Study of Postoperative Shock Predictors in Colorectal Perforation

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Abstract

We investigated the prediction of postoperative shock using preoperative and intraoperative factors in 176 patients who underwent surgery for colorectal perforation accompanied by diffuse peritonitis at our department from April 2007 to March 2015. Patients given catecholamines after surgery were classified as the catecholamine group, others as the non-catecholamine group. The following 11 items were investigated as predictors: age (≥ 80 years), severity of peritoneal contamination, time from the onset of abdominal pain (≥ 12 hours), presence/absence of chronic renal failure, presence/absence of steroid use, mean blood pressure (< 70 mmHg), presence/absence of systemic inflammatory response syndrome, white blood cell count ($< 4,000/\mu\text{L}$), platelet count ($< 150,000/\mu\text{L}$), serum total protein ($< 5\text{g/dL}$), and sequential organ failure assessment (SOFA) score (≥ 3). Univariate analysis showed the severity of peritoneal contamination, mean blood pressure, white blood cell count, serum total protein, and the SOFA score to correlate with shock occurrence. Multivariate analysis of these 5 items revealed the mean blood pressure (odds ratio, 8.46; $p=0.0003$), white blood cell count (odds ratio, 4.33; $p=0.0003$), and serum total protein level (odds ratio, 7.51; $p=0.0021$) to be independent risk factors. Careful postoperative management is required because of the poor prognosis in complicated postoperative shock.

Key words: colorectal perforation, shock, sepsis

Introduction

Colorectal perforation has a poor prognosis due to the onset of fecal peritonitis. The course is affected by postoperative complications such as disseminated intravascular coagulation (DIC), shock, and wound infection. Shock in particular is a complication to which attention must be paid because this condition requires multidisciplinary approaches including catecholamine administration and mechanical ventilator management, and a prolonged shock state can lead to organ failure, resulting in perioperative death. Circulatory disorders due to shock also affect wound healing. Therefore, it is widely accepted that, for patients with colorectal perforation, colostomy should be performed to avoid anastomotic leakage. Meanwhile, there are cases in which postoperative hemodynamics remain stable and no complications develop during the postoperative course. In such patients, the use of an artificial anus will contribute to decreased quality of life (QOL). Prediction of postoperative complications using preoperative and intraoperative factors is considered to be useful for selecting the most appropriate surgical techniques and postoperative management. Thus, we investigated whether preoperative and intraoperative factors could predict postoperative shock in our patients with colorectal perforation.

Patients and Methods

We investigated the predictive utility for postoperative shock of preoperative and intraoperative factors in 176 patients who underwent surgery for colorec-

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tal perforation accompanied by diffuse peritonitis (excluding iatrogenic perforation and acute appendicitis) at our department from April 2007 to March 2015. At our department, patients whose postoperative blood pressure cannot be maintained are initially given adequate intravenous (IV) fluids, and catecholamines are then administered only to those showing inadequate responses to fluids and other conservative treatments. In this study, postoperative shock was defined as a condition requiring catecholamine administration to maintain the circulation. Patients diagnosed with postoperative shock and who required catecholamine within 24 hours after surgery, with continued administration until at least 24 hours after surgery, were classified as the catecholamine group; the rest were classified as the non-catecholamine group. Criteria for catecholamine administration were at the discretion of the physician. Catecholamine therapies included monotherapy with dopamine, dobutamine, or noradrenaline, or combinations of any 2 or all of these 3 drugs. Patients who were given catecholamines intraoperatively, but in whom catecholamines could be discontinued after admission to the ICU, were classified as the non-catecholamine group. The following 11 items were investigated as predictors: age (< 80 years, ≥ 80 years), severity of peritoneal contamination, time from the onset of abdominal pain (< 12 hours, ≥ 12 hours), presence/absence of chronic renal failure, presence/absence of steroid use, mean blood pressure (< 70 mmHg, ≥ 70 mmHg), presence/absence of systemic inflammatory response syndrome (SIRS), white blood cell count ($< 4,000/\mu\text{L}$, $\geq 4,000/\mu\text{L}$), platelet count ($< 150,000/\mu\text{L}$, $\geq 150,000/\mu\text{L}$), serum total protein ($< 5\text{g/dL}$, $\geq 5\text{g/dL}$), and sequential organ failure assessment (SOFA) score¹⁾ (< 3 , ≥ 3). The severity of peritoneal contamination was evaluated in accordance with the Hinchey classification²⁾ as follows: Hinchey IV, contamination of the whole abdominal cavity with fecal fluids; Hinchey III, contamination with purulent ascites. Blood test data immediately before surgery were analyzed, with the cut-off levels for white blood cell and platelet counts set at the reference levels for these 2 counts at our hospital. Cut-off levels of serum total protein and SOFA scores were calculated using receiver-operating characteristic (ROC) curves: i.e. these cut-off levels were determined from the point at which the curve and the top left

