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Impact of Etiologic Factors and APACHE II and POSSUM Scores in Management and Clinical Outcome of Acute Intestinal Ischemic Disorders after Surgical Treatment

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Abstract

Background: Acute intestinal ischemic disorder (AIID) is an uncommon vascular disease with high mortality. According to etiology, it can be categorized into three groups: arterial occlusive mesenteric ischemia (AOMI), mesenteric venous thrombosis (MVT), and nonocclusive mesenteric ischemia (NOMI). This study analyzes the effect of classification on surgical outcome.

Patients and Methods: All AIID patients who underwent operative treatment at National Cheng Kung University Hospital between January 1989 and August 2003 were enrolled in this study. Preoperative information on these patients was compared to find predictors of outcome.

Results: Data from 77 patients (49 men and 28 women, median age 70 years) were analyzed. The etiology was AOMI in 30 patients, MVT in 19 patients, and NOMI in 28 patients. Median age was younger in MVT (54 years) than in AOMI (70 years) or NOMI (72 years). In addition, MVT usually involved the jejunum (74%, versus 31% in AOMI and 46% in NOMI), whereas both AOMI and NOMI involved ileum and colon. The patients with AOMI had shorter duration of symptoms and higher ratio of underlying hypertension than those with MVT. The overall mortality rate was 53.2% (41/77). The day 1 and day 30 mortality were 0% and 10.5% in MVT, 16.7% and 30% in AOMI, and 42.9% and 67.9% in NOMI, respectively ($P < 0.05$). Both the etiology and the APACHE II scores were significant risk factors for day 30 and long-term mortality. The patients with NOMI had higher POSSUM physiologic scores than patients with MVT. The P-POSSUM regression equation can accurately predict mortality.

Conclusions: Patients with MVT had a more favorable prognosis, whereas those with NOMI had the worst outlook. The APACHE II and POSSUM scoring systems are useful in predicting the clinical outcome. Early diagnosis and classification of AIID patients are useful for aggressive treatment to improve the clinical outcome.

Acute intestinal ischemic disorder (AIID) occurs infrequently but has very high mortality rates of 60%–80%.[1] Based on the underlying etiologic factors, AIID can be categorized into three types: arterial occlusive mesenteric ischemia (AOMI), mesenteric venous thrombosis (MVT), and nonocclusive mesenteric ischemia (NOMI). AOMI includes either acute arterial thrombosis or embolism of the superior mesenteric artery.[2] MVT, which

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may be primary or secondary, is associated with hypercoagulable states, portal hypertension, peritonitis, abdominal trauma, or malignant diseases.[3] NOMI comprises all forms of mesenteric ischemia without occlusion of the mesenteric arteries and is commonly caused by decreased cardiac output resulting in splanchnic hypoperfusion.[4] These three group have similar presentations but different risk factors and clinical outcomes. This study reviews our 15-year experience and evaluates clinical presentation, management, and outcomes.

PATIENTS AND METHODS

Between January 1989 and August 2003, all AIID patients who underwent laparotomy at National Cheng Kung University Hospital were enrolled in this study. Exclusion criteria included patients who received nonsurgical treatment; those who could not tolerate exploratory laparotomy; patients with AIID secondary to arteritis, mechanical obstruction, or adhesion; and AIID patients with a history of the disease longer than 4 weeks. Information about patients was collected from retrospective chart review and included age, gender, acute clinical presentation, previous medical/operative history, medications prior to operation, prodromal signs, laboratory findings on admission, postoperative morbidity, mortality, and length of hospital stay. Two prognostic outcome scores, APACHE II and POSSUM, were also used to predict outcome.

Preoperative clinical diagnosis was confirmed by single test or a combination of examinations such as ultrasonography, computed tomography (CT), or angiography. Operative intervention was performed urgently upon diagnosis, and patients with definite peritoneal signs had emergent operations. Final diagnosis of AIID was established during operation and confirmed by pathologic examination of resected bowel.

