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Monitoring the Sequential Organ Failure Assessment score in nonocclusive mesenteric ischemia increases the survival rate

A single-center observational study

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Abstract

Several large-scale studies have assessed the endovascular and surgical treatments for nonocclusive mesenteric ischemia (NOMI); nonetheless, the prognostic factors for NOMI remain unclear.

In this single-center study, we retrospectively reviewed the electronic medical records of 197, 149 patients were retrieved from the inpatient database of our hospital from January 2011 to January 2020; 79 patients with NOMI were observed. A total of 44 patients who underwent laparotomy were statistically analyzed and divided into the survivor and non-survivor groups. Prognostic factors were compared between the 2 groups. Exploratory laparotomy based on a second-look surgery was the first treatment choice.

The overall mortality rate was 61.3%, with a male-to-female ratio of 1.6:1. The median Sequential Organ Failure Assessment (SOFA) score was 11.06 [5.75-17.25]. The median SOFA score was 5 [interquartile range: 3-8] in the survivor group and 14.8 [interquartile range: 10.5-19] in the non-survivor group. The log-rank test showed a significant difference in the presence of diabetes mellitus (P = .025), hypoglycemia (P = .001), SOFA score ≥10 (P < .001), hemoglobin levels ≥11 g/dL (P = .003), platelet count ≥$12.9 \times 10^4/\mu$L (P = .01), lactate levels ≥2.6 mmol/L (P = .005), and base excess <-3.0 (P < .023). Multivariate analysis using the factors with significant differences revealed that SOFA score ≥10 (hazard ratio for death, 1.199; 95% confidence interval, 1.101-1.305; P < .001) was an independent prognostic factor.

The SOFA score can be used to assess disease severity. A SOFA score of ≥10 may be associated with increased mortality.

Abbreviations: CT = computed tomography, NOMI = nonocclusive mesenteric ischemia, P-POSSUM = Portsmouth Physiological and Operative Severity Score for the enUmeration of Mortality and Morbidity, SOFA = Sequential Organ Failure Assessment.

Keywords: laparotomy, nonocclusive mesenteric ischemia, prognostic factors, Sequential Organ Failure Assessment score, survival

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1. Introduction

Nonocclusive mesenteric ischemia (NOMI) leads to ischemia and necrosis of the intestinal tract, without organic obstruction of mesenteric blood vessels.[1] NOMI reportedly accounts for 5% to 16% of acute mesenteric ischemia cases,[2,3] with mortality at discharge ranging from 31% to 90%.[4–7] NOMI often occurs after cardiovascular surgery[4] and is observed under various conditions, such as dehydration and shock.[6–8] Physical findings in NOMI often include abdominal pain; however, evaluation is occasionally difficult due to impaired consciousness among patients.[9] A previous study reported a high level of intestinal fatty acid-binding proteins as a favorable diagnostic factor.[10] High lactate levels and low platelet counts are considered poor prognostic factors, as these values only indicate the general condition of the patients. Abdominal computed tomography (CT) can be used to detect intestinal ischemia. Nevertheless, despite diagnostic advancements, CT findings are nonspecific for determining the prognosis of patients with NOMI.[11,12]

Several large-scale studies on endovascular and surgical treatments for NOMI have emerged[13,14]; however, the prognostic factors for NOMI remain unclear. Furthermore, reports regarding surgical treatment are contradictory; some

