The role of serum lactate levels in predicting abdominal surgery in geriatric patients who had computed tomography

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ABSTRACT

Objective: We investigated the importance of serum lactate levels in making decision regarding abdominal surgery in elderly patients who underwent computed tomography.

Patients and Methods: Patients over 65 years of age who presented to the emergency department of a tertiary teaching hospital in 2019 were scanned within the hospital data processing system according to the criteria of tomography of the abdomen. Patients' age, gender, lactate levels, the medical reason for their visit, pathological condition of abdominal computed tomography (aCT), a recommendation of emergent surgery, mortality status, and length of stay in the hospital were collected. The patients were divided into four groups according to surgery recommendation and pathologic status in aCT.

Results: Of the 356 patients who were included in the study, 194 (54.5%) were male. The mean age of the participants was 77.1±7.82 years, and their mean lactate level was 2.59±2.41 mmol/liter. Lactate values were statistically significant according to ROC analysis that predict the state of surgery recommendation (AUC:0.796, p<0.001). There was a statistically significant difference in lactate values between the groups (1.78±1.46, 3.19±2.71, 4.44±3.22, I-II p<0.001, I-III p<0.001, II-III p=0.002).

Conclusion: In geriatric patients, the aCT results and lactate levels were found to be reliable in deciding to eliminate abdominal surgery.

Keywords: Geriatrics, Surgery, Lactates, Computed tomography, Emergency Department

1. INTRODUCTION

Abdominal pain is a common complaint in elderly patients [1]. Due to the increase in the geriatric population, about 25% of patients visiting the emergency department are over the age of 50 [2]. Elderly patients apply to the emergency department at older ages and with more non-specific symptoms [3]. Therefore, the clinical picture of an elderly patient presenting with abdominal pain may differ from that of a young patient [4]. Elderly patients need surgical intervention more than younger patients do [5]. It is important to make the emergency surgery decisions about elderly patients visiting the emergency department promptly, as a late diagnosis leads to both an increase in mortality and morbidity, and is more of a risk of misdiagnosis in elderly patients compared to young patients [4].

Computed tomography (CT), as a diagnostic method, is one of the imaging procedures used in patients with abdominal pain.

A routine CT is more reliable in making the surgical treatment decisions of patients with acute abdominal pain [6].

Lactate level is an early marker of tissue hypoxia. Lactate levels have been reported to increase in inflammatory and ischemic conditions, such as acute appendicitis and mesenteric ischemia [7,8]. In addition to the studies indicating that the lactate level increases in patients who undergo surgery due to the acute abdomen [9], there are also studies indicating that these levels are not sufficient for surgical decisions in these patients [10]. Since, elderly patients with acute abdominal pain may visit the hospital much later than younger patients, ischemia is thought to be a likely preexisting pathology, and serum lactate level is expected to increase.

We investigated the importance of serum lactate levels in making decision regarding abdominal surgery in elderly patients who underwent abdominal computed tomography (aCT).

2. PATIENTS and METHODS

Ethics committee approval for this single-center, retrospective study was obtained from the Necmettin Erbakan University, Meram Medical Faculty, Pharmaceutical and Non-Medical Device Studies Ethical Committee (decision number of 2020/2569).

Patients over 65 years of age who applied to the tertiary teaching hospital emergency department in 2019 were scanned within the hospital data processing system according to the findings of tomography of the abdomen. This procedure was performed by listing the patients aged over 65 years for whom the service codes of aCT and aCT aortography were entered (in the emergency department). A total of 1011 patients' records were examined. Of these, 144 were excluded from the study due to indicated traumatic conditions, 375 were excluded due to lacking blood lactate level measurements, six were excluded because they arrived in the emergency department with a direct cardiopulmonary arrest, and 130 were excluded for having a lung or cardiac-based diagnosis. Eventually, 356 patients who had aCT with no non-abdominal diagnoses and for whom lactate level measurements available, were included in the statistical analysis (Figure 1).
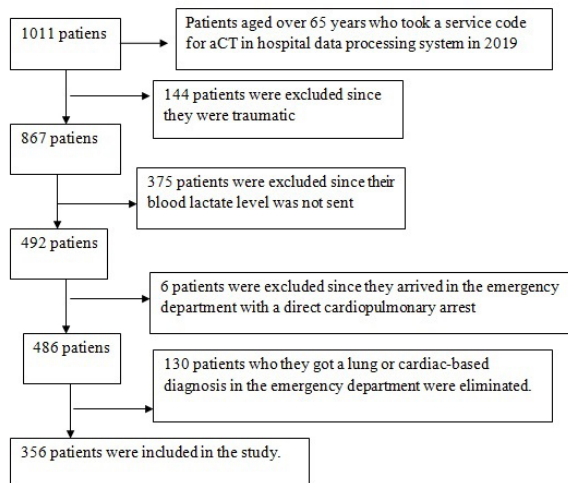