Categorical Criteria

According to previous studies,[1–10] the categorical criteria of AIID were as follows:

1. AOMI[1,2,5–8,10]:

- Previous medical history: cardiac arrhythmia, atherosclerotic heart disease, or arterial occlusive disease
- Abdominal contrasted CT: paper-thin intestinal wall, bowel dilatation with poor enhancement of intestinal wall after intravenous injection of contrast medium, gas within hepatic portal vessel, and intestinal pneumatosis
- Angiography: abrupt cutoff sign of superior mesenteric artery without evidence of collateral vessels
- Operative finding: thin intestinal wall and absence of mesenteric pulsation on palpation, usually involving ileum and/or colon rather than jejunum
- Pathological examination: presence of thromboemboli within the mesenteric vessel, whole-layer ischemic necrosis, or hemorrhagic necrosis

2. MVT[1–3,5,7–10]:

- Previous medical history: hematologic disease or long-term use of anticoagulant
- Abdominal contrasted CT: thickening of intestinal wall, presence of hypoperfusion and rim-enhancing wall with central low attenuation of superior mesenteric vein or collateral vessel formation after intravenous injection of contrast medium
- Angiography: normal arterial perfusion, used to exclude AOMI
- Operative findings: thickened, edematous, congestive change of intestinal wall and mesentery with preserved mesenteric pulsation, usually involving jejunum segment.
- Pathological examinations: whole-layer congestive changes of intestinal wall and mesentery

3. NOMI[1,4–7,10]:

- Previous medical history: decreased cardiac output, sepsis, dehydration, shock, cardiovascular surgery, or high-dose use of an inotropic agent
- Abdominal contrasted CT: diffuse change of small intestine including bowel distension, intestinal wall thickening, or mesenteric edema
- Angiography: demonstrated diffuse vasoconstriction of mesenteric vessels without evidence of luminal obstruction (“string of sausages” sign)
- Operative finding: long-segment bowel involvement associated with weak mesenteric pulsation, without clear-cut gross distinction between the ischemic and normal bowel segments; progression of ischemia with time
- Pathological examinations: whole-layer ischemic or hemorrhagic necrosis of intestinal wall

Prognostic Scores

The Physiological and Operative Severity Score for the enUmeration of Mortality and morbidity (POSSUM) score includes 12 preoperative factors and 6 operative factors. The result of the POSSUM data set is a physiology score of 12–88 and an operative score of 6–44. The higher the overall POSSUM score, the greater the risk of morbidity

and mortality.[11,12] We used the physiological score of POSSUM for risk predictors and the Portsmouth predictor modification (P-POSSUM) regression equation for predicting morality in these general surgical patients.[11] The Acute Physiology and Chronic Health Evaluation (APACHE) II is one of the popular scoring systems for intensive care, including 12 physiology variables, and, because of its ease of administration, it is the major scoring system for serial measurement of change in response to treatment. Therefore, all preoperative data for POSSUM and APACHE II scores were collected, and the effectiveness of these scoring systems was evaluated to determine its value in predicting the outcome of AIID patients.

Statistical Analysis

Statistical analyses were conducted using SAS version 9.13 (SAS Institute, USA). Univariate analysis was performed using χ^2 test or Fisher's exact test. Statistical comparison between two groups was done by independent sample *t*-test for continuous variables with normal distribution. Continuous variables that did not follow normal distribution were compared by nonparametric two-independent sample test. Risk factors associated with different categories of AIID were identified by univariate analysis and then determined by multivariate logistic regression with MVT as the reference group. Impact of index of disease severity (APACHE II and POSSUM scores) and other risk factors on 30-day mortality in different AIID categories were analyzed with multivariate logistic regression. Each model included age and gender as co-variates. Results were expressed as odds ratios (ORs) with 95% confidence intervals (CI) and corresponding two-tailed *p* values. The association of three categories and survival was assessed with the Kaplan-Meier method, and significance was tested with the log-rank test.

RESULTS

Demographic Data, Clinical Presentation in Different Etiology

There were 77 AIID patients, 49 men and 28 women with ratio of 1.75 and median age of 70 years, who received surgical intervention from January 1989 to August 2003. The etiologies of AIID were AOMI (30/77, 39%), MVT (19/77, 25%), and NOMI (28/77, 36%). The age was younger in MVT than in AOMI or NOMI. The gender ratio among the three categories did not vary significantly (Table 1).

Patients with AOMI and NOMI had a significantly higher percentage of diabetes mellitus and hypertension. The AOMI patients had a higher percentage of atrial fibrillation as compared to MVT patients ($P = 0.068$). On the other hand, a slightly higher percentage of hematology disease was noted in MVT, but without statistical significance (data not shown). The history of anticoagulant usage (warfarin, Coumadin) was significantly higher in the MVT group (6/19, 32%). The percentage of operative procedures including abdominal surgery prior to occurrence of AIID was higher in association with NOMI (Table 1). The APACHE II and POSSUM scoring systems had similar distribution in these three categories, with highest scores in the NOMI group and the lowest scores in MVT patients ($P < 0.05$).

