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Original Article

Assessment of Predictors of Mortality and Severity in Patients with Colorectal Perforation

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Abstract Colorectal perforation is a life-threatening disease with high mortality and morbidity. The correct and prompt diagnosis and accurate judgment of severity are necessary. We retrospectively investigated 30 patients with colorectal perforation to assess predictors of mortality and severity, and evaluated the usefulness of computed tomography (CT) for the initial diagnosis. The severity of peritonitis was assessed using clinical factors and Physiological and Operative Severity Score for the enUmeration of Mortality and morbidity (POSSUM) scores. Abdominal free air was detected by CT in 92% of patients with colorectal perforation, whereas only 36.6% showed evidence of abdominal free air by conventional radiography. The perforation site was correctly diagnosed in 14 of 25 cases (56%). Overall mortality was 16.7%. Survivors were younger than nonsurvivors, and POSSUM physiological and mortality scores were significantly lower for survivors compared with nonsurvivors. The amount of intraperitoneal soiling by large bowel content determined disease severity in terms of the need for postoperative respiratory management. In conclusion, CT is necessary for precise diagnosis, and the POSSUM score is helpful for the evaluation of disease mortality and severity.

Key words : Colorectal perforation, POSSUM, P-POSSUM

Introduction

Colorectal perforation due to colonic cancer or benign colorectal disease is a life-threatening condition associated with high morbidity and mortality. Despite recent advances in surgery and intensive medical care, mortality rates remain at approximately 15% to 30%[1)~6)]. Bacterial contamination of the peritoneal cavity may lead to septic shock, disseminated intravascular coagulation syndrome, and multiple organ failure. Correct and prompt diagnosis of colorectal perforation is crucial; precise judgment of severity and outcome are also important to determine proper treatment and accurately explain disease severity to patients' families.

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Abbreviations :
CT : computed tomography
POSSUM : Physiological and Operative Severity Score for the enUmeration of Mortality and morbidity
P-POSSUM : Portsmouth-POSSUM
APACHE II : Acute Physiology And Chronic Health Evaluation II
MPI : Mannheim Peritonitis Index
SAPS II : Simplified Acute Physiology Score II
PMX : polymyxin B-immobilized fiber column
CDDF : continuous hemodiafiltration

Computed tomography (CT) has been a valuable method in the diagnosis of alimentary tract perforation because of its rapidity, lack of need for patient preparation, and high sensitivity[7]. It can detect amounts of abdominal free air too small for detection by conventional radiography. Furthermore, indirect findings of bowel perforation, such as inflammation, abscess formation, peritoneal fluid collection, or extraluminal foreign bodies, can also be demonstrated by CT[8].

Various scoring systems to assess severity, such as the Acute Physiology And Chronic Health Evaluation II (APACHE II), Mannheim Peritonitis Index (MPI), Physiological and Operative Severity Score for the enUmeration of Mortality and morbidity (POSSUM), and the Simplified Acute Physiology Score II (SAPS II), have been reported[9)~11)]. However, a consensus regarding an ideal and generally accepted scoring system has not yet been reached.

Operative mortality is an objective outcome parameter that can be used to monitor surgical performance and compare treatment quality. POSSUM was first described as a method for normalizing patient data, which could then be used to compare patient outcomes despite differing patterns of referral and population[5] and predict patient morbidity and mortality. The mortality assessed by the original POSSUM has tended to be higher than that observed in hospitals ; thus, the Portsmouth-POSSUM (P-POSSUM) was developed as a modification of the original POSSUM to provide a more accurate prediction of mortality[12]. Here, to assess predictors of mortality and severity of colorectal perforation, we retrospectively investigated 30 patients with colorectal perforation. We also evaluated the importance of CT to the initial diagnosis with respect to the existence of abdominal free air and the site of perforation.

