Pancreatology 22 (2022) 348–355

Contents lists available at ScienceDirect

Pancreatology

journal homepage: www.elsevier.com/locate/pan

The course of acute pancreatitis in patients with different BMI groups

Ali Tüzün İnce [a, *], Gülseren Seven [a], Koray Koçhan [a], Sercan Kiremitçi [a], Kemal Yıldız [b], Hakan Şentürk [a]

[a] Gastroenterology Clinic, Adnan Menderes Bulvarı, Vatan Cad, 34093, Fatih, İstanbul, Turkey
[b] Internal Medicine Clinic, Medicana International Hospital, Beylikdüzü Cd. No:3, 34520, Beylikdüzü, İstanbul, Turkey

ARTICLE INFO

Article history:
Received 11 September 2021
Received in revised form
6 January 2022
Accepted 8 March 2022
Available online 17 March 2022

Keywords:
Acute pancreatitis
Obesity
Body mass index
Balthazar CTSI
Revised Atlanta classification

ABSTRACT

Objectives: To evaluate the risk factors, Atlanta severity score, Balthazar-CTSI score, and disease course in patients of varying weight with acute pancreatitis (AP).
Methods: A retrospective evaluation was made of normal weight (NW), overweight (OW), and obese (OB) patients (n:1134) with respect to demographic findings, diabetes (DM)/hypertension, smoking/alcohol use, etiologies, laboratory findings, Balthazar/Atlanta severity scores, and disease outcomes. After consistency and associations among the BMI, Balthazar, and Atlanta groups were evaluated, combined effects of risk factors on mortality, hospital and ICU stays were re-examined statistically.
Results: In the OB group, mean age ($p < 0.001$), female gender ($p < 0.001$), increased BUN($p < 0.027$) and Hct ($p = 0.039$), DM($p < 0.024$), and mortality ($p < 0.011$) were statistically significant. In the non-NW groups, the rates of complications (40.6%/38.6%), mortality (3.7%/4.9%), interventional procedures (36%/39%), and length of hospital stay (11.6%/9.8%) were increased. Obesity constituted 23.7% of severe AP(SAP) and 50% of mortality. There was no significant relationship between Atlanta and Balthazar groups and BMI, nor between Balthazar and moderate AP (MSAP) to SAP. Old age ($p = 0.000$), male sex ($p = 0.05$), obesity ($p = 0.046$), alcohol ($p = 0.014$), low Hct ($p = 0.044$), high CRP ($p = 0.024$), MSAP/SAP ($p = 0.02$/($p < 0.001$), and any complications ($p < 0.001$) increased the mortality risk. Female gender ($p = 0.024$), smoking ($p = 0.021$), hypertriglyceridemia ($p = 0.047$), idiopathic etiology ($p = 0.023$), and MSAP/SAP ($p < 0.001$) associations increased ICU admission. Co-occurrences of higher Balthazar score ($p < 0.001$), MSAP/SAP ($p < 0.001$), all kinds of complications ($p < 0.001$), and recurrence ($p = 0.040$) increased the hospital stay (≥11 days).
Conclusions: Although complications, mortality, longer hospitalization, and interventional procedures were observed more in the overweight and obese, successful prediction of Atlanta severity and Balthazar-CTSI scores based on BMI does not appear to be accurate. OB carries an increased risk for morbidity and mortality. The combined effects of risk factors increased mortality, longer hospital stays, and ICU admission.

1. Introduction

Acute pancreatitis (AP) is a potentially life-threatening acute inflammation of the pancreas. Its course is usually mild (80–85%) and recovery occurs within a week. Permanent organ failure (OF) develops in severe AP (SAP) requiring intensive care unit (ICU) treatment. Depending on the presence of or necrosis, while mortality is a very rare event in mild cases (usually less than 1%), it may reach up to 35% in SAP [1,2].

Currently, approximately 40% of adults are overweight (OW) [3]. Obesity, which used to be a sign of wealth, has now become an important health problem. Obesity is a component of metabolic syndrome (cardiovascular disease, diabetes mellitus (DM), dyslipidemia). Body mass index (BMI) is calculated by dividing the weight (in kg) of an individual by the square of height (in meters). A BMI value of <25 kg/m^2 is considered normal weight (NW), 25–30 kg/m^2 is overweight (OW), and >30 kg/m^2 is considered obese (OB). Increases in proinflammatory cytokines released from abdominal adipose tissue, in gallstone frequency, and in serum lipids in OB trigger AP. In Asian populations, AP can also be observed in individuals with lower weight [4]. In addition, lipolysis of peripancreatic/visceral triglycerides by lipase and increased

* Corresponding author.
E-mail address: dralince@gmail.com (A.T. İnce).

https://doi.org/10.1016/j.pan.2022.03.009
1424-3903/

release of unsaturated fatty acids causes pancreatic necrosis [5], SAP [6,7], and systemic complications [8,9]. Recent publications stated there was a relationship between OB and AP [10,11]. Obesity was shown to be associated with SAP, an increased risk of complications, and in-hospital mortality [12]. The coexistence of AP and DM increases mortality, local complications, ICU admission, and longer hospital stay [13,14]. Hypertension and smoking also increase AP risk [15,16]. Combined alcohol use and smoking is a strong and dose-dependent risk factor. Alcohol increases the risk by altering the immune response [17]. A large cohort study reported the hazard ratios for heavy drinkers versus non-drinkers, and regular smokers versus non-smokers as 1.52 (1.11–2.09; $p = 0.04$) and 1.45 (1.28–1.64; $p = 0.02$), respectively [18].

The aim of this retrospective study was to investigate the course and outcomes of AP when patients were grouped as NW, OW, and OB according to BMI, and results were interpreted after statistical evaluation.

