</b>			0.22	1.0	-
Normal (up to 1)	40 (17.2)	192 (82.7)		1.6 (0.7-3.90)	
Abnormal (> 1)	7 (10.9)	57 (89.0)			
<b>Total leukocyte Count, × 10<sup>3</sup>/cu mm</b>			0.25	1.0	-
Normal (4000 - 10000)	13 (27.6)	50 (20.0)		1.5 (0.74-30)	
Abnormal high (> 10000)	34 (72.3)	197 (79.1)		1.0	
Abnormal low (< 4000)	0	2 ( 0.80)			
<b>Platelet, /cu mm</b>			0.91	1.0	-
Normal (1 - 4 lakh)	44 (93.6)	232 (93.1)			
Abnormal (< 1 lakh)	3 (06.3)	17 (06.8)		1.0 (0.3-3.8)	
<b>Amylase, U/L</b>			0.31	1.0	-
Normal (30 - 130)	33 (70.2)	192 (77.1)		0.6 (0.3-1.3)	
Abnormal-high (> 130)	14 (29.7)	57 (22.8)			
<b>Lipase, U/L</b>			0.82	1.0	-
Normal (up to 60)	38 (80.8)	197 (79.1)			
Abnormal-high (> 60)	9 (19.1)	51 (20.4)		1.9 (0.4-2.4)	

<sup>a</sup>Values expressed as f (%).

et al. (16) reported a significant association of the elevation in serum amylase with spleen injury, and GIT injury.

Several clinical studies have demonstrated both histological and clinical evidence of ischemic pancreatic inflammation in a variety of shock states (31). Therefore, direct secretion of pancreatic enzymes into the circulation seems to have a reasonable correlation with progression of organ failure in trauma patient. More than a few studies have reported a mortality rate of 5.1% in patients with MOF (2). A mortality rate of 36.4% was reported in our study.

Malinoski et al. (19) observed that patients with an elevated amylase level were more at a risk of developing organ failure, present in shock and had a greater risk of death and patient with an elevated lipase level were likely to develop organ failure. In our study, patients with an elevated amylase level had a greater risk for renal failure and patients with an elevated lipase level were more prone to develop coagulopathy, MOF and had a greater risk of death. These patients were at higher risk of infection and had an abnormal level of platelet count.



**Table 6. [Part 1]** Analysis for Outcome (Univariate and Multivariate Analysis)

Parameters	Outcome		P Value	Odds Ratio (95% CI)	Adjusted Odds Ratio (95% CI)
	Alive	Dead			
<b>Sex<sup>a</sup></b>			0.41	1.0 1.4 (0.6 - 3.3)	-
Male	218 (86.5)	36 (81.8)			-
Female	34 (13.4)	8 (18.1)			
<b>Activated partial Thrombin time, sec</b>			0.01	1.0 6.2 (1.4 - 25.7)	1.0 1.0 (0.9 - 1.0)
Normal ( $\leq 49.2$ )	248 (98.4)	40 (90.9)			
Abnormal ( $> 49.2$ )	4 (01.5)	4 (09.0)			-
<b>Coagulopathy<sup>a</sup></b>			$< 0.001$	1.3 3.7 (1.6 - 8.20)	
No	229 (90.8)	32 (72.7)			1.0
Yes	23 (09.1)	12 (27.2)			-
<b>Glasgow coma scale<sup>a</sup></b>					-
Mild (13 - 15)	168 (66.6)	15 (34.0)		1.0 2.6 (0.9 - 7.5)	-
Moderate (9 - 12)	25 (09.9)	6 (13.6)	0.06	4.3 (2.1 - 8.9)	-
Severe (1 - 8)	59 (23.4)	23 (52.2)	$< 0.001$		
<b>Injury Severity Score</b>			0.74	1.3 (0.4 - 5.0)	-
$< 24$	238 (94.4)	41 (93.2)			
$> 24$	14 (5.7)	3 (6.8)			
<b>Systolic BP, mmHg<sup>a</sup></b>			0.96	1.0	-
Normal ( $\leq 130$ )	217 (86.1)	38 (86.3)		0.9 (0.3 - 2.4)	-
Abnormal ( $> 130$ )	35 (13.8)	6 (13.6)			-
<b>PCO<sub>2</sub>, mmHg</b>				1.0	-
Normal (35 - 45)	134 (53.1)	19 (43.1)			-
Abnormal-high ( $> 45$ )	27 (10.7)	6 (13.6)	0.38	1.5 (0.5 - 4.2)	-
Abnormal-low ( $< 35$ )	91 (36.1)	19 (43.1)	0.27	1.4 (0.7 - 2.9)	
<b>Hco<sub>3</sub>, mEq/L</b>					-
Normal (24 - 29)	88 (34.9)	14 (32.5)		1.0	
Abnormal high ( $> 29$ )	6 (02.3)	6 (13.6)	0.13	3.1 (0.7 - 14)	
Abnormal-low ( $< 24$ )	158 (62.7)	26 (60.4)	0.92	1.0 (0.5 - 2.0)	
<b>pH</b>					-
Normal (7.35 - 7.45)	098 (39.0)	15 (34.0)		1.0	
Abnormal low ( $< 7.35$ )	113 (45.0)	21 (47.7)	0.59	1.2 (0.5 - 2.4)	
Abnormal high ( $> 7.45$ )	40 (15.9)	8 (18.1)	0.57	1.3 (0.5 - 3.3)	
<b>Sodium, mEq/L<sup>a</sup></b>					-
Normal (135 - 145)	221 (88.0)	27 (61.3)		1.0	1.0
Abnormal high ( $> 145$ )	7 (02.9)	8 (18.1)	$< 0.001$	9.3 (3.1 - 27.8)	18.2 (2.6 - 124.5)
Abnormal low ( $< 135$ )	23 (09.1)	9 (20.4)	0.009	3.2 (1.3 - 7.60)	3.4 (0.6 - 17.20)

<sup>a</sup>Values expressed as f (%).