Materials and Methods

From January 2000 to December 2009, 30 patients who received emergent operations for colorectal perforation at Fukuoka-Higashi Medical Center were included in the present study. We retrospectively reviewed all patients' records and collected data regarding sex, age, cause, and site of the perforation ; type of intervention; laboratory examination findings including serum endotoxin ; physiological findings; presence of treatment by polymyxin B-immobilized fiber column (PMX) ; operative findings; perioperative complications; length of hospital stay ; and postoperative respirator management. The severity of peritonitis was also recorded according to the staging system of complicated colonic diverticulitis proposed by Hinchey et al. as follows[13] : Stage I, pericolic abscess ; Stage II, pelvic abscess ; Stage III, diffuse purulent ; and Stage IV, fecal.

The POSSUM and P-POSSUM use 12 physiological parameters (age, cardiac history, respiratory history, blood pressure, pulse rate, Glasgow Coma Scale, hemoglobin level, white cell count, urea concentration, sodium level, potassium level, and electrocardiography) and 6 operative parameters (operative severity, multiple procedures during operation, total blood loss, peritoneal soiling, presence of malignancy, and mode of surgery). The POSSUM mortality and morbidity are evaluated by the equation previously described[9)12)].

Statistical analyses were performed using chi-square analysis. A p value of less than 0.05 was considered statistically significant.

Results

Patients' ages ranged from 37 to 98 years (mean, 71.2 ± 15.8 years). There were 14 (46.7%) women aged 40 to 93 years (mean, 73.0 ± 17.7 years) and 16 (53.3%) men aged 37 to 98 years (mean, 69.6 ± 14.4 years). Colonic perforation sites consisted of the cecum to transverse colon (n = 9), the descending to sigmoid colon (n = 17), the rectum (n = 3), and the whole colon (n = 1). Colonic perforation causes consisted of malignancy (n = 8), diverticulitis (n = 9), foreign body (n = 6), ischemia/necrosis (n = 5), and idiopathic (n = 2).

Surgical procedures consisted of colostomy with or without resection of the perforation site ($n = 25$) and resection with direct anastomosis ($n = 5$). The PMX treatment was performed in 16 patients. The overall mortality rate was 16.7% (5/30).

The diagnostic imaging features of colorectal perforation are listed in Table 1. Abdominal free air was detected by CT in 23 of 25 cases (92%), whereas only 11 of 30 (36.6%) showed evidence of abdominal free air by conventional radiography. The colorectal perforation site was precisely diagnosed in 14 cases (56%), and the most common site of colorectal perforation was the sigmoid colon.

Comparisons of clinical factors between survivors and nonsurvivors of colorectal perforation are shown in Table 2. There were no significant differences in sex, causes of perforation, type of intervention, WBC counts, peritoneal soiling, serum endotoxin, or the presence of PMX treatment between survivors and nonsurvivors. In our study, nonsurvivors were elderly (84.2 ± 12.2 vs. 68.6 ± 15.3 years of age) and had higher POSSUM physiological (31.4 ± 4.9 vs. 23.3 ± 6.1) and mortality (54.6 ± 16.9 vs. 32.0 ± 20.0) scores.

Because the mortality assessed by the original POSSUM has tended to be higher than that observed in hospitals, the P-POSSUM was also used for evaluation. Nonsurvivors also had higher P-POSSUM mortality scores (41.2 ± 20.1 vs. 17.5 ± 16.8), and suffered from many postoperative complications, such as respiratory and infectious diseases.

Characteristics of 5 colorectal perforation nonsurvivors are listed in Table 3. Case 1 showed severe ischemia of the whole colon with multiple perforations; the pathological examination of the resected colon showed nonspecific inflammation of unknown cause. Case 2 suffered from right renal pelvis carcinoma with obstructive ileus due to tumor invasion. Case 3 had preoperative pseudomembranous colitis and postoperative anastomotic leakage and pneumonia. Case 4 had chronic heart failure due to severe dilated cardiomyopathy ; asthma; panperitonitis secondary to idiopathic transverse colon rupture ; atrial fibrillation and flutter; and wound infection. Case 5 had rheumatoid arthritis secondary to many years of steroid treatment ; panperitonitis due to perforation of sigmoid colon diverticulitis ; and postoperative pneumonia.