2. Methods

This retrospective study included 1334 patients, comprising 614 males and 720 females, aged ≥18 years, who were diagnosed with AP according to Revised Atlanta Classification (RAC) criteria. The study was initiated after Bezmialem Vakif University Ethical Board approval (03.09.2020,54022451–050.05.04-) and was listed on Clinical.trials.gov (NCT04901949). Patient data were obtained from the hospital records from the 2010–2020 period. According to RAC criteria, the presence of 2 of 3 findings was considered sufficient for diagnosis (characteristic pain, amylase/lipase values ≥3xULN, radiological imaging compatible with AP) [19]. Patients who refused treatment, had serious psychiatric problems, chronic pancreatitis, a history of pancreatic surgery, or had contraindications for contrast material were excluded from the study. A record was made for each patient of age, gender, cigarette/alcohol habits, presence of DM/hypertension, etiologies, and BMI. The patients were separated into 3 groups according to BMI as NW, OW, and OB. During the hospitalization period, laboratory tests were measured continuously every day, but the tests performed at the 48th hour and Balthazar-CTSI were used in the study. Balthazar-CTSI scores vary between 0 and 10 [0(A):normal, 1(B):increased pancreatic size, 2(C):inflammatory changes in pancreas/peripancreatic fatty tissue, 3(D):irregularly bordered, single fluid collection, 4(E):irregularly circumscribed, ≥2 fluid collection + various degrees of necrosis levels [20]. In the data analysis, scores were grouped as mild (0–3), moderate [4–6], and severe [7–10]. The Balthazar scores and score groups were compared. The laboratory tests included WBC (N:4.5-11 × 100/microliter), Hct (N:35.5–48%), CRP (N:0–5 mg/dl), BUN (N:9.8–20.1 mg/dL), and serum creatinine (N:0.57–1.11 mg/dl).

The severity of AP was classified as mild (no local complications or OF), moderate (local complications ± transient OF <48 h), and severe (permanent OF). These groups were also compared. A record was made of complications [none, local (pseudocyst/abscess/necrosis), systemic (OF), mixed (OF + serious co-morbidity) and infectious (other organ system infections and sepsis)], survival (alive/dead), hospitalization days, interventional procedures [endoscopic retrograde pancreato-cholangiography (ERCP) & endosonography (EUS)], ICU admission, and the number of recurrent attacks.

2.1. Statistical analysis

All subjects who met the inclusion criteria were included in the study. Due to the large number of subjects, there was no need for a separate power analysis. Data obtained in the study were analyzed statistically using SPSS version 23.0 software. Descriptive statistics for the obtained data were calculated as mean ± standard deviation (SD), minimum, maximum values, percentiles (25th, median, and 75th), and frequencies (number/percentage) depending on the type of variables. Consistency and relationships between the BMI groups, Balthazar, and Atlanta severity were analyzed using Kappa statistics and Kendall Tau-b statistics. The conformity of numerical variables to normal distribution was examined using the Shapiro-Wilk test. The One-Way ANOVA model of univariate analysis was used to compare BMI groups and the severity of AP in terms of numerical features, and significant differences were determined with the posthoc Tukey test. Relationships between categorical features and BMI and severity of AP were analyzed using the Pearson Chi-Square test. The combined effects of the measured features on mortality, ICU admission, and hospitalization for ≥11 days were re-examined with multivariate logistic regression analysis, in which factors with insignificant effects were removed from the model with the backward variable selection method. The level of statistical significance was accepted as $p \leq 0.05$.

3. Results

Descriptive values for numerical and categorical characteristics of patients are given in Table 1. Comparisons of BMI, RAC, and Balthazar-CTSI groups are shown in Table 2, and the patient characteristics of the BMI and RAC groups are given in Tables 3 and 4. Factors affecting survival, longer hospital stay, and ICU admission are given in Table 5.

3.1. Gender distributions

Of the 720 females, 46.2% were OB, 33% OW, and 20.8% were NW, 35.8% had complications, 9.6% died, 45.8% had an interventional procedure, 9.3% were hospitalized >11 days, 5.1% required ICU, and 24.3% had recurrent attacks. Of the 614 males (46.02%), 32.6% were OB, 42.6% OW, 24.8% were NW, 16.6% had complications, 6.5% died, 14.7% had interventional procedure, 3.4% were hospitalized for >11 days, 1.9% were admitted to ICU, and 6.7% had recurrent attacks.

3.2. BMI and RAC groups

The NW group comprised 302 (22.6%) patients, the OW group included 500 (37.5%), and the OB group, included 532 (39.9%) cases. Females constituted the majority of the OB group ($p < 0.001$). OW and OB patients were more likely to have DM ($p < 0.024$). The mortality rate ($p < 0.011$) and mean BUN level ($p < 0.027$) were significantly higher in the OB group than in the NW group. In the OB group, the rates of MAP, MSAP, and SAP were 58.5%, 17.8%, and 23.7%, respectively. The mean age varied significantly between the BMI groups, with the highest age in OB and the lowest in NW ($p < 0.001$). The mean Hct value was higher in the OW group than in the NW group ($p < 0.039$).

The MAP group included 762 (57.1%) patients, with MSAP including 272 (20.4%), and SAP including 300 (22.5%) cases. There were more interventional procedures ($p < 0.001$) and recurrent attacks ($p = 0.050$) in the MSAP group. Longer stays (>11 day) and ICU admission were more frequent in the MSAP and SAP groups than in the MAP group ($p < 0.001$). Mean age, CRP, BUN, and creatinine values were significantly higher in the SAP group compared to the MSAP and MAP groups ($p < 0.001$). The mean WBC value was higher in SAP compared to MAP ($p < 0.001$), and the mean Hct value was lower in the SAP group ($p = 0.05$). Smoking/alcohol habits, hypertension, etiologies, complications, interventions, in-hospital days, ICU admission, recurrent attacks, and WBC, CRP, and creatinine values showed no statistically significant difference between the BMI groups. In the RAC groups, gender,

Table 1
Descriptive values of the patients.