The independent predictors of organ failure in their study (19) were age; ISS, massive transfusion, elevated amy-

lase and lipase and the independent predictors for mortality were age, ISS, massive transfusion, shock and elevated

**Table 7. [Part 2]** Analysis for Outcome (Univariate and Multivariate Analysis)

Parameters	Outcome		P Value	Odds Ratio (95% CI)	Adjusted Odds Ratio(95% CI)
	Alive	Dead			
<b>Potassium, mEq/L</b>			0.02		1.0
Normal (3.5 - 5)	190 (75.4)	31 (70.4)		1.0	5.7 (0.8 - 37.5)
Abnormal-high (> 5)	15 (05.9)	7 (15.9)	0.03	2.8 (1.0 - 7.5)	0.3 (0.06-2.1)
Abnormal-low (< 3.5)	47 (18.6)	6 (13.6)	0.60	0.7 (0.3 - 1.9)	4.0 (1.1 - 14.0)
<b>Bilirubin, mg %</b>					-
Normal (up to 1)	204 (80.9)	28 (63.6)		1.0	1.0
Abnormal (> 1)	48 (19.0)	16 (36.3)	0.01	2.4 (1.2 - 4.8)	0.4 (0.1 - 2.1)
<b>Pulmonary failure</b>			0.25	1.0	-
No	55 (21.8)	16 (36.3)	< 0.001	1.0	1.0
Yes	197 (78.1)	28 (63.6)		0.4 (0.2 - 0.9)	0.0004 (.00001 - 0.01)
<b>Hepatic failure</b>			0.003		-
No	184 (73.0)	22 (50.0)		1.0	1.0
Yes	68 (26.9)	22 (50.0)		2.7 (1.4 - 5.1)	0.048 (.007 - 0.20)
<b>Renal failure</b>			0.31		-
No	251 (99.6)	38 (86.3)		1.0	1.0
Yes	1 (0.40)	6 (13.6)	0.82	39.6 (4.6 - 338.2)	5.5 (.08 - 346.4)
<b>Hemoglobin, gms/dL<sup>a</sup></b>			< 0.001		-
Normal ( $\geq$ 9)	225 (89.2)	28 (63.6)		1.0	1.0
Abnormal (< 9)	27 (10.7)	16 (36.3)		4.7 (2.2 - 9.9)	1.5 (0.3 - 6.70)
<b>Platelet, /cu mm</b>			0.05		
Normal (1 - 4 lakh)	238 (86.2)	38 (13.7)		1.0	1.0
Abnormal (< 1 lakh)	14 (70.0)	6 (30.0)		2.6 (0.9 - 7.4)	1.0 (0.1 - 8.8)
<b>Amylase, U/L*</b>			0.90		
Normal (30 - 130)	194 (76.9)	31 (70.4)		1.0	-
<b>Abnormal-high (&gt; 130)</b>	58 (23.0)	13 (29.5)		1.0 (0.5 - 1.9)	-
<b>Lipase, U/L<sup>a</sup></b>			0.040		
Normal (up to 60)	205 (81.6)	30 (68.1)		1.0	1.0
Abnormal-high (> 60)	46 (18.3)	14 (31.8)		2.1 (1.0 - 4.2)	1.3(0.3-6.0)
<b>Infection*</b>			0.02		
No	206 (81.7)	25 (56.8)		1.0	1.0
Yes	46 (18.2)	19 (43.1)		3.4 (1.7-6.6)	3.0 (0.7 - 11.8)
<b>Organ failure<sup>a</sup></b>					
No organ failure	45 (17.8)	2 (4.50)		1.0	1.0
Single organ failure	146 (57.9)	7 (15.9)	0.001	87.6 (6.6 - 1158.3)	149.8 (9.4 - 2374.7)
Multiple organ failure	61 (24.2)	35 (79.5)	< 0.001	12.9 (2.9 - 56.4)	183050.0 (1792 - 1.9)

<sup>a</sup>Values expressed as f (%).

amylase. In the present study, the predictors of organ failure were coagulopathy and infection. Predictors of mortal-

ity were organ failure, coagulopathy, infection, GCS, bilirubin, elevated lipase, hemoglobin and platelet count.

Our study corroborates the findings of previous studies in critically ill patients; the increase in serum pancreatic enzymes is associated with greater degrees of shock, injury severity, organ dysfunction, and death. The elevated lipase level was significantly correlated with the incidence of MOF in acutely injured trauma patients. Association between the elevated amylase and organ failure was not significant. Measuring levels of these enzymes after admission, coupled with other laboratory investigations (Hb, bilirubin, and creatinine) may be helpful in the identification of patients who are at a risk of infection and progression towards organ failure and ensuring optimum management of patients following trauma.

## Footnote

**Authors' Contributions:** All authors contributed in concepts, design, definition of intellectual content, literature search, clinical studies, experimental studies, data acquisition, data analysis, statistical analysis and manuscript preparation/ editing/ review.

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