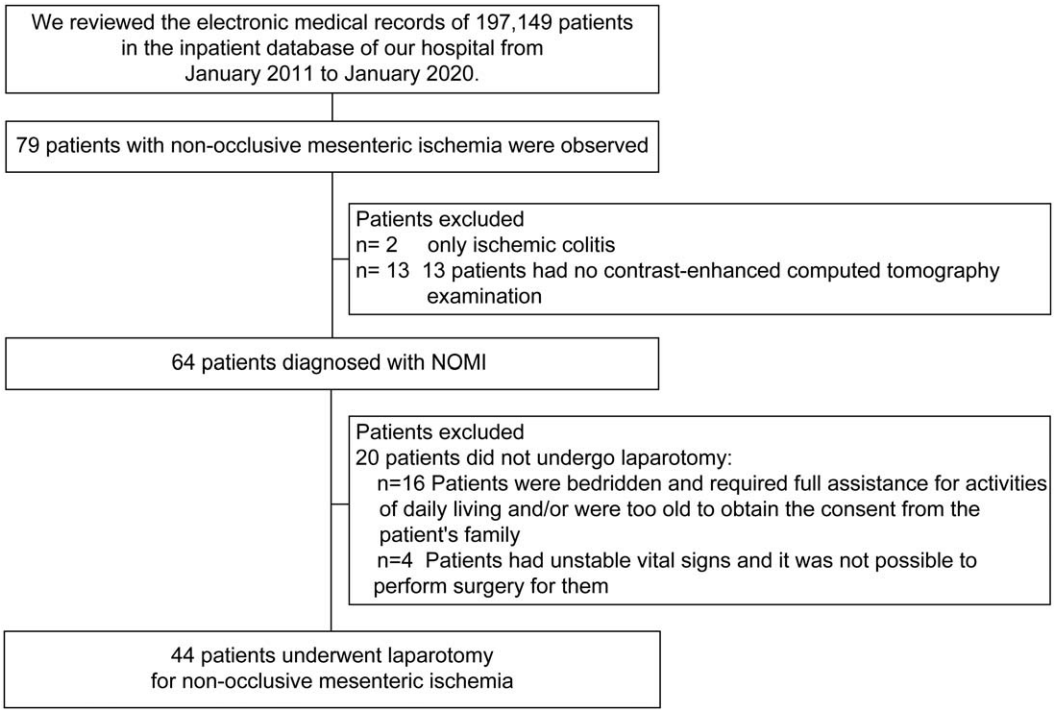

Figure 1. Summary of the patient flow. NOMI = nonocclusive mesenteric ischemia.

recommend a second-look operation,[15,16] whereas 1 study showed that surgery did not significantly improve survival.[17] Additionally, there is no severity classification for NOMI; thus, treatment cannot be accurately evaluated. Although some studies have examined prognostic factors for NOMI using the Sequential Organ Failure Assessment (SOFA) score[18] and the Portsmouth Physiological and Operative Severity Score for the enUmeration of Mortality and Morbidity (P-POSSUM),[19] these studies included a limited sample size. Currently, there are no large-scale studies on this subject.[20] Therefore, we aimed to perform a large single-center study to confirm the prognostic factors for NOMI.

2. Methods

For this single-center study, we reviewed the electronic medical records of 197, 149 patients from January 2011 to January 2020 were retrieved from the inpatient database of our hospital, and 79 patients with NOMI were observed. In general, NOMI was diagnosed based on contrast-enhanced CT findings, operative findings, autopsy findings, and the presence of pathological ischemic lesions without thrombus in the mesenteric blood vessels. Patients who were clinically suspected of having NOMI but did not undergo a contrast-enhanced CT examination or surgery were excluded. Additionally, ischemic changes in the inferior mesenteric artery region were excluded to distinguish them from ischemic colitis.[21]

Two out of 15 patients with only ischemic colitis and 13 patients who did not undergo a contrast-enhanced CT examination were excluded.

Of the 64 patients with NOMI, 20 did not undergo laparotomy. Among them, 16 patients were bedridden and required full assistance with activities of daily living and/or were too old, and the patients' families did not consent to surgery, whereas the other 4 patients had unstable vital signs; hence, it was not possible to perform surgery on them. Finally, 44 patients who underwent laparotomy were included in the statistical analysis (Fig. 1). The time point of definite diagnosis was determined as when a patient was diagnosed with NOMI by a surgeon. NOMI is often diagnosed and treated across multiple departments; therefore, delays in the diagnosis and treatment are common. Notably, early diagnosis is considered important to reduce the mortality associated with NOMI.[22] Because there was a discrepancy between the time of NOMI onset and the time of diagnosis, the onset time was determined as the time when symptoms such as abdominal pain, vomiting, and abdominal discomfort were observed. Alternatively, in patients with impaired consciousness, the onset time was determined as the time when a lactic acid level $\geq$2.0 mmol/L was observed.[9]

The treatment protocol in our hospital considers treatment of the underlying disease, removal of vasoconstrictors, antibiotic administration, treatment of heart failure and sepsis, and blood gas and hemodynamic monitoring, and exploratory laparotomy based on a second-look operation is the first treatment choice. The goals of the first surgery include the following: resection of the necrotic intestinal tract without anastomoses, shortening of the operative time, and immediate transfer of patients to the intensive care unit for systemic management. After 24 to –48 hour of observation in the intensive care unit, a planned second-look surgery was performed. Additional intestinal resection was performed if ischemia or intestinal necrosis was observed

The primary endpoint of this study was overall survival duration. This duration was defined as the time from NOMI diagnosis by a surgeon. A total of 44 patients were included in the analysis and divided into the survivor and non-survivor groups. Survival time analysis was performed with the patients' age, sex,

body mass index, comorbidities, and risk factors at the time of NOMI diagnosis by the surgeon, blood test results at the time of NOMI diagnosis by the surgeon, contrast-enhanced CT images (mural enhancement defect, pneumatosis intestinalis, hepatic portal venous gas, bowel wall thinning), symptoms, SOFA score immediately before surgery, initial diagnosing departments, time from onset to diagnosis, and time from diagnosis to laparotomy.