Figure 1. Study plan

The following data for 356 patients were saved: age, gender, serum lactate level, the medical reason for their visit to the emergency department, whether he/she had a pathologic diagnosis by aCT, pathological diagnosis type, abdominal surgery recommendation status, hospital mortality status, emergency outcome status (discharge, stay in the service, stay in the intensive care unit, exitus, voluntary discharge), and length of stay in the hospital.

The patients' aCTs were interpreted as "there is a pathological diagnosis" or "no pathological diagnosis" according to the official reports made by the radiology department through the hospital system. Any aCT interpretation, which may be a surgical indication, was considered pathological, regardless of the patient clinical condition. This interpretation was made by an independent physician who was not included in the study and blinded to the lactate levels and the status of surgery recommendations. The recommendation for abdominal surgery for patients was acquired by monitoring the clinical course of the patients.

The patients were grouped based on the status of obtaining a pathological diagnosis in aCT and undergoing an emergent surgery.

Group 1: No pathological diagnosis in aCT; no abdominal surgery was recommended

Group 2: Pathological diagnosis in aCT; no abdominal surgery was recommended

Group 3: Pathological diagnosis in aCT; abdominal surgery was recommended

Group 4: No pathological diagnosis in aCT; abdominal surgery was recommended.

The primary outcome of this study is a comparison of the lactate levels between these four groups and lactate levels between patients who were recommended for surgery and those who were not. Our secondary aim was to compare patients' age, gender, length of stay in the hospital, and mortality by intergroup and surgery recommendation status.

Statistical Analysis

Statistical analyses of the data were made by using SPSS 20.0 (SPSS Inc., Chicago, IL) packaged software. Analyses of normality of the data were made using histograms and Kolmogorov–Smirnov test. Quantitative data were stated as mean±standard deviation, while categorical variables were stated as frequency (percentage). The differences between the groups were investigated using the Mann–Whitney U test in non-normally distributed quantitative variables, while the Student t-test was used for normally distributed quantitative variables. Categorical variables were compared between groups using chi-square test. ROC analysis was performed to predict the status of mortality and the recommendation of emergent surgery by the lactate level. $p < 0.05$ value was accepted as statistically significant.

3. RESULTS

Of the 356 patients who were included in the study, 194 (54.5%) were male, their mean age was 77.1±7.82 years, and their mean lactate level was 2.59±2.41 mmol/liter, their mean length of stay in the hospital was 7.06±9.27 days. Twenty seven pathologies were detected on CT in 144 (40.4%) of 356 patients. Twelve patients had two pathologies, while the others had only one pathology. The three most common pathologies were ileus (48 (33.3%)), acute cholecystitis (14 (9.7%)), and perforation (13 (9%)) (Table I). The patients presented to the emergency

department with a total of 46 different complaints. Of the patients, 156 (43.8%) had one complaint, 133 (37.4%) had two complaints, 58 (16.3%) had three complaints, 8 (2.2%) had four complaints, and 1 (0.3%) had five complaints. The three most common complaints by patients were abdominal pain (193 (54.2%)), nausea (74 (20.8%)), and vomiting (72 (20.2%)). Table II shows the characteristics of the participants.