In the clinical presentation, abdominal pain was the most common complaint (70/77, 91%), which is cramping in character and abrupt in onset. Nausea and vomiting was the second most frequent symptom (28/77, 36%), followed by bloody diarrhea (17/77, 22%). The clinical presentation was similar in the three categories, and the differences carried no statistical significance (data not shown). Time from onset of symptoms to operation ranged from 1 to 21 days, with a median of 2 days. Patients with MVT had longer time to onset (median: 4 days; range: 1–10 days) but there was no statistical significance among the three categories (Table 1).

The mean leukocyte count was elevated with left shifting, but without significant differences in the three categories. Hemoconcentration with elevation of blood urea nitrogen and an increase in serum creatinine level were statistically significant in NOMI and AOMI ($P < 0.05$). Other findings such as elevated amylase and phosphate, high level of C-reactive protein, and metabolic acidosis were also noted but not consistent with a diagnosis of AIID. There were no significant differences in laboratory data in the three categories, except the percentage of preoperative acute renal failure was higher in the patients with NOMI than in the other two groups (Table 1).

Diagnostic Evaluation

Twenty-two patients had ultrasonography and 49 patients had abdominal CT before operation. Eleven patients had both ultrasonography and abdominal CT due to obscure presentation, and 17 patients did not undergo any imaging procedures because they presented in an

Table 1.
Demographics, clinical presentations, and preoperative laboratory data of patients with AIID, including different operative findings between the three categories, arterial occlusive mesenteric ischemia (AOMI), mesenteric venous thrombosis (MVT), and nonocclusive mesenteric ischemia (NOMI)

	AOMI	MVT	NOMI	*P* Value
No.	30 (39%)	19 (25%)	28 (36%)	
Age, median (range)	70 (44–91)	54 (39–82)	72 (37–84)	0.024
Gender				
Male	20 (67%)	11 (58%)	18 (64%)	0.821
Female	10 (33%)	8 (42%)	10 (36%)	
Previous medical history				
Diabetes mellitus	8 (27%)	0 (0%)	4 (14%)	0.034
Hypertension	18 (60%)	4 (21%)	18 (64%)	0.008
Atrial fibrillation	12 (40%)	2 (11%)	6 (21%)	0.068
Coronary artery disease	6 (20%)	0 (0%)	7 (25%)	0.056
Previous medication				
Coumadin	2 (7%)	6 (32%)	0 (0%)	0.002
Aspirin	1 (3%)	3 (16%)	7 (25%)	0.049
Previous operative history	15 (50%)	9 (47%)	25 (89%)	0.002
Abdominal surgery	5 (17%)	5 (26%)	10 (36%)	0.255
APACHE II	18 ± 11	12 ± 10	24 ± 9	< 0.001
POSSUM (physiologic score)	36 ± 16	26 ± 10	42 ± 12	0.001
Duration of symptoms, days, median (range)	2 (1–4)	4 (1–10)	2 (1–21)	0.078
Laboratory data, median (range)				
Blood urea nitrogen (mg/dl)	30 (10–110)	20 (9–77)	44 (12–183)	0.001
Creatinine (mg/dl)	1.9 (0.5–13.5)	0.9 (0.5–5.0)	3.8 (0.8–8.2)	< 0.001
Operative findings				
Jejunum	9 (31%)	14 (74%)	13 (46%)	0.015
Ileum	18 (62%)	9 (47%)	22 (79%)	0.085
Colon	16 (55%)	2 (11%)	16 (57%)	0.003
Ascites	27 (96%)	18 (100%)	26 (93%)	0.782

Table 2.
Different diagnostic tools for patients with AIID

	No. of patients	No. of patients receiving exam	No. of correct diagnoses	Positive rate	*P* Value
Sonography					
AOMI	30	8	4	50%	
MVT	19	9	9	100%	0.047
NOMI	28	5	3	60%	
Total	77	22	16	73%	
Computed tomography					
AOMI	30	17	16	94%	
MVT	19	12	12	100%	0.779
NOMI	28	20	18	90%	
Total	77	49	46	94%	

emergency state (Table 2). The overall diagnostic rate of ultrasonography was 73%, and was slightly higher in MVT than in AOMI and NOMI ($P = 0.047$). This difference is due to extension of thrombi from SMV to the portal vein in patients in the MVT group, a finding that can easily be demonstrated by ultrasonography. However, ultrasonography is not used for all patients because it requires a high level of technical skill. Forty-six patients had typical findings on abdominal CT, for a positive diagnostic rate of 94%. There was no difference in diagnostic rate among the three groups. Only four patients underwent angiography before operation. Three of the angiographs gave