2.1. Ethical considerations

The protocol for the research project was approved by the suitably constituted Ethics Committee of Shonan Kamakura General Hospital (approval no. TGE01538-024), and this study was conducted in accordance with the provisions outlined in the Declaration of Helsinki (as revised in Fortaleza, Brazil, October 2013). The requirement for informed consent was waived due to the retrospective nature of this study.

2.2. Statistical analysis

Categorical data were compared using the chi-squared test, and the results are presented as numbers (%). Continuous variables were compared using the nonparametric Mann–Whitney *U* test, and the results are expressed as median and interquartile range. The Shapiro–Wilk normality test was used to check the normality of the distribution of variables. Differences in mortality between the survivor and non-survivor groups were analyzed by Kaplan–Meier survival analysis, log-rank testing, and Cox regression. Receiver operating characteristic curves were created for continuous variables and the optimal cutoffs for discriminating for mortality by maximizing the Point (sensitivity+specificity) were calculated. These thresholds were employed to compare the survival curves using the log-rank test. A Cox proportional hazards regression model was used for multivariate analyses. A P value of $<.05$ was considered statistically significant. All statistical analyses were performed using EZR version 1.54 (Saitama Medical Center, Jichi Medical University, Japan), a modified version of R commander with statistical functions frequently used in biostatistics.

3. Results

3.1. Characteristics of the study population

A total of 64 patients were diagnosed with NOMI between January 2011 and January 2020, accounting for 0.032% of the total number of hospital admissions. Of these patients, 44 underwent laparotomy and were compared with respect to survival and non-survival at discharge (Table 1). The overall mortality rate was 62.9%, and the male-to-female ratio was 1.6:1. The SOFA median score was 11.06 [5.75-17.25] (5 [3-8] in the survivor group and 14.8 [10.5-19] in the non-survivor group). In the non-survivor group, circulatory insufficiency was observed in all cases. Chronic heart disease (65.9%) was the most frequent risk factor, followed by hemodialysis (34%) and diabetes mellitus (29.5%). Among the patients, 36 (81.8%) experienced abdominal pain, whereas 8 (18.8%) had impaired consciousness. No significant differences in the time from disease onset to diagnosis and the time from diagnosis to laparotomy were identified between both groups. Preoperative contrast-enhanced CT images revealed 34 cases of mural enhancement defect and 17 cases of a paper-thin wall, which are useful for determining NOMI.

3.2. Survival analysis of NOMI using the log-rank test and multivariate analysis

The log-rank test showed a significant difference in the presence of diabetes mellitus ($P=.025$), hypoglycemia ($P=.001$), SOFA score ≥ 10 ($P<.001$), hemoglobin levels ≥ 11 g/dL ($P=.003$), platelet count $\geq 12.9 \times 10^4/\mu$L ($P=.01$), lactate levels ≥ 2.6 mmol/L ($P=.005$), and base excess <-3.0 ($P < .023$) (Table 2). Multivariate analysis using the factors with a significant difference revealed that SOFA score ≥ 10 (hazard ratio for death, 1.199; 95% confidence interval, 1.101-1.305; $P<.001$) was an independent prognostic factor (Table 3 and Fig. 2)

3.3. Comparison of the characteristics and perioperative factors between the survivor and non-survivor groups with NOMI

There were no significant differences in the laparotomy results between the survivor and non-survivor groups in terms of the time from diagnosis to surgery, time of surgery, amount of bleeding, and presence or absence of colectomy (Table 4). Second-look surgery was performed in 27 cases and was not significantly different. Ten out of 17 patients who did not undergo a second-look surgery died within 48 hour after laparotomy because their vital signs were contraindicative for surgery, that is, increased need for vasopressors, significant deterioration in respiratory conditions. Seven patients did not undergo a second-look surgery at the discretion of their doctor. One patient survived with a SOFA score ≥ 10 after 48 hour. Twelve patients died within 48 hours postoperatively. The P-POSSUM score was 77.5 [21.4-91.8], and there was a significant difference in the physiological score (38.5 [33.7-42.5]) but not in the operative severity score (17 [17-19]).

3.4. Comparison of patient characteristics according to the SOFA score

The SOFA score was ≥ 10 in 23 patients, all of whom died. Among patients with a SOFA score <10, 17 patients survived, whereas 4 patients died (Table 5). Significant differences in body mass index, history of previous cardiovascular surgery, hemodialysis, catecholamine use, platelet counts, and lactic acid levels were observed. All patients with a SOFA score ≥ 10 had respiratory failure, circulatory insufficiency, and nephropathy. Hypoglycemia was not observed in any patient with a SOFA score of <10.