Table 1 Patients characteristics

Patients (no.)	176
Age (years)	73.1
Sex	
Male	91
Female	85
Cause of perforation	
Cancer	58
Diverticulum	56
Idiopathic	55
Ulcer	3
Ischemia	2
Inguinal Hernia	2
Site of perforation	
Cecum	1
Ascending colon	12
Transverse colon	9
Descending colon	14
Sigmoid colon	100
Rectum	40
Surgical techniques	
Hartmann's procedure	129
Resection and primary anastomosis	18
Exteriolization	14
Suture with diverting stoma	14
Simple closure and drainage	1

corner of the plot are closest. As for vital signs such as blood pressure, pulse rates, and body temperature, measurements taken immediately before patients entered the operating room were used. Patients meeting 2 or more of criteria for the diagnosis of SIRS were determined to have SIRS.

The statistical significance tests employed were the χ^2 test for univariate analysis and the logistic regression model for multivariate analysis, with the significance level set at $p < 0.05$.

Results

During the study period, we investigated 176 patients (91 men, 85 women, mean age of 73.1 years) with colorectal perforation. The primary diseases were diverticular perforation in 56 patients, colorectal cancer perforation in 58, idiopathic perforation in 55, ulcer perforation in 3, ischemic perforation in one, and inguinal hernia perforation in 2. The inguinal hernia perforations were of the adoral type and were due to occlusion. The most common perforation sites were the sigmoid colon ($n=100$) and the rectum ($n=40$), while the other perforation sites were the descending colon ($n=14$), the ascending colon ($n=12$), the transverse colon ($n=9$), and the ce-

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Table 2 Characteristics of catecholamine and non-catecholamine group

		catecholamine group	non-catecholamine group	p-value
Patients		73	103	
Age		74.6 (± 12.8)	70.0 (± 12.8)	n.s
Sex	Male	32	59	
	Female	41	44	
In-hospital mortality, (%)		16 (21.9%)	6 (5.8%)	0.0015

Table 3 Univariate analysis of the relation between catecholamine and non-catecholamine group

		catecholamine group (n=73)	non- catecholamine group (n=103)	p value
age	≥ 80 years (n=61)	27 (44.2%)	34 (55.7%)	0.5849
	< 80 years (n=115)	46 (40.0%)	69 (60.0%)	
Severity of peritoneal contamination	Hinchey IV (n=78)	42 (53.8%)	36 (46.2%)	0.0030
	Hinchey III (n=98)	31 (31.6%)	67 (68.4%)	
Time from the onset of perforation	≥ 12 hours (n=109)	47 (43.1%)	62 (56.9%)	0.5728
	< 12 hours (n=67)	26 (38.8%)	41 (61.2%)	
Chronic renal failure	presence (n=22)	12 (54.5%)	10 (45.5%)	0.1835
	absence (n=154)	61 (39.6%)	93 (60.4%)	
Steroid use	presence (n=16)	8 (50.0%)	8 (50.0%)	0.4680
	absence (n=160)	65 (40.6%)	95 (59.4%)	
Mean blood pressure	< 70 mmHg (n=34)	29 (85.3%)	5 (14.7%)	0.0000
	≥ 70 mmHg (n=142)	44 (31.0%)	98 (69.0%)	
SIRS	presence (n=127)	55 (43.3%)	72 (56.7%)	0.4276
	absence (n=49)	18 (36.7%)	31 (63.3%)	
White blood cell count	$< 4,000/\mu\text{l}$ (n=65)	40 (61.5%)	25 (38.5%)	0.0000
	$\geq 4,000/\mu\text{l}$ (n=111)	33 (29.7%)	78 (70.3%)	
Platelet count	$< 150,000/\mu\text{l}$ (n=35)	14 (40.0%)	21 (60.0%)	0.8429
	$\geq 150,000/\mu\text{l}$ (n=141)	59 (41.8%)	82 (58.2%)	
Serum total protein	$< 5.0\text{g/dl}$ (n=23)	19 (82.6%)	4 (17.4%)	0.0000
	$\geq 5.0\text{g/dl}$ (n=153)	54 (35.3%)	99 (64.7%)	
SOFA score	≥ 3 (n=81)	46 (56.8%)	35 (43.2%)	0.0001
	< 3 (n=95)	27 (28.4%)	68 (71.6%)	