To evaluate the factors affecting both disease mortality and severity, survivors were divided into 2 groups based on the necessity for postoperative respirator management. Comparisons of

Table 1 Diagnostic imaging features of colorectal perforation

Factor	No. of cases	Free air detection by X-p	Free air detection by CT	Site identification by CT
Site of perforation				
Cecum-Transverse	9	3/9	6/7	1/7
Descending-sigmoid	17	6/17	14/14	13/14
Rectum	3	1/3	2/3	0/3
Total colon	1	1/1	1/1	0/1
Diagnosis				
Malignancy	8	4/8	7/7	6/7
Diverticulum	9	1/9	6/8	4/8
Foreign body	6	2/6	4/4	2/4
Acute ischemia, necrosis	5	2/5	4/4	2/4
Idiopathic	2	2/2	2/2	0/2
Total	30	11/30	23/25	14/25
Correct diagnosis (%)		36.7%	92%	56%

Table 2 Comparison of clinical factors between survivors and nonsurvivors

Variable		Survivors (n=25)	Nonsurvivors (n=5)	
Age		68.6 ± 15.3	84.2 ± 12.2	$p < 0.05$
Sex	Male	13	3	NS
	Female	12	2	
Sites of perforation				
	Cecum to transverse	6	3	NS
	Descending, sigmoid	16	1	
	Rectum	3	0	
	Total colon	0	1	
Causes of perforation				
	Malignancy	7	1	NS
	Diverticulum	8	1	
	Foreign body	6	0	
	Ischemia, necrosis	4	1	
	Idiopathic	0	2	
Type of intervention				
	Colostomy (including Hartmann)	21	4	NS
	Resection with primary anastomosis	4	1	
WBC (/mm^3)				
	< 3,000	7	6	NS
	3,000–10,000	16	13	
	> 10,000	7	6	
Hb (g/dL)		12.8 ± 2.6	11.6 ± 2.3	NS
Platelet (x10^4/mm^3)		20.4 ± 9.0	29.2 ± 6.6	NS
Potassium (mEq/L)		3.78 ± 0.31	3.88 ± 0.83	NS
Sodium (mEq/L)		138 ± 3.6	139 ± 12.1	NS
Creatinine (mg/dL)		1.04 ± 0.65	1.14 ± 0.16	NS
BUN (mg/dL)		21.9 ± 12.3	28.5 ± 8.2	NS
Pulse rate (/min)		99.4 ± 21.4	80 ± 19.8	NS
Systemic blood pressure (mmHg)				
	< 80	2	1	NS
	80–170	22	4	
	> 170	1	0	
Operation time (min)		157 ± 38.2	131 ± 17.6	NS
Blood loss (g)		206 ± 261	32.5 ± 17.3	NS
Peritoneal soiling				
	local	14	3	NS
	free bowel content	11	2	
Hinchey				
	1	2	0	NS
	2	4	0	
	3	5	2	
	4	14	3	
Endotoxin				
	negative	8	1	NS
	positive	2	1	
PMX treatment				
	non	11	3	NS
	done	14	2	
POSSUM				
	Physiological	23.3 ± 6.1	31.4 ± 4.9	$p < 0.01$
	Operative	19.2 ± 3.2	19.8 ± 4.0	NS
	Morbidity	75.5 ± 20.0	93.4 ± 4.7	NS
	Mortality	32.0 ± 20.0	54.6 ± 16.9	$p < 0.05$
Portsmouth-POSSUM				
	Mortality	17.5 ± 16.8	41.2 ± 20.1	$p < 0.01$
Period of hospital stay (day)		71.4 ± 46.6	38.8 ± 29.8	NS
Period of respirator (day)		11.1 ± 27.6	9.4 ± 11.0	NS
Postoperative complication				
	Respiratory	5	3	NS
	Cardiac	2	1	
	Infection	14	2	
	Liver, renal	0	2	
	Others	2	2	