Table I. *Emergency pathology status in aCT*

Patalogy in aCT	144	100
Ileus	48	33.3%
Acute cholecystitis	14	9.7%
Perforation	13	9%
Herniation	12	8.3%
Mesenteric ischemia	11	7.6%
Cholangitis	8	5.6%
Abscess	7	4.9%
Acute appendicitis	7	4.9%
Pancreatitis	5	3.5%
Diverticulitis	4	2.8%
Abdominal aortic aneurysm	3	2.1%
Aortic dissection	3	2.1%
Anastomosis leakage	2	1.4%
Hematoma	2	1.4%
Necrotizing pancreatitis	2	1.4%
Intra-abdominal bleeding	2	1.4%
Necrotizing fasciitis	2	1.4%
Sigmoid volvulus	2	1.4%
Peritoneal carcinomatosis	1	0.7%
Renal artery thrombosis-renal infarction	1	0.7%
Superior mesenteric vein thrombosis	1	0.7%
Severe stenosis in the abdominal aorta	1	0.7%
Spleen infarction	1	0.7%
Abdominal aortic thrombus	1	0.7%
Rupture of the abdominal aortic aneurysm	1	0.7%
Rectovaginal fistula	1	0.7%

Table II. *The characteristics of patients*

Number of patients		356	100%
Gender	Male	194	54.5%
	Female	162	45.5%
Age		77.1±7.82	
Lactate levels (mEq/L)		2.59±2.41	
Length of stay in hospital (day)		7.06±9.27	
Emergency Outcome Status	Discharge	84	23.6%
	Stay in Service	156	43.8%
	Stay in Intensive Care Unit	96	27%
	Ex	3	0.8%
	Voluntary Discharge	17	4.8%
3 most common complaints	Abdominal pain	193	54.2%
	Nausea	74	20.8%
	Vomiting	72	20.2%

In-Hospital Mortality	Survivor	301	84.6%
	Non-survivor	54	15.4%
Surgery Recommendation	Recommended	65	18.3%
	Not – recommended	291	81.7%
Group 1[*]		208	58.4%
Group 2[**]		83	23.3%
Group 3[***]		61	17.1%
Group 4[****]		4	1.1%

[*]: No pathologic diagnosis in aCT, no abdominal surgery was recommended
[**]: Pathologic diagnosis in aCT, no abdominal surgery was recommended
[***]: Pathologic diagnosis in aCT, abdominal surgery was recommended
[****]: No pathologic diagnosis in aCT, abdominal surgery was recommended

Surgery was not recommended for 291 patients (81.7%), while it was recommended for 65 (18.3%) patients. Surgery was performed in 54 of 65 patients for whom surgery was recommended while 11 could not be operated for certain reasons. Surgical operation could not be performed because one of these 11 patients was considered inoperable, 2 of them died before the surgery, 3 of them rejected the operation, and 5 of them had invasive procedure by interventional radiology. Further, no pathology was found during operation in 3 of 54 patients who underwent surgery. The lactate levels of these 3 patients were 1.4, 1.5 and 2.7 mmol/liter and they were categorized in group 3, group 4 and group 3, respectively. The lactate level of patients in the surgery recommended group was statistically significantly higher than those of the group for whom surgery was not recommended (2.18±2, 4.42±3.15, p<0.001) (Table III). Lactate values were statistically significant according to the ROC analysis performed to predict the state of surgery recommendation (AUC:0.796, p<0.001). At 2.55 mmol/liter cut-off lactate level, the rates of 75.38% sensitivity, 79.38% specificity, 45% positive predictive value, and 93.5% negative predictive value were reached (Figure 2). When patients who had no pathology in aCT and who were below 2.55 mmol/liter of lactate were categorized, rates of 98.5% sensitivity, 63.2% specificity, 37.4% positive predictive value, and 99.5% negative predictive value were reached in those who had surgery recommendation.