cum (n=1); the percentage with left colon perforation was approximately 80% in all cases (**Table 1**). Surgical techniques included all types of colostomy in 157 patients and primary intestinal anastomosis in 19. There were 73 patients in the catecholamine group; 30 patients received dopamine alone and 43 were given noradrenaline. Of the 43, 31 patients received noradrenaline doses of 0.1 γ or higher. Of the 176 patients, 22 (12.5%) died during hospitalization. The mortality rate in the non-catecholamine group was 5.8%. However the mortality rate in the catecholamine group was 21.9%, which was significantly

higher ($p=0.0015$) (**Table 2**). Comparison of the 2 groups in terms of the predictors revealed significant differences in the severity of peritoneal contamination, mean blood pressure, white blood cell count, serum total protein, and the SOFA score, and these factors correlated with shock (**Table 3**). These 5 items, which were shown to correlate with shock in the univariate analysis, were also investigated using multivariate analysis; the mean blood pressure (odds ratio, 8.46; $p=0.0003$), white blood cell count (odds ratio, 4.33; $p=0.0003$), and serum to-

Table 4 Multivariate analysis of the relation between catecholamine and non-catecholamine group

	Odds ratio	95%CI	p-value
Severity of peritoneal contamination	1.3526	0.6227 - 2.9383	0.4454
Mean blood pressure	8.4621	2.6847 - 26.6724	0.0003
White blood cell count	4.3285	1.9490 - 9.6134	0.0003
Serum total protein	7.5110	2.0753 - 27.1849	0.0021
SOFA score	1.8066	0.8340 - 3.9134	0.1337

tal protein (odds ratio, 7.51; $p=0.0021$) were found to be independent risk factors (**Table 4**).

Discussion

The mortality rates of colorectal perforation reportedly range from 12% to 26%³⁻⁷⁾. Thus, it still has a poor prognosis despite recent advances in surgical techniques and intensive care. Therefore, predicting the severity of shock and postoperative complications is essential for allowing medical professionals to select optimal treatment methods, and this also provides patients and their families with useful information for understanding disease status. Various studies have attempted to predict outcomes based on patient factors such as age and underlying disease^{3,7,8)}, employing intraoperative findings such as the severity of peritoneal contamination^{3,4)}, or blood test findings such as the white blood cell count and BE (base excess)⁹⁾. Furthermore, increasing numbers of studies using scoring systems, into which the above factors and findings are integrated, such as the acute physiology and chronic health evaluation II score (APACHE II score)¹⁰⁾ and the physiological and operative severity score for enumeration of mortality and morbidity score (POSSUM score)¹¹⁾, have been reported¹²⁻¹⁴⁾. However, one problem with predicting outcomes is that preoperative factors do not always correlate with the cause of death; various factors contribute to mortality in patients with colorectal perforation, and in addition, complications that can prove fatal alter the postoperative course. Early in the postoperative course, the most common cause of death is circulatory failure due to septic shock. However, over time, this changes to organ failures such as acute respiratory distress syndrome (ARDS) due to prolonged sepsis. Even if patients recover from the acute phases of shock and associated disorders, it is not uncommon for infections such as residual intra-abdominal abscess to relapse and disuse syndrome and aspiration

pneumonia due to decreased ADL (activities of daily living) to occur in elderly patients, ultimately resulting in death. Accordingly, in patients receiving treatment over the long term, it is difficult to predict outcomes based on preoperative factors and the results therefore lack accuracy. Therefore, in this study, we focused not on prognosis, but on shock occurring immediately after surgery which is thought to be most affected by preoperative factors. A significantly higher mortality rate was noted in patients who developed postoperative shock, making it clear that postoperative shock is related to prognosis. To improve treatment outcomes, we consider taking measures against postoperative shock to be essential.

