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Serum Amylase Level on Admission in the Diagnosis of Blunt Injury to the Pancreas

Its Significance and Limitations

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Objective
The objective of this study was to elucidate the significance and limitations of serum amylase levels in the diagnosis of blunt injury to the pancreas.

Summary Background Data
Several recently published reports of analyses of patients with blunt abdominal trauma have indicated that determination of the serum amylase level on admission seemed to be of little value in the diagnosis of acute injury to the pancreas. Few previous reports have described clearly the significance and the limitations of the serum amylase level in diagnosing injury to the pancreas.

Methods
Retrospective analysis of 73 patients with blunt injury to the pancreas during 16-year period from February 1980 to January 1996 was performed. The factors analyzed in the current study included age, gender, time elapsed from injury to admission, hypotension on admission, type of injury to the pancreas, intra-abdominal- and intracranial-associated injuries, and death.

Results
The serum amylase level was found to be abnormal in all patients admitted more than 3 hours after trauma. Various comparisons between patients with elevated (n = 61, 83.6%) and nonelevated (n = 12, 16.4%) serum amylase levels showed the statistical significance solely of the time elapsed from injury to admission (7 ± 1.5 hours *vs.* 1.3 ± 0.2 hour, $p < 0.001$). The major factor that influences the serum amylase level on admission appeared to be the time elapsed from injury to admission. Determination of the serum amylase level is not diagnostic within 3 hours or fewer after trauma, irrespective of the type of injury.

Conclusions
To avoid failure in the detection of pancreatic injury, the authors advocate determination of serum amylase levels more than 3 hours after trauma.

The serum amylase level has been of interest as a parameter for diagnosis of traumatic injury to the pancreas.[1,2] Several recently published reports of analyses of patients with blunt abdominal trauma have indicated, however, that determination of the serum amylase level on admission seemed to be of little value in the diagnosis of acute injury to the pancreas.[3–14] To our knowledge, few previous reports have described clearly the significance and the limitations of the serum amylase level in diagnosing injury to the pancreas. Moreover, previous reports have not discussed in detail the factors that might influence the serum amylase level on admission in patients with injury to the pancreas, such as time elapsed from injury to admission or type of injury to the pancreas. We report here a retrospective analysis of our patients with blunt injury to the pancreas, which was designed to clarify the significance and the limitations of the serum amylase level on admission in the diagnosis of injury to the pancreas.

PATIENTS AND METHODS

During the 16-year period from February 1980 to January 1996, 81 patients with injury to the pancreas were treated at the Department of Traumatology and Critical Care Medicine and at the Department of Surgery, Kitasato University School of Medicine, Sagamihara, Kanagawa, Japan. We excluded from our analysis four (4.9%) patients who had sustained injury to the pancreas from penetrating abdominal trauma. We also excluded patients who had been admitted more than 3 days after trauma, as well as those patients who had been admitted in cardiopulmonary arrest. Thus, 73 patients with blunt injury to the pancreas were considered in the current retrospective analysis. There were 52 males and 21 females. The patients ranged in age from 3 to 68 years (mean, 31.2 years). The time elapsed from injury to admission ranged from 0.3 to 63 hours (mean, 6 hours). Hypotension, defined as a systolic arterial blood pressure below 90 mmHg, was observed in 16 (21.9%) patients on admission. Intra-abdominal-associated injuries were observed in 47 (64.4%) of the 73 patients, and intracranial-associated injuries were observed in 2 (2.7%). These two patients with intracranial-associated injuries had an acute epidural hemorrhage and a skull-base fracture, respectively. Seven of 73 patients died, with the overall mortality rate being 9.6%.

The pancreatic injuries were graded by reference to the classification of injuries to the pancreas provided by the Japanese Association for the Surgery of Trauma (Table 1).[15] The type of pancreatic injury was determined by computed tomography (CT), endoscopic retrograde pancreatography, or gross findings at laparotomy.[14,16–18] Results of enhanced CT on admission that were suggestive of injury to the pancreas included disruption, swelling, and/or heterogeneous staining of the pancreatic parenchyma, as well as accumulation of fluid in the peripancreatic area or the anterior pararenal space or both. Type I injury to the pancreas was recorded in 35 cases (47.9%), type II injury to the pancreas was recorded in 10 cases (13.7%), and type III injury to the pancreas was recorded in 28 cases (38.4%).