4. Discussion

To the best of our knowledge, this is the largest research study to evaluate the clinical characteristics of and prognostic factors for NOMI at a single facility using surgical therapy as the first treatment choice.

Effective management of NOMI requires early treatment of the underlying disease, removal of vasoconstrictors, treatment of heart failure and sepsis,[23] and blood gas, and hemodynamic monitoring.[24] Although there are no specific treatment protocols, the American Gastroenterological Association has established guidelines for the diagnosis and treatment of acute mesenteric ischemia.[25] Selective mesenteric angiography, which is an endovascular treatment, is considered the gold standard for diagnosing acute mesenteric ischemia[26] and preventing intesti-

Table 1

Characteristics of 44 patients with nonocclusive mesenteric ischemia.

	All ($n=44$)	Survivors ($n=17$)	Non-survivors ($n=27$)	*P* value
Age (yrs)	76.5 [70.7-83]	75 [71-85]	77 [71.5-82]	.971
Sex (male)	27 (61.36)	6 (35.3)	11 (40.7)	.965
Weight (kg)	55.5 [47.45-64]	54.0 [42.7-60.0]	59.2 [50.05-65]	.162
Height (cm)	165 [154-169.2]	165 [157-170]	165 [154-169]	.981
Body mass index (kg/m^2)	21.05 [19.1-24.8]	19.8 [18.5-21.1]	22.2 [19.9-26.4]	.0149
Comorbidities and risk factors				
Diabetes mellitus	13 (29.55)	9 (52.9)	4 (14.8)	.018
Chronic heart disease	29 (65.9)	8 (47)	21 (77.7)	.052
Cerebral infarction	4 (9.09)	1 (5.9)	3 (11.1)	.961
Chronic obstructive pulmonary disease	1 (2.27)	0 (0.0)	1 (3.7)	1
Hemodialysis	15 (34.09)	2 (11.8)	13 (48.1)	.031
Hypoglycemia	13 (29.55)	0 (0)	13 (48.1)	.002
Previous cardiovascular surgery	18 (40.91)	3 (17.6)	15 (55.6)	.03
Use of catecholamines	31 (70.45)	6 (35.3)	25 (92.6)	<.001
Overall survival (d)	11 [3.75-36.25]	47 [31-64]	5.5 [1.625-11]	<.001
SOFA score	11.06 [5.75-17.25]	5 [3-8]	14.8 [10.5-19]	<.001
Respiratory failure	36 (81.8)	10 (58.8)	26 (96.3)	.003
Coagulopathy	25 (56.8)	4 (23.5)	21 (77.8)	.008
Hepatopathy	17 (38.6)	2 (11.8)	15 (55.6)	.005
Circulatory insufficiency	37 (84)	10 (58.8)	27 (100)	.001
Central nervous system failure	30 (68.1)	6 (35.3)	24 (88.9)	<.001
Nephropathy	37 (84)	12 (70.6)	25 (92.6)	.089
Time from disease onset to diagnosis (h)	4.5 [2.375-12.18]	5 [3-12]	4 [2.25-19.25]	.561
Time from diagnosis to laparotomy (h)	2 [1.437-4]	2 [1.5-4]	2 [1.375-4]	.735
Blood test results				
Albumin (g/dL)	2.3 [2.0-3.1]	2.3 [2.1-3.4]	2.3 [1.85-2.85]	.282
Creatinine (mg/dL)	2.575 [1.575-3.787]	2.09 [0.88-3.78]	2.89 [1.62-3.59]	.596
C-reactive protein (mg/dL)	12.2 [3.675-18.68]	6.00 [1.44-16.36]	13.24 [6.7-19.23]	.159
Hemoglobin (g/dL)	10.7 [9.55-11.42]	10.3 [9.9-10.8]	10.9 [9.2-11.75]	.359
Platelets ($\times 10^4/\mu L$)	12.05 [5.45-18.05]	18.5 [11.2-23.1]	8.7 [3.85-12.65]	<.001
pH	7.36 [7.273-7.425]	7.36 [7.317-7.459]	7.36 [7.243-7.414]	.317
Base excess (mmol/L)	−5.85 [−11.5 to −2.95]	–3.7 [−8.6 to −4]	–6.7 [−12.9 to −4.05]	.06
Lactic acid (mmol/L)	[2.5-9.102]	2.35 [2.03-4.79]	7.05 [4.26-10.93]	.0156
Computed tomography findings				
Mural enhancement defect	34 (77.2)	14 (82.4)	20 (83.3)	1
Paper-thin wall	25 (56.8)	10 (58.8)	15 (68.2)	.789
Pneumatosis intestinalis	25 (56.8)	13 (76.5)	12 (50.0)	.165
Hepatic portal venous gas	19 (43.1)	12 (70.6)	7 (29.2)	.021
Symptoms				
Abdominal pain	36 (81.8)	16 (94.1)	20 (74.1)	.125
Consciousness disturbance	8 (18.1)	1 (5.9)	7 (25.9)	.202
Initial diagnosing departments				
Emergency physician	14 (31.8)	9 (52.9)	5 (18.5)	.04
Cardiovascular surgeon	18 (40.9)	3 (17.6)	15 (55.6)	.026
Internist	9 (20.4)	4 (23.5)	5 (18.5)	.986
General surgeon	3 (6.8)	1 (5.9)	2 (7.4)	1