	Mean	SD	Minimum	Maximum	Percentiles		
					25	Median	75
Age (years)	54.96	17.48	18.00	101.00	42.00	55.00	68.00
Height(cm)	165.57	9.18	103.00	192.00	160.00	165.00	171.00
Weight(kg)	79.98	16.00	27.70	193.00	70.00	80.00	90.00
BMI(kg/m2)	29.15	5,68	14.70	90.09	25.40	28.80	32.00
WBC(μL)	11.60	5.11	1.95	49.90	7.84	10.73	14,11
Hct(%)	38.92	6.70	18.9	68.20	35.30	39.40	43.06
CRP(mg/dl)	11.26	29.31	0.01	338.10	.56	2.11	9.39
BUN(mg/dl)	15.81	9.85	0.74	111.30	9.98	13.55	18.22
Creatinine(mg/dl)	0.96	0.92	0	21.70	0.69	0.80	0.96

		n(%)
Gender	Male	614 (46%)
	Female	720 (54.%)
BMI(kg/m^2)	<25 (normal-weight)	302 (22.6%)
	25-30 (overweight)	500 (37.5%)
	>30 (obese)	532 (39.9%)
Cigarette Smoking	No	1066 (79.9%)
	Yes	268 (20.1%)
Alcohol Use	No	1080 (81%)
	Yes	254 (19.0%)
Diabetes Mellitus	Absent	917 (68.7%)
	Present	417 (31.3%)
Hypertension	Absent	913 (68.4%)
	Present	421 (31.6%)
Etiology	Biliary	723 (54.2%)
	Alcohol	64 (4.8%)
	Hypertriglyceridemia	109 (8.2%)
	Hypercalcemia	21 (1.6%)
	Drug	44 (3.3%)
	Congenital	32 (2.4%)
	Idiopathic	223 (16.7%)
	Post-ERCP	7 (0.5%)
	Oddi sphincter dysfunction	12 (0.9%)
	Malignancy	18 (1.3%)
	Intrapapillary mucinous neoplasia	1 (0.1%)
	Primary Sclerosing Cholangitis	15 (1.1%)
	Autoimmunity	5 (0.4%)
	Multiple etiology	60 (4.5%)
Balthazar-CTSI Scoring	0(A)	23 (1.7%)
	1(B)	226 (16.9%)
	2(C)	399 (29.9%)
	3(D)	278 (20.8%)
	4(E)	239 (17.9%)
	5	50 (3.7%)
	6	37 (2.8%)
	7	38 (2.8%)
	8	30 (2.2%)
	9	13 (1%)
	10	1 (0.1%)
Balthazar-CTSI Groups	Mild (0–3)	926 (69.4%)
	Moderate (4–6)	326 (24.4%)
	Severe (7–10)	82 (6.2%)
Atlanta Severity Groups	Mild	762 (57.1%)
	Moderate	272 (20.4%)
	Severe	300 (22.5%)
Complications	None	762 (57.1%)
	Local	289 (21.7%)
	Systemic	140 (10.5%)
	Mixed	105 (7.9%)
	Infectious	38 (2.8%)
Survival	Alive	1202 (90.1%)
	Died	132 (9.9%)
Invasive Procedures	No	720 (54%)
	Yes	614 (46.0%)
Length of Hospital Stay(days)	≤10	1192 (89.4%)
	≥11	142 (10.6%)
ICU Admission	No	1273 (95.4%)
	Yes	61 (4.6%)
Number of Attacks	One attack	993 (74.4%)
	Multiple attacks	341 (25.6%)

Table 2
Comparisons of BMI, revised Atlanta classification and Balthazar-CTSI[a] groups.

		ATLANTA SEVERITY GROUPS			Total
		Mild	Moderate	Severe	
		n (%)			N
BMI(kg/m²)	<25 (normal weight)	183 (60.6%)	64 (21.2%)	55 (18.2%)	302
	25-30 (overweight)	268 (53.6%)	113 (22.6%)	119 (23.8%)	500
	>30 (obese)	311 (58.5%)	95 (17.8%)	126 (23.7%)	532
Total		762 (57.1%)	272 (20.4%)	300 (22.5%)	1334
Balthazar-CTSI Groups	Mild (0–3)	673 (72.7%)	69 (7.5%)	184 (19.9%)	926
	Moderate (4–6)	89 (27.3%)	154 (47.2%)	83 (25.5%)	326
	Severe (7–10)	0 (0%)	49 (59.8%)	33 (40.2%)	82
Total		762 (57.1%)	272 (20.4%)	300 (22.5%)	1334
		BALTHAZAR-CTSI GROUPS			
		Mild (0–3)	**Moderate** [4–6]	**Severe** [7–10]	**Total**
		n (%)			N
BMI(kg/m²)	<25 (normal weight)	209 (69.2%)	74 (24.5%)	19 (6.3%)	302
	25-30 (overweight)	337 (67.4%)	138 (27.6%)	25 (5%)	500
	>30 (obese)	380 (71.4%)	114 (21.4%)	38 (7.1%)	532
Total		926 (69.4%)	326 (244%)	82 (6.2%)	1334

[a] Kappa statistics.

Table 3
Patient characteristics of BMI groups*.