Table III. *Evaluation of the participants by their surgical status*

		Surgery not recommended (291)	Surgery recommended (65)[*]	p value
Gender	Male	155(53.3%)	39(60%)	p=0.324
	Female	136(46.7%)	26(40%)	
Number or mortality		33(11.3%)	22(33.8%)	**p<0.001**
Lactate levels (mEq/L)		2.18±2	4.42±3.15	**p<0.001**
Age		77.05±7.92	77.32±7.39	p=0.801
Emergent pathology in CT		83(28.5%)	61(93.8%)	**p<0.001**
Length of stay in hospital (day)		6.42±8.64	9.91±11.32	**p=0.006**

[*]Those who were considered as inop, who could not undergo a surgery because they died, who rejected surgery although it was recommended, and for whom invasive surgical intervention was performed were also included in this group.
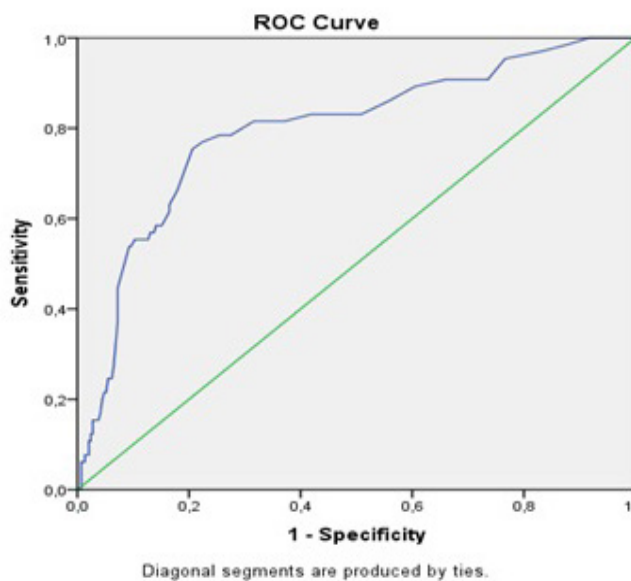
Figure 2. ROC analysis for the recommendation of surgery with lactate level

The participants were divided into four groups according to surgery recommendation and pathologic status on aCT. Four patients were found in Group 4, who had no pathology in aCT, but surgery was recommended. In the absence of pathology in CT, surgery might have been recommended based on the more dominant physical examination findings of the patients. These four patients were excluded because the between-groups comparison was not statistically possible. Statistical comparisons were made between the remaining three groups. These four patients in Group 4 were male, their mean age was 67.75±3.59 years, and their mean lactate level was 4.17±2.07 mmol/liter. There was a statistically significant difference in lactate values between the groups (Group 1: 1.78±1.46, Group 2: 3.19±2.71, Group 3: 4.44±3.22, I-II p<0.001, I-III p<0.001, II-III P=0.002). There was a statistically significant difference between

Group 1 and Group 3 in terms of the length of stay (days) in the hospital (Group 1: 5.98±8.86, Group 3: 9.89±11.68, P=0.011). There was a statistically significant difference between hospital mortality rates between groups (Group 1: 15(%7.2), Group 2: 18(%21.7), Group 3: 22(%36.1), p<0.001). Table 4 shows the comparisons between groups.

A total of 55 (15.4%) patients died at the hospital. There was a statistically significant difference between the lactate level of patients who survived and non-survived (non-survivor 5.70±4.23, survivor 2.02±1.25, p<0.001). According to the ROC analysis, lactate values were found to be statistically significant in predicting mortality status (AUC: 0.855, p<0.001). At a cut-off of 2.45 mmol/liter lactate level, the rates of 76.36% sensitivity, 75.75% specificity, 36.5% positive predictive value, and 94.65% negative predictive value were reached (Figure 3). Tables IV and V show the comparison of mortality status and other parameters.
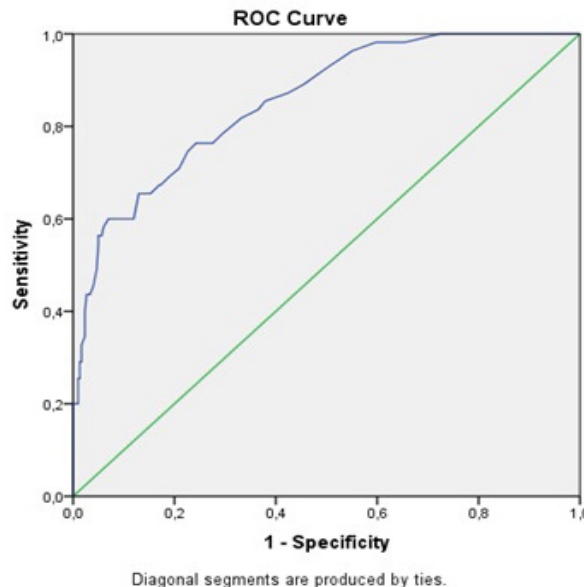