Table 3 Characteristics of 5 colorectal perforation cases who died after surgery

Case	Sex	Age	Site of perforation	Diagnosis	Type of intervention	Peritoneal Soiling	Preoperative complication	Post operative complication
1	F	88	total colon	ischemia	colostomy with resection	free bowel content	enterocolitis	Perforation of SI MRSA infection
2	F	79	cecum	malignancy	colostomy	free bowel content	renal pelvis tumor	renal failure
3	M	98	cecum	inflammation	resection with anastomosis	local	pseudomembranous colitis, OMI	anastomotic leakage pneumonia
4	M	66	transverse colon	idiopathic	colostomy	free bowel content	heart failure	cardiac arrest SSI
5	M	90	sigmoid colon	diverticulitis	colostomy	local	RA	pneumonia

Case	POSSUM				P-POSSUM	WBC	endotoxin	PMX	Hinchey
	Physiological	Operative	Morbidity	Mortality	Mortality				
1	36	20	97	70	62	12700	< 1.0	done	4
2	30	26	98	73	56	1500	-	done	4
3	37	15	95	54	48	9100	-	none	3
4	28	19	90	41	23	6400	-	none	4
5	26	19	87	35	17	6800	-	none	4

SI ; small intestine, SSI ; surgical site infection, RA ; rheumatoid arthritis, OMI ; old myocardiac infarction

clinical factors between patients with and without postoperative respirator management are listed in Table 4. In the current study, patients requiring respirator management were elderly (74.6 ± 10.5 vs. 62.1 ± 17.4 years of age), had severe peritoneal soiling (92.3% vs. 16.7%), and had higher POSSUM physiological (25.8 ± 5.3 vs. 20.6 ± 5.8), operative (21.2 ± 2.9 vs. 17.1 ± 2.0), morbidity (87.7 ± 9.5 vs. 62.3 ± 20.0), and mortality (43.9 ± 17.6 vs. 19.1 ± 13.5) scores ; they also had higher P-POSSUM mortality scores (25.8 ± 17.7 vs. 8.6 ± 10.5). The length of hospital stay was significantly longer in the group of patients requiring respirator management (104.3 ± 45.2 vs. 41.3 ± 20.5 days). Compared with survivors, nonsurvivors suffered from many postoperative complications, including respiratory, cardiac, and infectious diseases.

Discussion

In the present study, we retrospectively investigated 30 patients with colorectal perforation to assess predictors of mortality and severity ; we also evaluated the importance of CT to the initial diagnosis of colorectal perforation. Abdominal free air was detected by CT in 92% of patients with colorectal perforation, whereas only 36.7% of patients with colorectal perforation were correctly diagnosed by conventional radiography. CT is a quite valuable method for diagnosing alimentary tract perforations, allowing for prompt treatment of these diseases without complicated procedures[7].

There has been much discussion regarding factors influencing the prognosis of patients with colorectal perforation ; these factors include pre-and postoperative laboratory data, intraoperative findings, and operative procedures such as age, preoperative base excess, serum creatinine level, platelet count, postoperative WBC, presence of shock, mean blood pressure, diffuse peritonitis, and preoperative organ failure[3)4)6)14)15)]. In the present study, only age was related to mortality. Significant factors vary among the literature, probably indicating difficulty in determining single factors.

In general, scoring systems allow for objective and systematic assessment of disease severity. Such systems seem useful for the comparison of treatment effectiveness by disease severity.

Table 4 Comparison of clinical factors between patients with and without postoperative respirator management