		(Normal)	(Overweight)	(Obese)	
		n (%)			P**
Gender	Male	152 (50.3%)[a]	262 (52.4%)[a]	200 (37.6%)[b]	< **0.001**
	Female	150 (49.7%)[a]	238 (47.6%)[a]	332 (62.4%)[b]	
Diabetes Mellitus	Absent	226 (74.8%)[a]	341 (68.2%)[b]	350 (65.8%)[b]	**0.024**
	Present	76 (25.2%)[a]	159 (31.8%)[b]	182 (34.2%)[b]	
Survival	Alive	284 (94%)[a]	452 (90.4%)[ab]	466 (87.6%)[b]	**0.011**
	Dead	18 (6%)[a]	48 (9.6%)[ab]	66 (12.4%)[b]	

*Completely different letters next to the percentage values in the columns indicate significantly different BMI groups. **: Pearson Chi-Square test

BMI		N	Mean¥	SD	**95% CI for Mean**		Minimum	Maximum	P€
					Lower	Upper			
Age	<25	302	51.62[a]	19.36	49.43	5381	17.00	101.00	< **0.001**
	25-30	500	54.59[b]	17.84	53.02	56.15	14.00	100.00	
	>30	532	57.22[c]	15.61	55.89	58.55	19.00	94.00	
Hct	<25	302	38.13[a]	6.00	37.45	38.81	13.80	52.10	**0.039**
	25-30	500	39.38[b]	6.38	38.82	39.94	.30	57.10	
	>30	532	38.94[ab]	7,32	38.31	39.56	.01	68.20	
BUN	<25	302	14.77[a]	9.04	13.74	15.79	.74	64.95	**0.027**
	25-30	500	15.57[ab]	9.71	14.72	16.43	2.80	101.00	
	>30	532	16.61[b]	10.36	15.73	17.50	4.21	111.30	

¥: The letters (a,b,c) next to mean values show the difference of BMI groups. Significant groups bear completely different letters. €:One-Way ANOVA and post-hoc Tukey test.

cigarette/alcohol habits, DM, and etiologies did not have statistically significant differences (Tables 3 and 4).

3.3. Balthazar-CTSI groups

The mild group comprised 926 (69.4%) patients, the moderate group 326 (24.4%), and the severe group 82 (6.2%). The most frequent grades were B, C, and D, and the necrosis rate was 7.9% (n:106). With respect to the compatibility of Atlanta severity and Balthazar scores, the Balthazar-CTSI score was mild for 72.7% of the MAP patients, moderate for 47.2% of MSAP patients, and severe for 40.2% of SAP patients (Table 1).

3.4. Agreement and consistencies between BMI, Atlanta severity and Balthazar-CTSI groups

No agreement was detected between BMI and Atlanta (Kappa = 0.03; P = 0.071), no significance was present in the MSAP/SAP groups, and no agreement was found between the Balthazar-CTSI and BMI groups (Kappa = 0.021; p = 0.127). A significant and moderate agreement was found between the Balthazar score and Atlanta score (Kappa = 0.342; p < 0.001). The Atlanta score was MAP for 72.7% of those with mild Balthazar score, MSAP for 47.2% of those with a moderate Balthazar score, and SAP for 40.2% of those with a severe Balthazar score. The success of the Balthazar score was determined to be 88.3% in predicting MAP, and 56.6% in predicting MSAP (Table 2).

Consistencies between BMI with Balthazar and Atlanta scores and between BMI and Balthazar were examined with Kendall Tau-b statistics. There was no significant relationship between BMI and Balthazar scores/score groups, or with Atlanta groups. A moderate correlation was seen between Balthazar scores (r = 0.365, p < 0.001) and score groups and Atlanta (r = 0.374, p < 0.001).

Table 4
Patient characteristics of the Atlanta severity groups[a].

		Mild	Moderate	Severe	
		n(%)			P[b]
Gender	Male	316 (41.5%)[a]	132 (48.5%)[b]	166 (55.3%)[b]	< **0.001**
	Female	446 (58.5%)[a]	140 (51.5%)[b]	134 (44.7%)[b]	
Complications	None	762 (100%)[a]	0 (0%)[b]	0 (0%)[b]	< **0.001**
	Local	0 (0%)[a]	269 (98.9%)[c]	20 (6.7%)[b]	
	Systemic	0 (0%)[a]	0 (0%)[a]	140 (46.7%)[b]	
	Mixed	0 (0%)[a]	0 (0%)[a]	105 (35%)[b]	
	Infectious	0 (0%)[a]	3 (1.1%)[b]	35 (11.7%)[c]	
Survival	Alive	762 (100%)[a]	255 (93.8%)[b]	185 (61.7%)[c]	< **0.001**
	Dead	0 (0%)[a]	17 (6.3%)[b]	115 (38,3%)[c]	
Interventional Procedures	No	453 (59.4%)[a]	102 (37.5%)[b]	165 (55%)[a]	< **0.001**
	Yes	309 (40.6%)[a]	170 (62.5%)[b]	135 (45%)[a]	
Length of Hospital Stay(day)	≤10	734 (96.3%)[a]	213 (78.3%)[b]	245 (81.7%)[b]	< **0.001**
	≥11	28 (3.7%)[a]	59 (21.7%)[b]	55 (18.3%)[b]	
Need for ICU	No	748 (98.2%)[a]	246 (90.4%)[b]	279 (93%)[b]	< **0.001**
	Yes	14 (1.8%)[a]	26 (9.6%)[b]	21 (7%)[b]	
Number of Attacks	One attack	579 (76%)[a]	187 (68.8%)[b]	227 (75.7%)[a]	**0.050**
	Multiple attacks	183 (24%)[a]	85 (31.3%)[b]	73 (24.3%)[a]	

[a]: Completely different letters next to the percentage values in the columns indicate the Atlanta severity groups differ significantly.[b]: Pearson Chi-Square test