Figure 3. ROC analysis of lactate level and mortality status

Table IV. Comparison of patient groups with other parameters

		Group1 (n=208)	Group2 (n=83)	Group3 (n=61)	P value	I-II p value	I-III p value	II-III p value
Gender	Male	106(51%)	49(59%)	35(57.4%)	p=0.387			
	Female	102(49%)	34(41%)	26(42.6%)				
Lactate Levels (mEq/L)		1.78±1.46	3.19±2.71	4.44±3.22		**p<0.001**	**p<0.001**	**p=0.002**
Age		76.89±7.91	77.45±8	77.95±7.15		p=0.85	p=0.622	p=0.922
Length of Stay in Hospital (day)		5.98±8.86	7.52±8.02	9.89±11.68		p=0.406	**p=0.011**	p=0.282
Mortality status		15(7.2%)	18(21.7%)	22(36.1%)	**p<0.001**			

Table V. Comparison of mortality status and other parameters

		Non-Survivor(55)	Survivor(301)	P value
Age		78.96±7.23	76.76±7.89	P=0.055
Gender	Male	35(63.6%)	159(52.8%)	P=0.139
	Female	20(36.4%)	142(47.2%)	
Lactate Levels (mEq/L)		5.70±4.23	2.02±1.25	**p<0.001**
Length of stay in hospital (day)		9.36±9.81	6.63±9.12	P=0.059
Emergent pathology in CT		40(72.7%)	104(34.6%)	**p<0.001**

4. DISCUSSION

Geriatric patients' management in the emergency department is difficult. It is important to detect the pathology that will require abdominal surgery in geriatric patients presenting to the emergency department. In this study, we assessed the potential of making decision regarding abdominal surgery in geriatric patients with the use of aCT results along with the blood lactate level. In this study population, the mean lactate level was significantly higher in those for whom surgery was recommended than in those for whom surgery was not recommended. There was a statistically significant difference and increasing mean blood lactate levels in patients who had no pathology in aCT and for whom surgery was not recommended, who had pathology in aCT and for whom surgery was not recommended, and who had pathology in aCT and for whom surgery was recommended. This is the first time observation of grouping of this kind in the literature.

In a study conducted by Verma et al., examining patients of all age groups over 15 years with acute abdominal pain, 30 of whom underwent an emergent surgery and 20 who did not, peritoneal lactate levels between the groups were found as 14.65±1.19 and 5.92±0.97, respectively, which was a statistically significant difference [9]. The blood lactate level was also significantly higher in the surgery recommended group in this study. The reason for the high lactate levels in the surgery recommended group may be due to the ischemic and inflammatory origin of pathologies that may cause acute surgical indications. Since, geriatric patients have more comorbidity than younger patients, they have a higher risk for the operation. This may have led physicians to take a sounder step in making decisions regarding surgery for geriatric patients. This sound choice may have reduced the likelihood of diagnosing surgical pathologies at the onset of the ischemic and inflammatory conditions with no increased lactate levels.

In this study, there was a statistically significantly higher hospital mortality rate among those for whom surgery was recommended than among those for whom surgery was not recommended. Further, the hospital mortality rate was significantly different between the patients who had no pathology in aCT and for whom the surgery was not recommended, who had pathology in aCT and for whom the surgery was not recommended, and who had pathology in aCT and for whom the surgery was recommended. In their study of 195 patients who had elective major abdominal

surgery, Veličković et al., found that perioperative high lactate levels were associated with postoperative comorbidity and mortality [11]. Ravishankaran et al., determined that high lactate levels were associated with prognosis in patients with acute abdominal pain who underwent a surgery [12]. In the current study, a 33.8% mortality rate was observed in the surgery recommended group. In their study of 710 patients over 70 years of age who underwent emergent abdominal surgery, Arenal et al., found a mortality rate as 22% [13]. In another study, Rangel et al., found a mortality rate of 32.5% [14], while Brandt et al., found the 90-day mortality rate of 42.7% in 150 patients who underwent geriatric abdominal surgery [15]. Thus, the findings from our study are consistent with those of previous studies.