In this study, vascular disorders correlated with the following predictors: mean blood pressure below 70 mmHg, white blood cell count below 4,000/ μ L, and serum total protein below 5g/dL. These were not patient factors such as age or severity of peritoneal contamination, but rather systemic reaction factors such as blood test findings. Generally, higher mortality is expected in patients who are elderly, who have severe peritoneal contamination, or who have long disease durations; however, no correlations with such patient factors were noted in this study. This is considered to result from these patient factors, such as age, severity of peritoneal contamination, and time from the onset of abdominal pain, affecting disease conditions but with major variability among individual patients, i.e. some 80-year-old patients maintain independent ADL, while others are bedridden, some patients with severe peritoneal contamination present to the hospital early because of severe abdominal symptoms, while others lapse into markedly disturbed consciousness following septic or hypovolemic shock. Responses to peritonitis also vary markedly among individual patients. Therefore, systemic reactions such as blood test findings or blood pressure, which

are reactions to bodily invasion, are more reflective of patient conditions. Given that preoperative hypotension is attributable to septic shock, this condition may not improve immediately after surgery. It is empirically evident that inflammatory responses due to hypercytokinemia will persist for several days, at least, after surgery even if an infectious origin is removed. Thus, for patients whose blood pressure has not been maintained before the start of surgery, it must be taken into consideration that a shock state may persist even after surgery. In addition, white blood cell levels generally increase during inflammatory states such as peritonitis, but decrease in the presence of severe infection¹⁵⁾, due to neutrophil migration to the infected tissues¹⁶⁾. In addition, decreased serum total protein is due to increased vascular permeability associated with inflammatory states such as peritonitis. These processes primarily function in the maintenance of physical equilibrium, e.g. tissue restoration or defense against infection. However, excessive invasion is thought to occasionally cause inflammatory mediators to be released to an extent that exceeds bodily control, and this condition develops into a systemic inflammatory state, in which systemic inflammatory responses progress and cause systemic damage, resulting in organ failure and possibly death. Accordingly, a decreased white blood cell count and decreased serum total protein are both considered to be indicators of systemic reactions to excessive invasion.

Surgical treatment of colorectal perforation comprises peritoneal contamination removal and procedures for dealing with perforation. Colostomy is commonly performed as a procedure for managing perforation, in efforts to avoid the risk of anastomotic leakage. However, for those who have recovered from the acute phases of shock, colostomy will likely delay social rehabilitation as well as decreasing the QOL of these patients. Furthermore, it must be taken into consideration that, at the time of colostomy closure, laparotomy under general anesthesia can also result in anastomotic leakage. There are studies showing that, in patients with diverticular perforation of the left colon, the incidence of complications following primary anastomosis was lower than that of complications following colostomy¹⁷⁾, and that, even in patients with Hinchey III / IV diverticular perforation, the incidence of anastomotic leakage

was low unless there were vascular lesions or risks such as an immunosuppressed state¹⁸⁾. Thus, primary anastomosis can be performed after carefully assessing the features of each individual case. The necessity of clarifying the criteria for its indications must be kept in mind. Risk factors associated with anastomotic leakage include incomplete anastomotic techniques and underlying diseases such as diabetes mellitus and hepatic cirrhosis. Decreased blood flow at anastomotic sites is also a major factor¹⁹⁾. Therefore, for patients with shock, anastomosis should always be avoided if possible because decreased blood flow at anastomotic sites and exacerbation of blood flow disorders due to the use of vasoactive agonists can be expected to occur in these patients. This study showed preoperative shock, and decreases in the white blood cell count and serum total protein to be risk factors for shock, raising the possibility of these factors serving as indicators for the selection of surgical techniques. On the other hand, for patients in whom the onset of shock is thought to be avoidable, primary anastomosis is an option, though it requires comprehensive analysis since anastomotic leakage is affected not only by blood flow but also by other factors such as intra-intestinal pressure, and since anastomotic leakage does occur in some patients who have undergone a routine colectomy.

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