Table 1. TYPES OF PANCREATIC INJURY GRADED BY REFERENCE TO THE CLASSIFICATION OF PANCREATIC INJURIES PROVIDED BY THE JAPANESE ASSOCIATION FOR THE SURGERY OF TRAUMA[15]

Type I: Contusion
A mild pancreatic injury without any laceration of the retroperitoneal fascia that allows the pancreatic fluid to spread into the peritoneal cavity
Type II: Laceration
Various parenchymal injuries without injury to the main pancreatic ducts
Type III: Ductal injury
IIIa*: Injury to the main pancreatic duct in the body or the tail of the pancreas
IIIb*: Injury to the main pancreatic duct in the head of the pancreas, injury to the accessory pancreatic duct, or injury to the intrapancreatic bile duct

* The borderline used to discriminate between type IIIa and type IIIb is the right margin of the superior mesenteric vein.

In patients with abdominal trauma, the serum amylase level is determined on admission to our institution. This routine determination of the serum amylase level on admission is part of our institution's policy for management of patients with abdominal trauma. Because four different methods had been used consecutively for the determinations of serum amylase levels during the period of the current analysis, normal ranges of serum amylase level varied (70–220 international units/L, 40–190 international units/L, 57–226 international units/L, and 50–160 international units/L, respectively). Therefore, the percentage of the upper limit of normal levels during each era was used for comparisons of actual values of serum amylase levels.

To elucidate the significance and the limitations of the serum amylase level on admission in the diagnosis of blunt injury to the pancreas, we performed a statistical analysis of several factors that we thought might influence the serum amylase level on admission.[3,19–24] The factors

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Table 2. PATIENTS WITH BLUNT INJURY TO THE PANCREAS (n = 73): RELATIONSHIP BETWEEN THE SERUM AMYLASE LEVEL ON ADMISSION AND TIME ELAPSED FROM INJURY TO ADMISSION

Time Elapsed from Injury to Admission (hr)	Number of Patients	Serum Amylase Not Elevated [number (%)]	Serum Amylase Elevated [number (%)]
≤1.0	14	5 (35.1)	9 (64.3)
1.0–2.0	23	5 (21.7)	18 (78.3)
2.0–3.0	13	2 (15.4)	11 (84.6)
3.0–4.0	3	0	3 (100)
4.0–5.0	1	0	1 (100)
5.0–6.0	2	0	2 (100)
>6.0	17	0	17 (100)
Total	73	12 (16.4)	61 (83.6)

analyzed in the current study included age, gender, time elapsed from injury to admission, hypotension on admission, type of injury to the pancreas, intra-abdominal- and intracranial-associated injuries, and death.

Statistical Analysis

Categoric variables were compared by the chi square test with Yates' correction when necessary. Continuous variables were compared by the Mann–Whitney *U* test. Continuous variables were expressed as means ± standard error of the mean. All cited probability values are two-tailed. All probability values below 0.05 were considered to be statistically significant.

RESULTS

The serum amylase level was already elevated on admission in 61 (83.6%) of 73 patients with blunt injury to the pancreas, whereas it was not elevated on admission in the remaining 12 (16.4%) patients (Table 2). Fifty patients were admitted to our institution 3 hours or fewer after trauma. Among these 50 patients, elevation of serum amylase level was observed in 38 patients (76%). The incidence of patients with an elevated serum amylase level gradually increased with the passage of time after trauma. None of the remaining 23 patients, admitted more than 3 hours after trauma, had a normal serum amylase level on admission.

A comparison was made between patients whose serum amylase level on admission was already elevated and those whose level was not yet elevated (Table 3). This comparison showed the statistical significance of the time elapsed from injury to admission ($p < 0.001$). The incidence of patients with intra-abdominal-associated injuries among patients whose serum amylase level on admission was not yet elevated (n = 11, 91.7%) was considerably higher than that among patients whose serum amylase level on admission was already elevated (n = 36, 59%). For the 47 patients with intra-abdominal-associated injuries, a comparison was made between patients whose serum amylase level on admission was elevated and those whose level was not yet elevated (Table 4). We found that the time elapsed from injury to admission in patients with an elevated serum amylase level on admission was markedly longer than that in patients with a normal serum amylase level on admission, but no statistical significance was observed for any variables, including the time elapsed from injury to admission, that were compared between these two groups. Subsequently, we analyzed the intra-abdominal organs that had been injured in association with injury to the pancreas in the same two groups (Table 5). Injury to the liver was the most common intra-abdominal-associated injury in both groups, followed by injury to the mesentery in patients whose serum amylase level was not yet elevated and then by injury to the duodenum in patients whose serum amylase level on admission was already elevated. The incidence of patients with associated injury to the duodenum showed a marked discrepancy between patients with or without an elevated serum amylase level on admission. However, when these two groups were compared, no variables, including the incidence of patients with associated injury to the duodenum, exhibited any statistical significance.