		N	Mean[a]	SD	**95% CI for Mean** Lower	Upper	Minimum	Maximum	P[b]
Age	**Mild**	762	52.25[a]	17.00	51.04	53.46	17.00	96.0	< **0.001**
	Moderate	272	53.70[a]	16.62	51.71	55.68	14.00	94.0	
	Severe	300	63.01[b]	17.06	61.07	64.95	20.00	101.0	
WBC	**Mild**	762	10.88[a]	4.42	10.57	11.19	3.00	43.36	< **0.001**
	Moderate	272	12.09[bc]	5.13	11.47	12.70	1.95	28.36	
	Severe	300	12.98[c]	6.27	12.27	13.69	3.52	49.9	
Hct	**Mild**	762	39.22[a]	6.17	38.78	39.66	0.01	68.2	**0.050**
	Moderate	272	38.94[ab]	7.19	38.09	39.80	0,30	55.3	
	Severe	300	38.13[b]	7.47	37.28	38.98	0,40	54.86	
CRP	**Mild**	762	8.29[a]	23.44	6.62	9.96	0.01	332.42	< **0.001**
	Moderate	272	9.84[a]	18.29	7.66	12.03	0.01	118.26	
	Severe	300	20.08[b]	45.02	14.97	25.20	0.01	338.1	
BUN	**Mild**	762	14.05[a]	6.67	13.57	14.52	2.80	64.02	< **0.001**
	Moderate	272	14.27[a]	7.01	13.43	15.10	2.80	64.49	
	Severe	300	21.67[b]	15.18	19.95	23.40	0.74	111.3	
Creatinine	**Mild**	762	0.82[a]	0,22	0.80	0.83	0.20	1.88	< **0.001**
	Moderate	272	0.80[a]	0.23	0.77	0.83	0.20	1.82	
	Severe	300	1.46[b]	1.80	1.25	1.66	0	21.7	

[a] The letters (a,b,c) next to the average values show the difference of the Atlanta severity groups. It has different contents compared to each other.
[b] One-Way ANOVA and post-hoc Tukey test.

3.5. Outcomes

The overall complication rate was 42.9% (n:572) [local (21.7%)/systemic (10.5%)/mixed (7.9%)/infectious (2.8%)]. In the NW, OW, and OB groups, the rates were 20.8%, 40.6%, and 38.6%, respectively. The rates of local, systemic, mixed, and infectious complications were 19.1%, 9.8%, 9.8%, and 2.8% in OB, 23.8%, 12.6%, 7.2%, and 2.8% in OW, and 22.5%, 8.3%, 5.6%, and 2.9% in NW groups, respectively. No complications were seen in MAP ($p < 0.001$) and were mostly found in MSAP followed by SAP. Systemic and mixed complications were more frequent in SAP. Infectious complications and mortality were more frequent in SAP than MSAP and no mortality was observed in MAP. The mortality rates for NW, OW, and OB patients were 1.3%, 3.7%, and 4.9% respectively. The overall mortality rate was 9.9% (n:132), of which half were OB, and 87% were SAP group patients (Tables 4 and 5).

Interventional procedure rates were 25%, 36%, and 39% in NW, OW, and OB groups, respectively, and 31%, 28%, and 22% in the MAP, MSAP, and SAP groups, respectively. Longer hospital stays (≥11 days) were seen at the rate of 10.6% overall, with 22.6% in NW, 40.8% in OW, and 36.6% in OB, and 19.7%, 41.5%, and 38.7% in the MAP, MSAP, and SAP groups, respectively. ICU admission rates were 31%, 21%, and 48% for NW, OW, and OB groups, and 23%, 42.6%, and 34.4% for MAP, MSAP, and SAP groups, respectively. The majority of patients had a single AP attack (n:993), and recurrent attacks were less frequent (n:341). The rates of recurrent attacks were 24% in NW, 40.2% in OW, and 35.8% in OB, and 53.7%, 24.9%, and 21.4% in the MAP, MSAP, and SAP groups, respectively.

3.6. Combined effects of the risk factors

The combined effects of risk factors were also evaluated. Mortality risk was significantly associated with male sex ($p = 0.05$), obesity ($p = 0.046$), alcohol ($p = 0.014$), MSAP ($p = 0.02$), SAP

Table 5
Factors affecting the mortality, ICU and length of hospital stay.