Table 3.
Morbidity, 1-day, 30-day, and total mortality rate in the three AIID categories, AOMI, MVT, and NOMI

	AOMI	MVT	NOMI	Total	*P* Value
No.	30	19	28	77	
Morbidity	17 (56.7%)	10 (52.6%)	9 (32.1%)	36 (46.8%)	0.146
One-day mortality	5 (16.7%)	0 (0%)	12 (42.9%)	17 (22.1%)	0.0016
Thirty-day mortality	9 (30.0%)	2 (10.5%)	19 (67.9%)	30 (39.0%)	0.0002
POSSUM-predicted mortality	39.8%	10.8%	68.6%	37.2%	0.002
V-POSSUM-predicted mortality	39.0%	13.1%	64.7%	37.2%	0.002
Total mortality	16 (53.3%)	3 (15.8%)	22 (78.6%)	41 (53.2%)	0.0001

clear diagnostic results (one AOMI, two NOMI), but one patient had a normal mesentery vascular pattern that later proved to be MVT. Six patients underwent preoperative sigmoidscopy for bleeding, and four had ischemic changes of the mucosa (two AOMI, two NOMI). One patient was noted to have bleeding from the proximal colon but during operation the condition proved to be AOMI. One patient with normal sigmoidoscopic findings was found to have thickening of the colonic wall by abdominal CT and poor perfusion of ascending colon at operation (AOMI).

Surgical Findings and Treatment

Most patients were found to have ascites during operation (71/77, 92%). The involved bowel segments were different in the three AIID categories: MVT usually involved the jejunum (74%, versus 31% in AOMI and 46% in NOMI, $P = 0.015$). AOMI and NOMI had similar areas of involvement, mainly of the ileum and colon (Table 1).

A total of 57 patients (58/77, 75%) underwent bowel resection because of gangrenous changes; these operations included 49 small bowel resections, 18 colon resections, and 9 combined resections. Eight patients (6 in the NOMI group and 2 in the AOMI group) were found to have massive bowel necrosis at laparotomy, precluding further surgical intervention, and so the surgical procedure was limited to an open-close diagnostic laparotomy.

Unstable hemodynamic status was noted in 18 patients during operation, and, to shorten the operative time, ileostomy or colostomy was performed instead of primary anastomosis. One patient in the AOMI group underwent aortomesenteric bypass, and one in the MVT group underwent a thrombectomy carried out by a cardiovascular surgeon. Revascularization was not routinely performed, either because of bowel gangrene in most patients or because of a lack of available vascular surgeons.

Morbidity and Mortality

Morbidity, 1-day, 30-day, and total mortality rates are shown in Table 3. No difference in morbidity rate was found among three categories. Pulmonary complications were the most common cause of morbidity (16%), followed by pathogen-induced sepsis (proved by blood culture, 14%) and wound infection (13%). Postoperative deterioration from intestinal ischemia was noted in two patients, one NOMI patient, who underwent a second operation for bowel resection, and one AOMI patient whose disease was complicated by further mesenteric venous thrombosis.

The overall mortality rate was 53.2% (Table 3). Patients with NOMI had the worst prognosis with the highest mortality rate; 12 patients died on postoperative day 1 (POD 1) (42.9%) and 19 patients had died by POD 30 (67.9%). Patients with MVT had a more favorable prognosis (POD 1 = 0%, POD 30 = 10.5%). The mortality rate in patients with AOMI was 16.7% on POD 1 and 30.0% by POD 30. The survival time was significantly different in the three categories (Fig. 1), but the predicted mortality by P-POSSUM was slightly higher in the AOMI group (Table 3).

In multivariate analysis of predictors for 30-day and long-term mortality, the etiology and the APACHE II scores were the most significant factors (Table 4). The patients with AOMI had a 4.31-fold greater risk of 30-day mortality and a 3.47-fold greater risk of long-term mortality than the patients with MVT. The patients with NOMI had a 12.37-fold risk of 30-day mortality and a 5.06-fold risk of long-term mortality.