We compared patients with type I, type II, and type III injury to the pancreas (Table 6). The serum amylase level in patients with type III injury to the pancreas was approximately twice that in patients with type I or type II injury to the pancreas. A statistically significant difference was found, however, solely when we compared the ages of patients with type I and type II injury to the pancreas ($p < 0.05$), as well as when we compared patients with type I and type III injury to the pancreas ($p < 0.01$). Subsequent to this comparison, we divided our 73 patients into 2 subgroups by reference to the time elapsed from injury to admission, namely, 3 hours or fewer and more than 3 hours after trauma, and we compared the subgroups (Table 7). Among patients admitted 3 hours or fewer after trauma, no statistically significant difference was observed either in the time elapsed from injury to admission or in the serum amylase level on admission. By contrast, among patients admitted more than 3 hours after trauma, a statistically significant difference was

Table 3. PATIENTS WITH BLUNT INJURY TO THE PANCREAS (n = 73): COMPARISON OF PATIENTS WITH ELEVATED AND NONELEVATED SERUM AMYLASE LEVELS ON ADMISSION

	Serum Amylase Not Elevated (n = 12, 16.4%)	Serum Amylase Elevated (n = 61, 83.6%)	Statistical Significance of Difference
Age (yr)	30.8 ± 4.2	31.3 ± 2.2	NS
Gender (male:female)	9:3	43:18	NS
Time elapsed from injury to admission (hr)*	1.3 ± 0.2	7.0 ± 1.5	$p < 0.001$
Hypotension (SABP < 90 mmHg) on admission	4 (33.3%)	12 (18.2%)	NS
Type of injury (type I:type II:type III)	6:2:4	29:8:24	NS
Number of patients with intra-abdominal associated injury	11 (91.7%)	36 (59.0%)	NS
Number of patients with intracranial injury	1 (8.3%)	1 (1.6%)	NS
Number of patients who died	0	7 (11.5%)	NS

SABP = systolic arterial blood pressure; NS = not significant.
* Mann–Whitney U test.

found in the serum amylase level on admission when we compared patients with type I and type III injury to the pancreas ($p < 0.05$).

DISCUSSION

There is general agreement that elevation of the serum amylase level can be associated with various abdominal disorders in which decreased renal clearance (*e.g.*, chronic renal failure, macroamylasemia), perforation of the abdominal hollow viscus, and pancreatitis occur, and there is evidence that the regulation of the serum amylase level is multifactorial.[3,19,23,25] In the management of patients who are traumatized, the serum amylase level has been reported to be a useful diagnostic indicator of injury to the pancreas.[1,2] Boulanger et al.[21] reported, in their recent analysis of 4316 patients with blunt trauma, that hyperamylasemia was significantly associated with a greater injury severity score and death rate, as well as with increased incidence of brain injury, pancreatic and hollow viscus injuries, and hypotension. Failure to detect injury to the pancreas in the acute phase of trauma can result in severe complications, including pancreatic pseudocyst, intraperitoneal and retroperitoneal abscess, and death. Therefore, adequate examination of the pancreas is necessary when the serum amylase level is elevated in patients with blunt abdominal trauma.[7,26] A delay in the diagnosis of injury to the pancreas beyond 24 hours after trauma is associated with marked increases in morbidity and mortality.[26] Olsen[3] reported, however, that a determination of serum amylase within a few hours after blunt trauma could neither identify nor exclude serious pancreatic in-

Table 4. PATIENTS WITH INTRA-ABDOMINAL ASSOCIATED INJURIES (n = 47): COMPARISON BETWEEN PATIENTS WITH INTRA-ABDOMINAL ASSOCIATED INJURIES WHOSE SERUM AMYLASE LEVEL WAS ELEVATED (n = 36) AND THOSE WHOSE LEVEL WAS NOT ELEVATED (n = 11) ON ADMISSION

	Serum Amylase Not Elevated (n = 11)	Serum Amylase Elevated (n = 36)	Statistical Significance of Difference
Age (yr)	31.5 ± 4.5	33.0 ± 2.6	NS
Gender (male:female)	8:3	28:8	NS
Time elapsed from injury to admission (hr)	1.4 ± 0.3	6.0 ± 2.0	NS
Hypotension (SABP < 90 mmHg) on admission	4 (36.4%)	10 (27.8%)	NS
Type of injury (type I:type II:type III)	6:2:3	17:5:14	NS
Number of patients with intracranial injury	1 (9.1%)	0	NS
Number of patients who died	0	6 (16.7%)	NS

SABP = systolic arterial blood pressure; NS = not significant.