MORTALITY			
	OR	95% CI.	
		(Lower-Upper)	P[a]
Gender(male/female)	1.830	(.956–3.502)	**0.050**
Age	1.048	(1.027–1.069)	**0.000**
BMI(kg/m^2) (25–30/ < 25) (Group 2/1)	2.131	(.835–5.436)	0.113
BMI(kg/m^2) (> 30/ < 25) (Group 3/1)	2.594	(1.017–6.615)	**0.046**
Alcohol(yes/no)	2.403	(1.194–4837)	**0.014**
Hct(%)	.960	(.922-.999)	**0.044**
CRP(mg/dl)	.981	(.964-.997)	**0.024**
Atlanta Severity Groups			
Moderate/Mild	45.415	(4.031–511.647)	**0.002**
Severe/Mild	314.659	(35.509–2788.345)	< **0.001**
Complications			
Local/None	68.921	(9.278–511.945)	< **0.001**
Systemic/None	52.282	6.569–416.108)	< **0.001**
Mixed/None	5385.538	(696.487–41643.321	< **0.001**
Infectious/None	171.839	(20.506–1440.000	< **0.001**
Constant	.000		< **0.001**
STAYING IN ICU			
Gender(male/female)	.515	(.284-.933)	**0.029**
Cigarette(yes/no)	2.059	(1.113–3.809)	**0.021**
Etiology			
Alcohol/Biliary	1.643	(.602–4.485)	0.333
Hypertriglyceridemia	2.208	(1.010–4.828)	**0.047**
Hypercalcemia	1.234	(.154–9.907)	0.843
Drug	2.419	(.768–7.619)	0.131
Congenital	.000	(.000––)	0.998
Idiopathic	.098	(.013-.727)	**0.023**
Post-ERCP	.000	(.000- –)	0.999
Oddi sphincter dysfunction	.000	(.000––)	0.999
Malignancy	1.280	(.155–10.562)	0.819
Intrapapillary mucinous neoplasia	.000	(.000-.)	1.000
Primary sclerosing cholangitis	1.493	(.180–12.365)	0.710
Autoimmune	.000	(.000––)	0.999
Multiple etiology	1.975	(.706–5.521)	0.195
WBC	.950	(.896–1.006)	0.079
Hct(%)	1.040	(.993–1.088)	0.094
Atlanta Severity Groups			
Moderate/Mild	6.979	(3.459–14.084)	< **0.001**
Severe/Mild	4.981	(2.417–10.265)	< **0.001**
Interventional Procedures(Yes/No)	.613	(.349–1.075)	0.088
Constant	.009		**0.000**
LENGTH OF HOSPITAL STAY			
Hypertension(present/absent)	1.224	(.829–1.808)	0.309
Balthazar	1.202	(1.084–1.334)	**0.001**
Atlanta Severity Groups			
Moderate/Mild	35.300	(6.705–185.842)	< **0.001**
Severe/Mild	11.185	(4.999–25.024)	< **0.001**
Complications			
Local/Absent	6,.82	(4.095–10.580)	< **0.001**
Systemic/Absent	4.887	(2.706–8828)	< **0.001**
Mixed/Absent	5.792	(3.103–10.808)	< **0.001**
Infectious/Absent	17.096	(8.059–36.266)	< **0.001**
Attack(yes/no)	1.514	(1.019–2.249)	**0.040**
Constant	.021		**0.000**

[a] Multivariate logistic regression analysis.

($p < 0.001$), all kinds of complications ($p < 0.001$), aging ($p = 0.000$), low Hct ($p = 0.044$), and increased CRP ($p = 0.024$). The risk of ICU admission was significantly higher in females ($p = 0.024$), with hypertriglyceridemia ($p = 0.07$), smoking ($p = 0.021$), idiopathic etiology ($p = 0.023$), and with MSAP/SAP ($p < 0.001$). The risk of longer (≥11 days) hospitalization increased as the Balthazar score increased ($p < 0.001$), with MSAP/SAP ($p < 0.001$), all kinds of complications ($p < 0.001$), and with more attacks ($p = 0.040$) (Table 5).

4. Discussion

As there was no agreement or consistency between BMI and AP severity, it can be concluded that AP severity cannot be predicted successfully by examining BMI only. While no correlation was found between OW/OB (BMI >25 kg/m^2) and SAP ($p = 0.40$) [21] in one study, no correlation was found between BMI and post-ERCP pancreatitis in another study [22]. Other studies also showed no direct correlation between BMI, mortality, and late complications

[23,24]. In contrast, the SAP risk was observed to be increased in OW subjects, and the mortality risk was increased 3-fold in OB [25]. It was stated that SAP, local complications, and mortality increased with OB, but systemic complications were absent [26]. In a previous study, OB was found to be an important risk factor for SAP, local and systemic complications at the rates of 23.7%, 16.7%, and 13.3%, respectively, and overall mortality was found to be 2.4%, demonstrating that obesity had a significant effect on SAP and mortality [6]. The SAP, local, and systemic complication rates in the OB group in the current study were 23.7%, 19.2%, and 9.8%, respectively, and these results were almost in line with those in the literature. In the current study, no significant agreement was determined between Atlanta and Balthazar scores, but significant and moderate consistency was found. The handicaps of Balthazar-CTSI are extra-pancreatic and vascular complications, OF, and contrast problems [27]. A cutoff value of >6 was found to have specificity of 98.7% and 99.2% sensitivity for predicting pancreatic/extra-pancreatic complications (AUC = 0.96/0.96). A Balthazar grade of >C was shown to have sensitivity of 98.4% for predicting pancreatic/extra-pancreatic complications (AUC = 0.95) with pancreatic necrosis the only parameter significantly associated with mortality (HR:5.83, p = 0.045) [28]. The modified-CTSI was shown to be a more successful tool than the Balthazar-CTSI [29,30]. In addition, since agreement and consistency between BMI and Balthazar score cannot be determined, the Balthazar score cannot be estimated from BMI. In one of the few studies on this subject, Balthazar scores were shown to increase as the degree of obesity increased (p < 0.050.95%CI) [31].

Biliary AP was the most common cause of AP in our study (54.2%). Although 19% of the patients in the study consumed alcohol, the rate of alcohol-related AP was 4.8%. Normally, alcoholic AP is the second most common cause of AP after biliary AP. Alcoholic AP develops in people who have had 4-5 drinks a day for more than five years [32]. In reality, alcohol consumption is less in our community than elsewhere. Some alcoholics hide their use of alcohol for social reasons, so some alcoholics may be included in the idiopathic AP etiology group. Also, in this study, the most important cause of AP was written in the etiology. For example, the etiology may have been recorded as biliary AP in a patient who presented with both alcoholic AP and gallstones. Multiple etiologies were detected in 4.5% of the patients in the study.