Categorical data are shown as *n* (%), and continuous data are expressed as median [interquartile range].
SOFA = Sequential Organ Failure Assessment.

nal necrosis. As compared to conservative treatment, continuous arterial infusion of papaverine hydrochloride significantly increases the survival rate.[27] Continuous arterial infusion of prostaglandin E1 is another option for these patients.[17] However, arterial infusions are invasive, and the risk of thrombosis, catheter infection, and hematoma hinders the use of standard treatment. While intravenous prostaglandin therapy is simple, easy to administer, and commonly used in studies evaluating vasodilators[13]; however, large-scale observational studies on the use of intravenous prostaglandin therapy are lacking.[28]

Patients with NOMI often exhibit marked hypotension. In our hospital, arterial papaverine injection was administered in 2 cases, and surgery was subsequently performed. In contrast, no patient underwent angiography in the study conducted by Bender et al,[29] and only 1 patient underwent angiography in the study performed by Yukaya et al.[20]

In our study, 27 out of 36 patients with hypotension died; thus, extreme caution is necessary when using vasodilators that cause hypotension. In our hospital, if patients with NOMI have decreased blood pressure, we prefer to perform laparotomy. In this study, the surgeon diagnosed the underlying disease using

Table 2

Survival analysis of nonocclusive mesenteric ischemia using the log-rank test.