Table 5. INTRA-ABDOMINAL INJURY TO ORGANS ASSOCIATED WITH INJURY TO THE PANCREAS

	Serum Amylase Not Elevated (n = 11)	Serum Amylase Elevated (n = 36)	Statistical Significance of Difference
Liver	6	15	NS
Common bile duct	0	3	NS
Spleen	2	7	NS
Kidney	2	5	NS
Stomach	1	0	NS
Duodenum	1	11 [9]†	NS
Small intestine	0	1 [1]†	NS
Colon	1	2	NS
Omentum	1	1	NS
Mesentery	3	5	NS
Inferior vena cava	0	2	NS
Portal vein	0	3	NS
Miscellaneous*	0	2	NS

NS = not significant.
* Injury to the gastric artery and gastroduodenal artery.
† Values inside brackets indicate numbers of patients with rupture or disruption of the hollow viscus.

jury. In a review of the recently published literature on blunt injury to the pancreas, we found substantially elevated serum amylase levels on admission in 14% to 78% of patients.[8–13] Therefore, various reports have concluded that a determination of the serum amylase level on admission seemed to be of little value and to be nonspecific in the diagnosis of acute injury to the pancreas.[3–14] In the majority of these previous reports, however, the time elapsed from injury to the determination of the serum amylase level, as well as the type of injury to the pancreas, was not described clearly.

In Western countries, penetrating trauma accounts for approximately two thirds of injuries to the pancreas.[5,7] By contrast, only 4 (4.9%) of our initial group of 81 patients sustained injury to the pancreas from penetrating abdominal trauma. Our retrospective analysis of 73 patients with blunt injury to the pancreas showed that 16.4% of them had a normal serum amylase level on admission. Hence, our results showed that approximately three fourths of blunt injuries to the pancreas could be detected, within 3 hours after blunt abdominal trauma, by the routine determination of the serum amylase level on admission. Although no definitive conclusions can be drawn from our data because we reviewed only patients with proven injury to the pancreas, we emphasize that determination of the serum amylase level remains useful in the diagnosis of acute injury to the pancreas. In patients with isolated injury to the pancreas, the failure to develop physical

Table 6. COMPARISON OF PATIENTS IN TERMS OF TYPE OF INJURY TO THE PANCREAS

	Type I (n = 35)	Type II (n = 10)	Type III (n = 28)
Age (yr)	24.1 ± 1.0*†	41.0 ± 6.3*	36.5 ± 2.9†
Time elapsed from injury to admission (hr)	4.9 ± 1.0	9.5 ± 6.0	6.2 ± 2.3
Hypotension (SABP < 90 mmHg) on admission	8 (22.9%)	2 (20.0%)	6 (21.4%)
Number of patients with normal serum amylase level	6 (17.1%)	2 (20.0%)	4 (14.3%)
Serum amylase level on admission (%‡)	170.4 ± 19.7	162.0 ± 27.6	321.8 ± 68.9
Number of patients with intra-abdominal associated injury	23 (65.7%)	7 (70.0%)	17 (60.7%)
Number of patients with intracranial injury	2 (5.7%)	0	0
Number of patients who died	2 (5.7%)	3 (30.0%)	2 (7.1%)

SABP = systolic arterial blood pressure.
* $p < 0.05$, † $p < 0.01$, Mann–Whitney U test.
‡ Percentage of the upper limit of the normal range determined in each consecutive era.

Table 7. COMPARISON OF PATIENTS IN TERMS OF TYPE OF INJURY TO THE PANCREASE: PATIENTS DIVIDED INTO TWO SUBGROUPS BY REFERENCE TO THE TIME ELAPSED FROM INJURY TO ADMISSION (≤3 HOURS AND >3 HOURS AFTER TRAUMA)

	Type I (n = 35)	Type II (n = 10)	Type III (n = 28)
Number of patients admitted within ≤3 hr	24 (68.6%)	6 (60.0%)	20 (71.4%)
Time elapsed from injury to admission (hr)	1.5 ± 0.2	1.9 ± 0.2	1.6 ± 0.2
Serum amylase level on admission (%†)	129.7 ± 9.8	148.1 ± 37.0	180.4 ± 26.5
Number of patients admitted after >3 hr	11 (31.4%)	4 (40.4%)	8 (28.6%)
Time elapsed from injury to admission (hr)	12.5 ± 1.7	21.0 ± 14.1	17.8 ± 6.8
Serum amylase level on admission (%†)	259.3 ± 50.8*	233.9 ± 28.3	675.1 ± 185.2*