In this study, the lactate levels in the non-survivor group was statistically significantly higher than the survivor group. In their study of 455 patients who stayed in the intensive care unit following their application to the emergency department, Dündar et al., found that high lactate levels were associated with in-hospital mortality [16]. In a study conducted with 1278 emergency patients with signs of infection, Shapiro et al., found that serum lactate is reliable in predicting mortality [17]. Portal et al., found that a high lactate level was associated with mortality in patients over 65 years of age who visited to the emergency department, and had no infection [18]. Due to the high mortality relationship of lactate in both sepsis and geriatric patients, the high level of lactate in the non-survivor group in this study was compatible with the literature. In this study, no statistically significant difference was found in the mortality rates between the genders. In their study of 710 patients who were over 70 years of age and underwent emergent abdominal surgery, Arenal et al., did not find any statistical difference between male and female genders [13].

The mean age of the patients in this study was 77.1±7.82 years. In their study carried out with 220 patients who were over 65 years of age and underwent abdominal surgery, Joseph et al., found the mean age as 75.5±7.7 years [19]. The most common complaint in this study was abdominal pain with 54.2%. In the study carried out by Grundmann et al., that examined the epidemiologic review of patients presenting with acute abdomen, patients presenting with acute abdomen applied mostly with non-specific abdominal pain with 24-44.3% [20]. In this study, the most common pathology seen on aCT was ileus (33.3%). This finding is consistent with those of previous studies. For example, Arenal et al., evaluated 710 patients who underwent emergent abdominal surgery and found that the most common etiological reason was intestinal obstruction in the age group between 70-79 with 37% and in the age group over 80 years with 45% [13]. Bugliosi et al's report on 127 patients over 65 years of age who visited the emergency department with non-traumatic abdominal pain indicated that the most common etiological cause in those who underwent an operation was small bowel obstruction and biliary tract diseases [21].

Limitation

This study, in which we suppose that serum lactate with aCT would support the evaluation of surgery for elderly patients,

had some limitations, given its retrospective nature. The clinical decision of patients excluded due to lack of blood lactate levels were not known; thus, we could not assess how the result would have been affected should their lactate levels available and included in our analysis. The fact that the research was a retrospective study causes the surgical decision-making physician not to be blind to the lactate level. However, we excluded this limitation because only three of the patients who underwent surgery had no pathology at the time of operation (intraoperative) and their lactate levels were not high. Another limitation is that aCT imaging is non standard in terms of contrast. Considering that the physician evaluates the patient as a whole under aCT, physical examination, consultation, and laboratory examination, and eliminates the surgical pathology, we ignored this limitation. Further, the fact that the study was single-centered increased the subjectivity of the pathology and surgical decisions. Another limitation is that patients who underwent emergency surgery with ultrasonography were not evaluated.

5. CONCLUSION

We investigated whether serum lactate levels together with aCT findings would support emergent surgery decisions in elderly patients. The results of aCT and lactate levels in geriatric patients were found to be reliable physician's decisions to eliminate acute abdominal surgery. Our findings reveal that geriatric patients are less likely to be diagnosed with surgical pathologies at the beginning of the ischemic and inflammatory disorders with no increased lactate levels. Yet, there is a need for prospective multicenter studies to further validate these findings.

Compliance with Ethical Standards

Ethical approval: Ethics committee approval for this single-center, retrospective study was obtained from the Necmettin Erbakan University, Meram Medical Faculty, Pharmaceutical and Non-Medical Device Studies Ethical Committee (decision number of 2020/2569).

Funding: The study was not supported by any funds.

Conflict of Interest: The authors have no conflicts of interest to declare.

Authors' Contributions: KK: Idea/Concept, KK: Design, KK: Data Collection/Processing, KK and MKA: Analysis/Interpretation: KK and MKA, Literature Review: KK and MKA, Drafting/Writing: KK and MKA, Critical Review: KK and MKA. Both authors read and approved the final version of this article.

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