In the current study, complications, mortality, and longer hospitalizations were more frequent in the OW and OB groups, complications and mortality were not detected in MAP, and local complications mostly occurred in the MSAP group. Systemic, mixed and infectious complications were higher in SAP compared to MSAP. While the overall mortality rate was reported in the literature to vary between 2 and 35% [1,33,34], it decreased from 12% to 2% in the USA [35]. The mortality rate of 9.9% in the current study was caused by the presence of severe comorbidities, and mostly occurred in the OB and SAP groups, which is in parallel with the findings of the above-mentioned literature. Interventions were mostly performed in OB and then in OW and in MSAP groups. Longer stays (≥11 days) were determined in 10.6% of the patients (36.6% OB, 38.7% SAP). ICU was required by <5% of the patients, mostly in the OB and MSAP groups. This rate of ICU admission was close to the rate reported in a previous study (6.3% vs. 4.6%) [36]. The proportion of multiple/single attacks (341/993) was ~1/3. Interestingly, the recurrent attacks were mostly in the OW and MAP groups. In a previous study with a mean follow-up period of 7.8 years, the recurrent attack rate was found to be 16.5% [37]. The mean Hct value in the current study was significantly higher in the OW and SAP groups. A large-scale cohort study reported that females with AP had significantly lower rates of mortality, shock, sepsis, acute kidney injury, ICU admission, and pancreatic drainage than males (p < 0.01 for all) [38]. In the current study, higher rates were determined in females than males in the OB group with respect to complications (35.8%/16.6%), mortality (9.6%/6.5%), interventions (45.8%/14.7%), longer hospitalization (9.3%/3.4%), ICU admission (5.1%/1.9%), and multiple attacks (24.3%/6.7%) but the differences were not statistically significant, which was in line with the previous study.

Predicting the prognosis in AP has been gaining importance. Although many scoring systems are currently in use attempt to estimate the severity, none is 100% accurate yet. Each risk factor exacerbates the course of disease. Therefore, it would be better to consider the combined effects of risk factors. Mortality is increased significantly by the combined presence of risk factors such as male sex, OB, alcohol, MSAP and SAP, all kinds of complications, old age, low Hct, and high CRP. The risk of ICU admission was found to be significantly higher in females, those with hypertriglyceridemia, smokers, idiopathic etiology, and in the MSAP and SAP groups. Longer stays had a significantly higher rate with increased Balthazar scores, MSAP and SAP groups, all kinds of complications, and multiple attacks. A previous study reported that progression from MAP to MSAP or SAP was associated with a glucose level on admission of >11 mmol/L, BMI >25, and APACHE II > 5 [39].

5. Conclusion

In OB AP patients, older age, female gender, DM, increased BUN, complications, mortality, longer hospitalization, and interventions are common. Although obesity is an important risk for morbidity and mortality in AP, the Atlanta severity and Balthazar-CTSI cannot be predicted successfully by BMI alone. OB females with AP have increased morbidity and mortality rates. The combined effects of different risk factors in patients with AP increase the risk of mortality, longer hospital stays, and ICU admission. Mortality is significantly increased by the combined presence of risk factors such as male sex, OB, alcohol, MSAP, SAP, all kinds of complications, old age, low Hct, and high CRP.

Author contributions

ATI: Conception, design, data collection, data analysis, and interpretation. GS: interpretation and review of the manuscript. KK, SK, and KY: data collection and manuscript writing, HŞ: reviewed and revised the article.

Acknowledgements

The authors have no conflict of interests to declare.

References

[1] Schepers NJ, Bakker OJ, Besselink MG, Ahmed Ali U, Bollen TL, Gooszen HG, et al. Dutch Pancreatitis Study Group. Impact of characteristics of organ failure and infected necrosis on mortality in necrotising pancreatitis. Gut 2019;68:1044–51.
[2] Hegyi P, Erőss E, Izbéki F, Párniczky A, Szentesi A. Accelerating the translational medicine cAycle: the Academia Europaea pilot. Nat Med 2021;27:1317–9.
[3] https://www.who.int/news-room/fact-sheets/detail/obesity-and-overweight.
[4] Shin KY, Lee WS, Chung DW, Heo J, Jung MK, Tak WY, et al. Influence of obesity on the severity and clinical outcome of acute pancreatitis. Gut Liver 2011;5:335–9.
[5] Pawan N, Krutika P, Chandra D, Ram NT, Cristiane de O, Michael DC, et al. Peripancreatic fat necrosis worsens acute pancreatitis independent of pancreatic necrosis via unsaturated fatty acids increased in human pancreatic necrosis collections. Gut 2016;65:100–11.
[6] Katuchova J, Bober J, Harbulak P, Hudak A, Gajdzik T, Kalanin R, et al. Obesity as a risk factor for severe acute pancreatitis patients. Wien Klin Wochenschr 2014;126:223–7.
[7] Hegyi P, Szakács Z, Sahin-Tóth M. Lipotoxicity and cytokine storm in severe