* $p < 0.05$, Mann–Whitney U test.
† Percentage of the upper limit of the normal range determined in each consecutive era.

signs and symptoms has been described previously.[7,20,26,27] This failure of physical signs and symptoms to develop has been considered likely to be related to the retroperitoneal location of the pancreas, to pancreatic enzymes remaining inactive after an isolated injury, and to the decreased secretion of pancreatic fluid that accompanies parenchymal damage.[28] Some of these factors could be associated with the normal level of serum amylase during acute phase of blunt injury to the pancreas.

In the current analysis of patients with or without an elevated serum amylase level on admission, a significant difference was noted solely in the time elapsed from injury to admission. Ninety percent of patients with injury to the pancreas have been reported to have at least one associated injury, with an average of 3 to 3.5 intra-abdominal-associated injuries per patient.[5,7] We found that 64.4% of our patients with blunt injury to the pancreas had some intra-abdominal-associated injuries, but no statistically significant difference was noted between the groups with and without intra-abdominal-associated injuries. There also was no significant difference in the incidence of each organ injured in association with injury to the pancreas. Other factors, including incidence of hypotension on admission, type of injury to the pancreas, incidence of intracranial injuries, and death, also exhibited no statistically significant differences when the same groups were compared. As a result of the current analysis, we propose that the time elapsed from injury to admission is the most important factor that influences the serum amylase level in patients with blunt injury to the pancreas. Our results further indicate that the longest time during which the serum amylase level remains in the normal range might be a 3-hour period after the initial blunt abdominal trauma. Thus, blunt injury to the pancreas cannot be ruled out within 3 hours after trauma by a normal serum amylase level. Further serial determinations of the serum amylase level more than 3 hours after trauma are advocated when acute injury to the pancreas is difficult to rule out by physical examination or from the mechanism of blunt abdominal trauma.

In a comparison of types of injury to the pancreas, a statistically significant difference was found in terms of age between patients with type I and type II injury to the pancreas and between patients with type I and type III injury to the pancreas. We reported previously that eight pediatric patients who sustained blunt injury to the pancreas when they were 15 years old or younger were treated in our institution.[29] Seven of these eight pediatric patients belonged to the group of patients with type I injury to the pancreas. Although many factors, even age and gender, have been reported to influence significantly the serum amylase level, we consider that inclusion of these pediatric victims in the group of patients with type I injury was the only reason that a statistically significant difference was found between these groups.[19]

Indications for the surgical treatment of pancreatic injury have been described as being dependent on the presence or absence of injury to the main pancreatic duct.[5,7,14,18] We also believe that the majority of patients with injury to the pancreatic ductal branch should undergo laparotomy.[30] Therefore, type I injury to the pancreas should be treated conservatively, whereas most type II and all type III injuries to the pancreas should be treated surgically. The current analysis indicates that the serum amylase level on admission, determined 3 hours or fewer after trauma, is not an appropriate guide to the choice of treatment for patients with injury to the pancreas. Among patients admitted more than 3 hours after trauma, by contrast, the serum amylase level on admission was two to three times higher than the upper limit of the normal level in patients with type I injury to the pancreas and six to seven times higher than the upper limit in patients with type III injury to the pancreas. This difference was statistically significant. It is accepted that the serum amylase level is not correlated with the severity of injury to the pancreas.[27] We reported previously, however, that the se-

rum amylase level determined in patients with type I or type III injury to the pancreas was significantly correlated with the time elapsed from injury to admission.[31] The results of our current analysis suggest that the presence or absence of injury to the main pancreatic ducts might influence the extent of the elevation of the serum amylase level on admission in patients with blunt injury to the pancreas. Our results also suggest the possibility that the serum amylase level on admission, determined more than 3 hours after trauma, might help physicians to differentiate between type I and type III injury to the pancreas.

In conclusion, our analysis of 73 patients with blunt injury to the pancreas showed the following:

1. The most important factor that influences the serum amylase level on admission in patients with blunt injury to the pancreas is the time elapsed from injury to admission.
2. A normal serum amylase level determined on admission within 3 hours after blunt abdominal trauma does not directly allow elimination of the possibility of injury to the pancreas.
3. Serial determinations of the serum amylase level more than 3 hours after trauma might be helpful in avoiding failure to detect injury to the pancreas.

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