Table 1 shows the risk factors for patients in the three categories of AIID calculated by univariate analysis. In the multivariate analysis, patients with AOMI were more likely to be older, have positive hypertension history, shorter duration of symptoms, and less use of Coumadin than patients with MVT. In the comparison of patients with

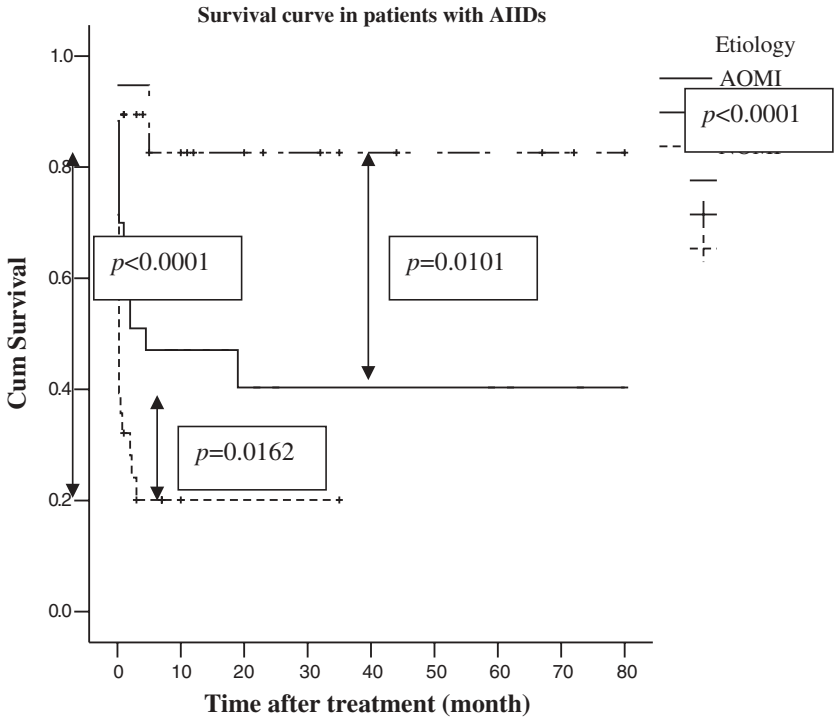

Figure 1. Survival curve in patients with acute intestinal ischemic disorder (AIID) showing a comparison between the three categories, arterial occlusive mesenteric ischemia (AOMI), mesenteric venous thrombosis (MVT), and nonocclusive mesenteric ischemia (NOMI).

Table 4.
Multivariate analysis of risk factors for 30-day and long-term mortality in patients with AIID

	30-day mortality		
	OR	95% CI	*P* Value
Age	0.958	0.899–1.019	0.175
Gender (Male versus female)	1.628	0.345–7.690	0.538
AOMI versus MVT	4.313	0.461–40.386	0.200
NOMI versus MVT	12.367	1.450–105.455	0.021
APACHE II score	1.193	1.096–1.298	< 0.0001
	Long-term mortality		
Age	1.003	0.972–1.034	0.857
Gender (Male versus female)	1.164	0.556–2.435	0.688
AOMI versus MVT	3.473	0.978–12.332	0.054
NOMI versus MVT	5.060	1.411–18.149	0.013
APACHE II score	1.114	1.070–1.160	< 0.0001

OR: odds ratio; CI: confidence interval.

NOMI and MVT, the higher POSSUM physiologic score was the risk factor for NOMI (Table 5).

Follow-up and Outcome

A total of 36 patients with AIID (14 AOMI, 16 MVT, and 6 NOMI patients) survived to follow-up. The average follow-up time in these 36 patients was 19.4 ± 24.1 months, with a range of 1–80 months, with no significant difference in the three categories. Twelve MVT patients (12/16, 75%) received postoperative anticoagulant therapy (intravenous heparin infusion, followed by oral Coumadin admistration) for an average of 17.9 ± 26.8 months. In contrast, nine AOMI patients (7/14, 50%) and one NOMI patient (1/6, 17%) received postoperative anticoagulant therapy ($P < 0.001$).

Table 5.
Multivariate analysis of risk factors in patients with AMOI and NOMI, in comparison with MVT

	AOMI versus MVT		
	OR	95% CI	*P* Value
Age	1.100	1.014–1.193	0.021
Gender (Male versus female)	3.509	0.418–29.412	0.248
Duration of symptoms	0.092	0.013–0.624	0.015
Hypertension	6.513	1.037–40.909	0.046
Coumadin use	0.063	0.006–0.663	0.021
	NOMI versus MVT		
Age	1.047	0.982–1.118	0.162
Gender (Male versus female)	1.718	0.284–10.417	0.556
POSSUM (physiologic score)	1.119	1.038–1.207	0.003