Factor	Group	*n*	Survivors	Non-survivors	Median survival time [d] (95% confidence interval)	*P* value
Age (yrs)	<76	20	9 (52.9)	11 (40.7)	16.5 (4-NA)	.44
	≥76	24	8 (47.1)	16 (59.3)	15 (2-NA)	
Sex	Male	27	11 (64.7)	16 (59.3)	23 (4-NA)	.727
	Female	17	6 (35.3)	11 (40.7)	11 (2-NA)	
Height (cm)	<156	5	3 (17.6)	2 (7.4)	NA (1.25-NA)	.44
	≥156	39	14 (82.4)	25 (92.6)	15 (5.5-99)	
Weight (kg)	<52.5	23	12 (70.6)	11 (40.7)	NA (10-NA)	.09
	≥52.5	21	5 (29.4)	16 (59.3)	8 (3-36)	
Body mass index (kg/m^2)	<21.8	23	13 (76.5)	10 (37.0)	NA (8-NA)	.025
	≥21.8	21	4 (23.5)	17 (63.0)	10 (2-27)	
Comorbidities and risk factors						
Diabetes mellitus	−	31	8 (47.1)	23 (85.2)	10 (4-27)	.025
	+	13	9 (52.9)	4 (14.8)	NA (10-NA)	
Chronic heart disease	−	15	9 (52.9)	6 (22.2)	NA (2-NA)	.117
	+	29	8 (47)	21 (77.7)	11 (4.5-27)	
Cerebral infarction	−	40	16 (94.1)	24 (88.9)	22 (5-NA)	.679
	+	4	1 (5.9)	3 (11.1)	10 (7-NA)	
Chronic obstructive pulmonary disease	−	43	17 (100.0)	26 (96.3)	15 (7-NA)	.75
	+	1	0 (0.0)	1 (3.7)	22 (NA-NA)	
Hemodialysis	−	29	15 (88.2)	14 (51.9)	NA (3-NA)	.135
	+	15	2 (11.8)	13 (48.1)	11 (4.5-23)	
Hypoglycemia	−	31	17 (100.0)	14 (51.9)	NA (10-NA)	.001
	+	13	0 (0.0)	13 (48.1)	5.5 (1.25-11)	
Previous cardiovascular surgery	−	26	14 (82.4)	12 (44.4)	99 (10-NA)	.0121
	+	18	3 (17.6)	15 (55.6)	6.25 (2-11)	
Use of catecholamines	−	13	11 (64.7)	2 (7.4)	NA (22-NA)	<.001
	+	31	6 (35.3)	25 (92.6)	8 (3-15)	
SOFA score	<10	21	17 (100.0)	4 (14.8)	NA (NA-NA)	<.001
	≥10	23	0 (0.0)	23 (85.2)	4.5 (1.25-10)	
Respiratory failure	−	8	7 (41.2)	1 (3.7)	NA (2-NA)	.0189
	+	36	10 (58.8)	26 (96.3)	10.5 (4.5-27)	
Coagulopathy	−	25	4 (23.5)	21 (77.8)	NA (23-NA)	.002
	+	9	6 (35.3)	3 (11.1)	8 (3-15)	
Hepatopathy	−	27	15 (88.2)	12 (44.4)	NA (15-NA)	<.001
	+	17	2 (11.8)	15 (55.6)	3 (0.583-7)	
Circulatory insufficiency	−	7	7 (41.2)	0 (0.0)	NA (NA-NA)	.0085
	+	37	10 (58.8)	27 (100.0)	10 (4.5-27)	
Time from disease onset to diagnosis (h)	<2.75	12	4 (23.5)	8 (29.6)	22 (2-NA)	.687
	≥2.75	32	13 (76.5)	19 (70.4)	10.5 (4-NA)	
Time from diagnosis to laparotomy (h)	<2.5	25	10 (58.8)	15 (55.6)	11 (4-NA)	.907
	≥2.5	19	7 (41.2)	12 (44.4)	22 (4.5-NA)	
Blood test results						
Albumin	<1.3	1	1 (5.9)	0 (0.0)	NA (NA-NA)	.32
	≥1.3	43	16 (94.1)	27 (100.0)	15 (7-99)	
Creatinine	<1.37	9	6 (35.3)	3 (11.1)	NA (0.29-NA)	.127
	≥1.37	35	11 (64.7)	24 (88.9)	11 (5.5-36)	
C-reactive protein	<10.1	20	11 (64.7)	9 (33.3)	NA (3-NA)	.18
	≥10.1	24	6 (35.3)	18 (66.7)	13 (4-36)	
Hemoglobin	<11	30	15 (88.2)	14 (51.9)	99 (7-NA)	.003
	≥11	14	2 (11.8)	13 (48.1)	6 (1-15)	
Platelets	<12.9	25	12 (70.6)	7 (25.9)	7 (3-22)	.01
	≥12.9	19	3 (17.6)	0 (0.0)	NA (15-NA)	
Lactic acid	<2.6	10	8 (61.5)	2 (8.3)	NA (5.5-NA)	.005
	≥2.6	27	5 (38.5)	22 (91.7)	10 (3-23)	
pH	<7.589	43	9 (52.9)	14 (51.9)	15 (3-NA)	.847
	≥7.589	1	8 (47.1)	13 (48.1)	22 (5.5-NA)	
Base excess	<-3.0	32	9 (52.9)	23 (85.2)	10 (3-27)	.023
	≥-3.0	12	8 (47.1)	4 (14.8)	NA (5.5-NA)	
Computed tomography findings						
Mural enhancement defect	−	7	3 (17.6)	4 (16.7)	15 (4-NA)	.664
	+	34	14 (82.4)	20 (83.3)	23 (7-NA)	

(*continued*)

Table 2

(continued).

Factor	Group	*n*	Survivors	Non-survivors	Median survival time [d] (95% confidence interval)	*P* value
Paper-thin wall	–	14	7 (41.2)	7 (31.8)	99 (10-NA)	.25
	+	25	10 (58.8)	15 (68.2)	23 (4-NA)	
Pneumatosis intestinalis	–	16	4 (23.5)	12 (50.0)	12.5 (4-99)	.312
	+	25	13 (76.5)	12 (50.0)	23 (8-NA)	
Hepatic portal venous gas	–	22	5 (29.4)	17 (70.8)	11 (4-36)	.062
	+	19	12 (70.6)	7 (29.2)	NA (7-NA)	
Symptoms						
Abdominal pain	–	8	1 (5.9)	7 (25.9)	6.75 (1-15)	.064
	+	36	16 (94.1)	20 (74.1)	27 (7-NA)	
Consciousness disturbance	–	36	16 (94.1)	20 (74.1)	27 (7-NA)	.064
	+	8	1 (5.9)	7 (25.9)	6.75 (1-15)	
Initial diagnosing departments						
Emergency physician	–	30	12 (57.1)	18 (78.3)	10 (4-27)	.059
	+	14	9 (42.9)	5 (1.7)	NA (8-NA)	
Cardiovascular surgeon	–	26	14 (82.4)	12 (44.4)	99 (10-NA)	.014
	+	18	3 (17.6)	15 (55.6)	6.25 (2-22)	
Internist	–	35	13 (76.5)	22 (81.5)	22 (5.5-NA)	.554
	+	9	4 (23.5)	5 (18.5)	11 (0.29-NA)	
General surgeon	–	41	16 (94.1)	25 (92.6)	15 (7-NA)	.962
	+	3	1 (5.9)	2 (7.4)	99 (2-NA)	