acute pancreatitis and COVID-19. Gastroenterology 2020;159:824–7.
[8] Yoko Y, Hiroyuki I, Takeshi T, Rie N, Keisuke Y, Suguru M, et al. A large volume of visceral adipose tissue leads to severe acute pancreatitis. J Gastroenterol 2011;46:1213–8.
[9] de Oliveira C, Khatua B, Noel P, Kostenko S, Bag A, Balakrishnan B, et al. Pancreatic triglyceride lipase mediates lipotoxic systemic inflammation. J Clin Invest 2020;130:1931–47.
[10] Khatua B, El-Kurdi B, Singh VP. Obesity and pancreatitis. Curr Opin Gastroenterol 2017;33:374–82.
[11] Moran RA, García-Rayado G, de la Iglesia-García D, Martínez-Moneo E, Fort-Martorell E, Lauret-Braña E, et al. Influence of age, body mass index and comorbidity on major outcomes in acute pancreatitis, a prospective nation-wide multicentre study. United Eur Gastroenterol J 2018;6:1508–18.
[12] Su MC, Guang SX, Shu MW. Is obesity an indicator of complications and mortality in acute pancreatitis? An updated meta-analysis. J Dig Dis 2012;13:244–51.
[13] Nøjgaard C. Prognosis of acute and chronic pancreatitis - a 30-year follow-up of a Danish cohort. Dan Med Bull 2010;57:B4228.
[14] Shen HN, Lu CL, Li CY. Effect of diabetes on severity and hospital mortality in patients with acute pancreatitis. A national population-based study. Diabetes Care 2012;35:1061–6.
[15] Szentesi A, Párniczky A, Vincze A, Bajor J, Gódi S, Sarlós P, et al. Multiple hits in acute pancreatitis: components of metabolic syndrome synergize each other's deteriorating effects. Front Physiol 2019;10:1202.
[16] Majumder S, Gierisch JM, Bastian LA. The association of smoking and acute pancreatitis: a systematic review and meta-analysis. Pancreas 2015;44:540–6.
[17] Yadav D, Whitcomb DC. The role of alcohol and smoking in pancreatitis. Nat Rev Gastroenterol Hepatol 2010;7:131–45.
[18] Pang Y, Kartsonaki C, Turnbull I, Guo Y, Yang L, Bian Z, et al. Metabolic and lifestyle risk factors for acute pancreatitis in Chinese adults: a prospective cohort study of 0.5 million people. PLoS Med 2018;15:e1002618.
[19] Banks PA, Bollen TL, Dervenis C, Gooszen HG, Johnson CD, Sarr MG, et al. Acute Pancreatitis Classification Working Group. Classification of acute pancreatitis — 2012: revision of the Atlanta classification and definitions by international consensus. Gut 2013;62:102–11.
[20] Balthazar JE. Acute pancreatitis: assessment of severity with clinical and CT evaluation. Radiology 2002;223:603–13.
[21] Yeung YP, Lam BYK, Yip AWC. Apache system is better than Ranson system in the prediction of severity of acute pancreatitis. Hepatobiliary Pancreat Dis Int 2006;5:294–9.
[22] Zheng L, Hong W, Geng W, Stock S, Pan J. A comparison of the BISAP score and Amylase and BMI (CAB) score versus for predicting severe acute pancreatitis. Acta Gastroenterol Belg 2019;82:397–400.
[23] Lankisch PG, Schirren CA. Increased body weight as a prognostic parameter for complications in the course of acute pancreatitis. Pancreas 1990;5:626–9.
[24] Tsai CJ. Is obesity a significant prognostic factor in acute pancreatitis? Dig Dis Sci 1998;43:2251–4.
[25] Dobszai D, Mátrai P, Gyöngyi Z, Csupor D, Bajor J, Erőss B, et al. Hungarian Pancreatic Study Group. Body-mass index correlates with severity and mortality in acute pancreatitis: a meta-analysis. World J Gastroenterol 2019;25:729–43.
[26] Wang SQ, Li SJ, Feng QX, Feng XY, Xu L, Zhao QC. Overweight is an additional prognostic factor in acute pancreatitis: a meta-analysis. Pancreatology 2011;11:92–8.
[27] Balthazar EJ, Robinson DL, Megibow AJ, Ranson JH. Acute pancreatitis: value of CT in establishing prognosis. Radiology 1990;174:331–6.
[28] Taydas O, Unal E, Karaosmanoglu AD, Onur MR, Akpinar E. Accuracy of early CT findings for predicting disease course in patients with acute pancreatitis. Jpn J Radiol 2018;36:151–8.
[29] Banday IA, Gattoo I, Khan AM, Javeed J, Gupta G, Latief M. Modified computed tomography severity index for evaluation of acute pancreatitis, and its correlation with clinical outcome: a tertiary care hospital based observational study. J Clin Diagn Res 2015;9. TC01-5.
[30] Raghuwanshi S, Gupta R, Vyas MM, Sharma R. CT evaluation of acute pancreatitis and its prognostic correlation with CT severity index. J Clin Diagn Res 2016;10:TC06–11.
[31] Padureanu V, Florescu DN, Padureanu R, Radulescu D, Pomacu MM, Firu DM, et al. The role of the body mass index in the acute pancreatitis evolution. Curr Health Sci J 2021;47:1.
[32] DiMagno MJ. Oktoberfest excessive alcohol consumption and acute pancreatitis: really no association? Clin Gastroenterol Hepatol 2011;9:920–2.
[33] Popa CC, Badiu DC, Rusu OC, Grigorean VT, Neagu SI, Strugaru CR. Mortality prognostic factors in acute pancreatitis. J Med Life 2016;9:413–8.
[34] Lowham A, Lavelle J, Leese T. Mortality from acute pancreatitis. Late septic deaths can be avoided but some early deaths still occur. Int J Pancreatol 1999;25:103–6.
[35] Fagenholz PJ, Castillo CF, Harris NS, Pelletier AJ, Camargo Jr CA. Increasing United States hospital admissions for acute pancreatitis, 1988-2003. Ann Epidemiol 2007;17:491.
[36] Nesvaderani M, Eslick GD, Vagg D, Faraj S, Cox MR. Epidemiology, aetiology and outcomes of acute pancreatitis: a retrospective cohort study. Int J Surg 2015;23(Pt A):68–74.
[37] Lankisch PG, Breuer N, Bruns A, Weber-Dany B, Lowenfels AB, Maisonneuve P. Natural history of acute pancreatitis: a long-term population-based study. Am J Gastroenterol 2009;104:2797–805. quiz 2806.
[38] Sharma S, Weissman S, Aburayyan K, Acharya A, Aziz M, Systrom HK, et al. Sex differences in outcomes of acute pancreatitis: findings from a nationwide analysis. J Hepatobiliary Pancreat Sci 2021;28:280–6.
[39] Jin Z, Xu L, Wang X, Yang D. Risk factors for worsening of acute pancreatitis in patients admitted with mild acute pancreatitis. Med Sci Mon Int Med J Exp Clin Res 2017;23:1026–32.