DISCUSSION

Acute intestinal ischemic disorder is a fatal vascular emergency with an overall mortality rate of 59%∼93%.[13] This disease entity can be categorized into three specific types based on cause[1,2]: AOMI results from a superior mesenteric artery embolus or thrombus and is responsible for 60%∼70% of AIID cases.[5,14] Preoperative suspicion of intestinal ischemia is noted in only 33% of AOMI patients. Most AOMI patients are misdiagnosed and are managed nonoperatively.[15] In patients with severe atherosclerotic disease, the narrow lumen of SMA combined with the presence of splanchnic hypoperfusion results in NOMI, which accounts for approximately 20%∼30% of AIID cases and is precipitated by low cardiac output, gastrointestinal tract vasoconstriction, or multiple organ failure syndrome.[4,16] Nearly 10%∼15% of AIID cases result from MVT, which may be either primary or secondary. The most common etiologic causes of MVT are hypercoagulable states, heritable or acquired coagulation disorder, cancer, intra-abdominal inflammatory conditions, major operation, liver cirrhosis, portal hypertension, and idiopathy.[3,17]

Most laboratory findings are not helpful in identifying patients with early stage AIID, but they become more useful in late stage disease.[14] In our data, leukocytosis with immature cells; prolonged prothrombin time; and elevation of serum urea-nitrogen, creatinine, liver enzyme, amylase, bilirubin, C-reactive protein, inorganic phosphate, and metabolic acidosis were present without any significant difference in the three categories of AIID. Lactic acid was not routinely checked in our institute. The laboratory data of patients in the AOMI and NOMI groups were likely to be worse than data for the MVT group, but without statistical significance. This indicates the possibility that the patients in the AOMI and NOMI groups have a longer length of nonviable bowel. In general, it seems that contemporary laboratory data reflect the severity of intestinal ischemia and are predictive of postoperative outcome, but they are not helpful in the prevention of later ischemic complications.

A standard diagnostic tool for AIID is mesenteric angiography. Angiography can identify the presence and site of emboli or thrombi in the occlusive forms of AIID, and it can also reveal the presence of mesenteric vasoconstriction in the nonocclusive forms of the disease.[2,6,18] Mesenteric angiography has high sensitivity (74%∼100%) and specificity (100%).[19] However, it has a relatively lower sensitivity (71%) in mesenteric venous thrombosis, and it is not available in all hospitals.[20] In our institute, angiography cannot be made generally available because there are not enough radiologists. It was therefore performed in only four of our patients.

With recent improvements in equipment, CT-angiography provides excellent information, and the finer modern CT scanner may substitute for traditional angiography— except in its therapeutic role—with less invasiveness and more rapid diagnosis. In our hospital, CT angiography was recently introduced, and its usefulness in AIID is ongoing.

In the diagnosis of acute intestinal ischemia, the relatively noninvasive technique of abdominal CT is becoming the radiologic study of choice, with 92% specificity and 64% sensitivity.[7] In our study, preoperative CT studies were performed in 49 patients and the sensitivity was 94%. Because of the high diagnostic rate, our hospital has tended toward increased use of abdominal CT, but

the mortality rate with and without imaging has shown no significant improvement. Furthermore, we have observed that dependency on imaging studies results in delayed diagnosis: the time from emergence of symptoms to operation in patients who received abdominal CT was 3.7 ± 5.1 days, and that in patients who did not receive abdominal CT was 2.3 ± 1.8 days ($P = 0.087$). Appropriate use of CT might improve the diagnostic rate of AIID, but in patients with peritoneal signs, emergent laparotomy should be performed immediately, without delay for CT or angiography.

In the operative treatment of AOMI, the intestinal circulation should be restored by antegrade or retrograde aortomesenteric bypass or thrombectomy, and the nonviable bowel should be resected.[14,21,22] Bingol *et al*. combined intra-arterial tissue plasminogen activator infusion, systemic heparinization, embolectomy, and extended bowel resection in 24 patients with reversal of bowel ischemia at the borderline areas.[23] In our patients with AOMI, preoperative peritoneal signs implied bowel necrosis. The operative finding of nonviable bowel precluded medical treatment with intravenous papaverine or thrombolytic agents, revascularization with embolectomy, or aortomesenteric bypass. There was only one patient who received revascularization by embolectomy due to thrombus in dissecting aneurysm of descending aorta. That patient survived after vascular surgery for the dissecting aortic aneurysm. The remaining 29 patients with AOMI underwent exploratory laparotomy and intestinal resection of nonviable bowel. Perioperative mortality for AOMI in our experience has been 30%, similar to the 30-day mortality of 32% reported by Park *et al*.[24]