Variable		Respirator − (n=25)	Respirator + (n=13)	
Age		62.1 ± 17.4	74.6 ± 10.5	$p < 0.05$
Sex	Male	5	8	NS
	Female	7	5	
Sites of perforation				
	Cecum to transverse	3	3	NS
	Descending, sigmoid	7	9	
	Rectum	2	1	
	Total colon	0	0	
Diagnosis				
	Malignancy	3	4	NS
	Diverticulum	6	2	
	Foreign body	2	4	
	Ischemia, necrosis	1	3	
	Idiopathic	0	0	
Type of intervention				
	Colostomy (including Hartmann)	8	13	NS
	Resection with primary anastomosis	4	0	
WBC (/mm^3)				
	< 3,000	1	5	NS
	3,000–10,000	6	7	
	> 10,000	5	1	
Hb (g/dL)		12.6 ± 3.0	12.6 ± 2.7	NS
Platelet (x10^4/mm^3)		19.8 ± 9.7	20.4 ± 8.9	NS
Potassium (mEq/L)		3.86 ± 0.34	3.77 ± 0.31	NS
Sodium (mEq/L)		138 ± 3.6	138 ± 4.3	NS
Creatinine (mg/dL)		1.05 ± 0.42	1.04 ± 0.65	NS
BUN (mg/dL)		22.8 ± 8.9	21.9 ± 12.3	NS
Pulse rate (/min)		103 ± 25.2	99 ± 21.3	NS
Systemic blood pressure (mmHg)				
	< 80	2	1	NS
	80–170	22	4	
	> 170	1	0	
Operation time (min)		141 ± 25	157 ± 38.2	NS
Blood loss (g)		169 ± 17.3	206 ± 261	
Peritoneal soiling				
	local	10	1	$p < 0.01$
	free bowel content	2	12	
Hinchey				
	1	2	0	$p < 0.01$
	2	4	0	
	3	4	1	
	4	2	12	
Endotoxin				
	negative	3	5	NS
	positive	0	2	
PMX treatment				
	non	9	2	NS
	done	3	11	
POSSUM				
	Physiological	20.6 ± 5.8	25.8 ± 5.3	$p < 0.05$
	Operative	17.1 ± 2.0	21.2 ± 2.9	$p < 0.01$
	Morbidity	62.3 ± 20.0	87.7 ± 9.5	$p < 0.01$
	Mortality	19.1 ± 13.5	43.9 ± 17.6	$p < 0.01$
Portsmouth-POSSUM				
	Mortality	8.6 ± 10.5	25.8 ± 17.7	$p < 0.01$
Period of hospital stay (day)		41.3 ± 20.5	104.3 ± 45.2	$p < 0.01$
Period of respirator (day)		−	21.4 ± 36.0	
Postoperative complication				
	Respiratory	0	5	NS
	Cardiac	0	2	
	Infection	5	9	
	Liver, renal	0	0	
	Others	1	1	

Prognostic scoring systems such as ASA, APACHE II, Sequential Organ Failure Assessment (SOFA), and the MPI are reportedly significantly related to poor prognoses of colorectal emergent diseases[4)6)14)]. For example, APACHE II scores, which are routinely used in the emergency room to evaluate the severity of patients, have some advantages, such as the ability to compare pre-and postoperative physiological conditions ; however, they do not contain factors related to peritonitis or surgical stress. On the other hand, the MPI contains information regarding peritonitis, but does not reflect the physiological response caused by body damage. Furthermore, some factors in the MPI are subjective or unable to be precisely judged[15)]. If the assessment was only performed based on the macroscopic degree of peritonitis at the time of operation, then other factors that influence the physiological response, such as the time from the onset of perforation to the operation, could be ignored.

The POSSUM score was devised specifically for prediction of surgical treatment. It consists of 12 physiological and 6 operative variables that can be easily recorded and satisfactorily reproduced by resident staff with minimal difficulty. The POSSUM is a good predictor of morbidity and mortality in patients undergoing emergent laparotomy ; the P-POSSUM predicts mortality equally well[16)]. Jones et al. compared POSSUM and APACHE II scoring systems for prediction of surgical patient outcomes in a high-dependency unit and concluded that the POSSUM score was of great value[17)]. The advantage of the POSSUM score is that it contains both physiological and operative values, conveniently evaluating the severity of patients who undergo surgery. In the current study, both the mortality and severity of colorectal perforations were correlated with POSSUM physiological scores and POSSUM and P-POSSUM mortality scores. It might be useful to apply POSSUM and P-POSSUM mortality scores to the determination of surgical indications and procedures. The mortality cutoff point differs in each hospital because there are some limitations, such as the hospital volume and the number of surgeons.