NA = not available, SOFA = Sequential Organ Failure Assessment.

contrast-enhanced CT examination in 8 patients before hypotension was observed. All 8 patients survived postoperatively. Seven patients who underwent surgery exhibited necrosis, and intestinal resection was not performed in 1 patient during surgery. This might be the only case in which endovascular treatment could have been performed safely.

NOMI is often diagnosed and treated across multiple departments; therefore, delays in the diagnosis and treatment are common problems. Early diagnosis is considered important to reduce mortality.[29] In this study, no significant differences in the time from NOMI onset to diagnosis and the time from diagnosis to laparotomy were observed between the survivors and non-survivors. By the time that NOMI was diagnosed, 37 patients (84%) had experienced circulatory failure. The median SOFA score was 11.06 [5.75-17.25], and 42 patients (95.4%) were diagnosed with sepsis. This is consistent with a recent report in which decreased cardiac output and a high SOFA score were independent predictors of NOMI onset.[6]

A previous study reported similar survival rates after primary surgical treatment,[17] whereas another study recommended a second-look operation.[15] Ward et al[26] reported that a second-look surgery was performed in 76% of patients with NOMI and that 50% of these patients required enterectomy. In our hospital, exploratory laparotomy based on a second-look operation is the first treatment choice. The concept is similar to that of the so-called "damage control surgery",[30] in which the site of intestinal necrosis is resected, and laparotomy is repeated after the general condition of the patient improves. Because our treatment policy is based on a second-look operation, the operative time was short and the amount of bleeding was small; however, the death rate among patients who underwent surgery was relatively higher (61.3%) than that in previous reports.[15,16,20] In our study, perioperative factors might not be relevant as prognostic factors, and the SOFA and P-POSSUM scores were high. Nonetheless, given that there is currently no severity classification for NOMI, accurate judgment of treatment outcomes was difficult.

In a large-scale study that evaluated prognostic factors in NOMI patients who underwent surgery,[14] preoperative low mean blood pressure and decreased base excess were predictors of a poor prognosis. Moreover, although the P-POSSUM score is a prognostic factor, the use of this scale is complicated, and it can only be applied to patients undergoing surgery.[20] Thus, the SOFA score is preferable because it can also be applied to preoperative cases, and the scale comprises simple and measurable elements that can be calculated before laparotomy. As the SOFA score may reflect the general condition of patients, its relationship with prognosis is reasonable.

The study has several limitations. The main limitation of this study was its single-center design and retrospective nature. Although determining the usefulness of surgery for NOMI using

Table 3

Multivariate analysis of factors with significant difference and age.

	Hazard ratio	95% confidence interval (lower limit)	95% confidence interval (upper limit)	*P* value
SOFA score ≥10	1.199	1.101	1.305	<.001

SOFA = Sequential Organ Failure Assessment.