Based on conventional management of NOMI, continuous intra-arterial papaverine infusion is reserved for those without peritoneal signs. Urgent exploratory laparotomy is indicated for those patients with persistent peritoneal signs.[1,2,16,19,25] The prognosis not only depends on bowel ischemia but also on the underlying disease entity such as heart failure or the type of major operation or trauma. The mortality rate is high, ranging from 40% to 80%.[1,4,24] We had only one experience of postoperative papaverine infusion in a 74-year-old female with long segment of bowel ischemia NOMI, but the response was not positive, and the patient died on POD 1. Twelve patients in the NOMI group (42.9%) died on POD 1, and the 30-day mortality rate in NOMI was 67.9%, for a total mortality rate of 78.6%. Those patients who died immediately after operation had a longer segment of bowel ischemia.

We concluded that the main cause of death in these patients was delayed diagnosis and not the choice of treatment method. However, we should be cautious with this interpretation, because we included only NOMI patients who had a surgical intervention; those who were unable to tolerate the operation or those who improved soon after medical treatment were excluded. In addition, some patients without peritoneal signs who recovered after volume resuscitation and medical treatment were not included in this study. We believe that, in NOMI, high suspicion and early diagnosis are most important for survival.

Surgical exploration of MVT is not necessary in all patients. Immediate anticoagulant therapy during the early course of the disease can reverse venous circulation.[17,20] The necessity of operation for patients with MVT is also decreasing after improvement in diagnosis in our hospital. In the past 10 years, we have had five patients with MVT who received only anticoagulation treatment. For patients with peritoneal signs, however, surgical intervention is the only choice. When treated nonoperatively, the mortality rate is approaches 95% in patients with bowel gangrene.[26] Resection of nonviable bowel and perioperative anticoagulant therapy is the gold standard of treatment although the mortality rate after operation ranges from 11% to 80%.[17,20,27–29] Venous thrombectomy is difficult because of the presence of diffuse venous thrombosis with distal extension in most patients.[20] In our series, MVT had the most favorable outcome among the three categories of AIID, with a total mortality rate of 15.8%. In six of our patients (31.6%) with mesenteric venous thrombosis there was a history of Coumadin use. Mesenteric hematoma after anticoagulant therapy probably impedes venous return, resulting in ischemic changes of the bowel.[30] We agree that anticoagulant therapy may complicate the diagnosis of gastrointestinal vascular disease.[31]

With systematic review of 45 observational studies of 3692 patients with acute mesenteric ischemia, Schoots *et al*. found large differences in prognosis depending on etiology. The overall mortality rate in their series was 64%, and the prognosis of MVT was best, with a mean mortality rate of 32.1%. This is comparatively lower than arterial embolism, arterial thrombosis, and nonocclusive ischemia, with a mean mortality of 54.1%, 77.4%, and 72.7%, respectively.[13] In our series of AIID patients, those with MVT had the best prognosis followed by those with AOMI and then those with NOMI, with respective total mortality rates of 15.8%, 53.3%, and 78.6% (Table 3, Fig. 1).