Controversy surrounds the choice between colostomy (i.e., Hartmann's procedure) and primary anastomosis for resection of colonic perforations. Studies have compared colostomy with primary anastomosis[18)19)]. Gooszen reported that primary anastomosis is safe and effective in nonobstructed cases of complicated diverticular disease[18)]. Nespoli et al. determined that the type of surgical procedure did not influence the outcome, but that mortality rate was related to the severity of peritonitis as measured by APACHE II and MPI[19)]. They suggested that in Hinchey's stages 1 and 2 diseases (e.g., localized peritonitis), which are generally associated with low APACHE II scores, primary resection and anastomosis might be optimal19). In the current study, there was no significant survival difference in the surgical procedures between resection with anastomosis and resection or nonresection without anastomosis (Hartmann's operation and simple colostomy). This might have been due to the selection bias of choosing the latter procedures because the majority of cases were categorized into Hinchey's stages 3 and 4 (24 of 30).

The PMX is widely used in Japan as a new technique for selective endotoxin removal, whereas the indication for this therapy is still controversial[20)]. In the current study, the PMX treatment was performed in 16 patients, including 2 nonsurvivors. There was no significant difference in survival between the cases with and without PMX treatment. Komatsu S et al. investigated the predictive value of various severity scoring systems for survival and efficacy of PMX treatment. Although some scoring systems may be useful for determining the ineffectiveness of PMX, further investigation is required to evaluate the precise indications for PMX treatment[21)].

To investigate the factors regulating disease

severity, survivors were divided into 2 groups based on the necessity for postoperative respirator management. Because patients with severe physiological conditions such as sepsis and multiple organ failure required postoperative respiratory management, this could be a parameter of disease severity. In the current study, peritoneal soiling (Hinchey's classification) and POSSUM and P-POSSUM scores were significantly correlated with the necessity for postoperative respirator management. Horiuchi et al. selected continuous hemodiafiltration (CHDF) to determine the severity of colonic perforation, and reported that APACHE II and MPI scores were higher in patients with CHDF than in patients without CHDF. They concluded that scoring systems such as the APACHE II and MPI seem likely to become indices for the determination of patients' treatment location. Interestingly, mortality and morbidity are closely related to the extent of intraperitoneal infection according to Hinchey's classification[15]. Together with our results, scoring systems such as POSSUM and P-POSSUM could be helpful for the determination of treatment, and Hinchey's classification might be helpful for the determination of therapeutic options.

We herein reviewed cases of colorectal perforation to clarify the clinically important factors related to diagnosis and management ; we also evaluated the significance of scoring systems for this disease. CT is necessary for precise diagnosis of colorectal perforation, and the POSSUM score is helpful for the evaluation of both disease mortality and severity.

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（和文抄録）

大腸穿孔症例における死亡率及び重症度予測因子についての検討

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大腸穿孔症例は未だに死亡率が非常に高く，正確で迅速な診断および重症度判定が必要とされる．我々は，レトロスペクティブに 30 例の大腸穿孔症例を解析し，初期診断における CT の有用性，また死亡率及び重症度予測因子についての検討を行った．腹膜炎の重症度については，臨床上の諸因子および POSSUM スコアを用いて評価した．腹腔内遊離ガスの同定は，単純 X 線検査では 36.7% のみであったのに対して，CT では 92% で同定可能であった．さらに穿孔部位の同定も CT 上 25 例中 14 例（56%）で可能であった．本研究における大腸穿孔に対する手術症例の死亡率は 16.7% であった．生存例は死亡例と比較し，年齢が若く，POSSUM スコア（Physiological score, Mortality）が有意に低かった．腹腔内汚染腹水の程度は，術後呼吸器管理の必要性を指標とした重症度と関連していた．大腸穿孔の診断には CT が優れており，POSSUM スコアは死亡率および重症度の評価に有用であった．