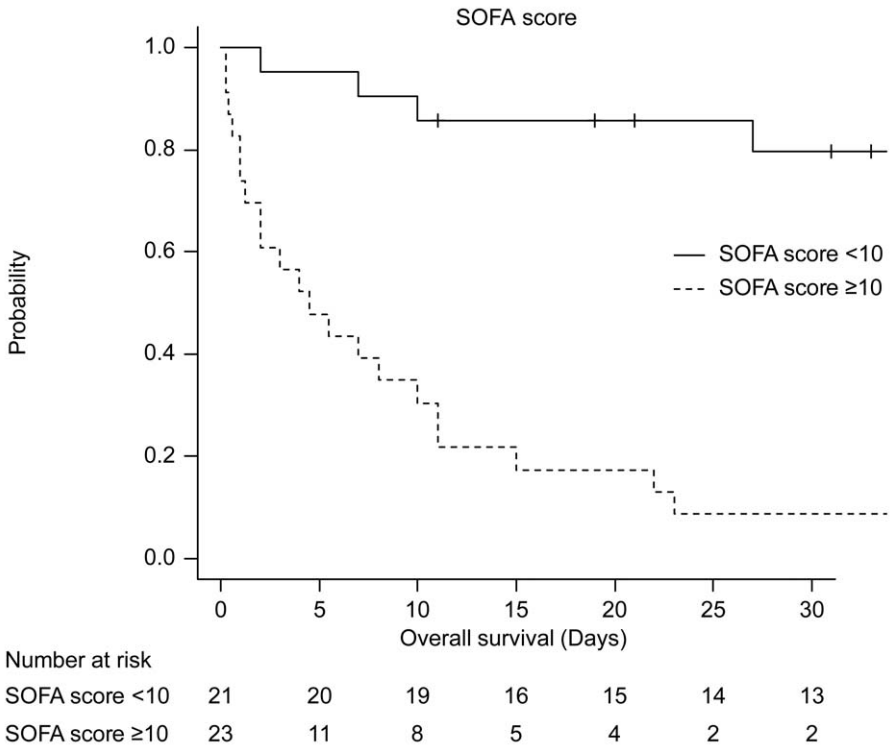

Figure 2. Multivariate analysis of parameters with significant difference and age. Results show that Sequential Organ Failure Assessment (SOFA) score ≥10 is an independent prognostic factor.

a randomized controlled trial would be difficult and impractical, large-scale cohort studies involving several institutions are needed. We cannot exclude the possibility that there are further relevant differences (e.g., severe comorbidities, protocols for each surgeon, and surgical conditions prior to developing NOMI) between both groups, which could have influenced our results.

In conclusion, this study confirmed the usefulness of the SOFA score for the determination of NOMI severity. A SOFA score ≥10 may be associated with increased mortality.

Table 4

Comparison of characteristics and perioperative factors between the survival and non-survival groups with nonocclusive mesenteric ischemia.

	All (n = 44)	Survivors (n = 17, 38.6%)	Non-survivors (n = 27, 61.3%)	*P* value
Operative time (min)				.842
Median	44	44	50.5	
Interquartile range	26.5-65.5	32-64	25-67.5	
Range	0-162	18-102	0-162	
Bleeding (mL)				.146
Median	30	30	30	
Interquartile range	30-105	30-30	30-326	
Range	0-2740	5-1300	0-2740	
Colectomy	17 (38.6)	4 (23.5)	13 (48.1)	.124
Second-look operation	27 (61.3)	13 (76.5)	14 (51.9)	.188
SOFA 48 h after surgery	12.5 [9-17.75]	8 [7-9]	16 [13-19]	<.001
P-POSSUM	77.5 [21.4-91.8]	21.9 [8.6-36.6]	89.9 [81.2-95.3]	<.001
Physiological score	38.5 [33.7-42.5]	26 [21-29]	50 [42-54]	<.001
Operative severity score	17 [17-19]	17 [17-17]	17 [17-19]	.092

P-POSSUM = Portsmouth Physiological and Operative Severity Score for the enumeration of Mortality and Morbidity, SOFA = Sequential Organ Failure Assessment.

Table 5

Comparison of patient characteristics according to the Sequential Organ Failure Assessment score.

	SOFA score <10	SOFA score ≥10	*P* value
Survivors	17	0	<.001
Non-survivors	4	23	
Age (yrs)	73.29 (13.37)	76.35 (7.81)	.971
Sex (male)	11 (52.4)	16 (69.6)	.965
Weight (kg)	52.83 (10.35)	59.79 (12.97)	.162
Height (cm)	160.74 (9.83)	163.26 (9.14)	.981
Body mass index (kg/m^2)	21.51 (6.20)	22.78 (4.13)	.0149
Comorbidities and risk factors			
Chronic heart disease	10 (47.6)	19 (82.6)	.025
Hemodialysis	3 (14.3)	12 (52.2)	.02
Hypoglycemia	0 (0.0)	13 (56.5)	<.001
Previous cardiovascular surgery	4 (19.0)	14 (60.9)	.012
Use of catecholamines	10 (47.6)	21 (91.3)	.004
Overall survival (d)	46.33 (38.80)	11.64 (21.06)	.001
SOFA score			
Respiratory failure	13 (61.9)	23 (100.0)	.004
Coagulopathy	5 (23.8)	20 (87.0)	<.001
Hepatopathy	2 (9.5)	15 (65.2)	.001
Circulatory insufficiency	12 (57.1)	23 (100.0)	.002
Central nervous system failure	8 (38.1)	22 (95.7)	<.001
Nephropathy	14 (66.7)	23 (100.0)	.009
Time from disease onset to diagnosis (h)	8.63 (14.63)	14.62 (18.09)	.237
Time from diagnosis to laparotomy (h)	4.13 (4.80)	3.70 (3.97)	.744
Blood test results			
Platelets ($\times 10^4/\mu L$)	16.87 (7.91)	8.27 (5.66)	<.001
Lactic acid (mmol/L)	4.77 (4.00)	9.42 (6.64)	.016

SOFA = Sequential Organ Failure Assessment.

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