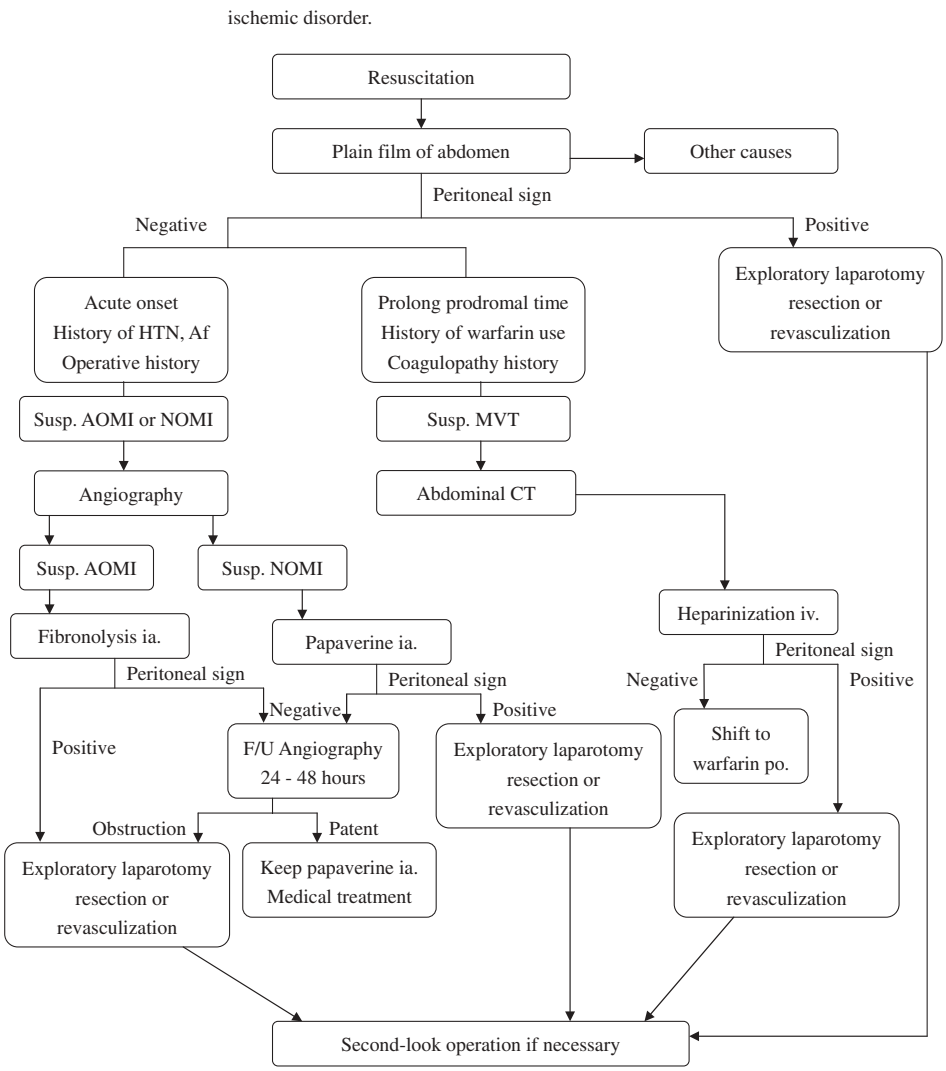

Figure 2. Schema for the diagnosis and treatment of patients at risk of AIID.

Advanced age is believed to be a strong risk factor for AIID, regardless of disease etiologies.[32] Mohil *et al.* agree that the POSSUM scoring system is valid in patients undergoing emergency laparotomy.[12] But Neary *et al.* point out that an individual regression equation is necessary for each index procedure in specialist surgery.[11] We did not use an equation as a predictor index because most of our patients did not undergo vascular reconstruction. In our study, the most important predictor for survival was the etiology in multivariate analysis. The higher APACHE II score was a predictor of mortality, and the P-POSSUM score was useful in estimating the 30-day mortality.

Based on our experience and a review of the literature, we suggested the treatment algorithm shown in Figure 2. Early diagnosis, especially before bowel infarction, might improve survival.[10,19] Exploratory laparotomy is mandatory when signs of peritonitis are present, and resection of nonviable bowel with revasculization should be performed in patients with AIID.[10] In patients without peritoneal signs, abdominal CT is suggested for those with risks of MVT, and angiography or CT-angiography should be used for those with risk of AOMI or NOMI.[5–9] Intravenous heparin is suggested in patients with MVT, when viable bowel is suspicious on physical examination and abdominal CT.[10,17,20,26–28] Intra-arterial fibrinolysis via angiography with urokinase, streptokinase, or tissues plasminogen activator is a therapeutic option in patients with AOMI without peritoneal signs.[10,14,23,33] Intra-arterial infusion of papaverine may be useful in patients with NOMI.[10,18,20] But in most patients with AOMI or NOMI, non-surgical management is not a choice because of rapid deterioration. Patients with symptoms of failed medical treatment or those with definite peritoneal signs should be moved to the operating room for immediate exploratory laparotomy. During operation, resection of nonviable bowel is indicated, but revascularization procedures depend on the surgeon's experience. Second-

look operations can be arranged if viability of the remaining intestine appears questionable during the initial operation.

CONCLUSIONS

Acute intestinal ischemic disorder is a life-threatening high-mortality condition that requires rapid diagnosis and treatment. Categorizing AIID into subgroups according to etiology is useful. MVT had a more favorable prognosis compared with AOMI and NOMI. The APACHE II scoring system has predictive power for prognosis, and the P-POSSUM regression equation can be used to predict the 30-day mortality. Increased clinical experience, a high index of suspicion, and early use of advanced diagnostic imaging studies such computed tomography (CT) and angiography can result in improved clinical outcome when combined with aggressive medical and surgical management.

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