Influence of Time on Risk of Bowel Resection in Complete Small Bowel Obstruction

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BACKGROUND: Little is known about the effect of passing time on risk of resection among patients with complete small bowel obstruction. We sought to provide a benchmark of the relationship of time from symptom onset to surgical treatment on the need for resection in patients with complete small bowel obstruction.

STUDY DESIGN: We performed an observational study of patients with surgically treated complete small bowel obstruction at an inner-city urban tertiary referral center and a municipal hospital. Patients were sampled randomly retrospectively (n = 60), and prospectively (n = 81), for a final sample of 141. Detailed clinical and time data were abstracted from medical records including out-of-hospital examinations. Risk of resection was calculated using actuarial life table methods. Linear regression was used to determine factors affecting time to treatment.

RESULTS: All patients were treated surgically for obstruction; 45% underwent resection. Resected patients had longer (11 days versus 8 days; p = 0.01) and more complicated (31% versus 14% in ICU; p = 0.01) hospital stays. The risk of resection was 4% among patients with 24 hours of unresponsive symptoms; it increased to 10% to 14% through 96 hours, then dropped slightly but did not disappear. Patients treated first with a tube had longer times between first examination and operation, system-time (40.6 hours versus 10.2 hours; p = 0.0007), but this was not associated with an increased resection risk. System-times were shorter among patients seen first in the emergency department (median: 25.7 hours versus 59.7 hours; p = 0.0001).

CONCLUSIONS: Physicians should be cautious in postponing surgery beyond 24 hours in patients with unresponsive symptoms from complete obstruction. The risk of resection rises dramatically, remains elevated through 96 hours of unresolved symptoms, then declines but does not disappear. (J Am Coll Surg 2005;201:847–854. © 2005 by the American College of Surgeons)

Delays in care result in worse outcomes for patients with acute surgical conditions. For complete small bowel obstruction, substantial delays between symptom onset and definitive treatment may increase the need for resection, placing patients at increased risk for infection and other complications.[1-4] Yet there are few data to help guide the swiftness with which surgical intervention should take place in these patients.[4-7] Past research has failed to identify clinical factors that might enable physicians to reliably predict which patients could safely undergo conservative care.

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The lack of definitive clinical parameters to assess a patient's risk of resection highlights the need to identify additional objective measurable risk factors. Time between symptom onset and surgery may be one such factor. But previous research has not established a conclusive association between time to operation and risk of resection, perhaps owing to inconsistent data collection and data analysis methods.[3,4,6-11] We undertook this study to provide benchmark data of the relationship of increasing time between symptom onset and treatment to risk of resection among patients with complete small bowel obstruction. Such data can serve to guide the speed with which surgeons should intervene in patients with complete obstruction. To overcome the methodologic limitations of earlier studies, we used rigorous methods to measure time of symptom onset, entry into the health-care system for treatment, and time of definitive therapy.

We focused on resection rather than mortality and

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perforated or gangrenous bowel, relatively uncommon outcomes, because resection is commonly performed in cases of obstruction and is associated with prolonged hospitalizations, the need for repeated operations, increased risk of infection, and increased risk of subsequent adhesion formation.[1,4]

METHODS

This study, conducted in two phases at two New York City hospitals (a 1,171-bed tertiary referral center and a 450-bed municipal teaching hospital) was part of a larger study designed to measure the relationship of time between symptom onset and treatment and risk of poor outcomes, and to assess the reasons for delays to treatment. The first phase was a retrospective assessment of the relationship between time and outcomes (January 1, 1996, to December 31, 1998). The second phase, a prospective survey assessment of physician and patient perceptions of elements that facilitated or impeded care (June 1, 2001, to December 31, 2002), also included the same chart abstraction as in phase I. For both phases, inpatient, emergency department, clinic, and physician office medical records were abstracted after hospital discharge. One hundred twenty-five physician offices provided access to their medical records. Chart abstraction data from both phases were pooled to increase the sample size and power. This article reports the association between time and risk of resection as determined from medical record review. The Institutional Review Boards of both facilities approved the study protocols.

In both study phases, patients of all ages having an ICD-9-CM code diagnosis for one of the following conditions were included: intussusception (560.0); volvulus (560.2); other specified bowel obstruction (560.8); bowel or peritoneal adhesions with obstruction (560.81); unspecified bowel obstruction (560.9); and perforation of bowel (569.83). Patients who lacked objective evidence of small bowel obstruction on imaging studies or at operation were excluded. Radiographic evidence of obstruction was defined as dilated loops of small bowel with minimal gas in the colon. Complete obstruction was confirmed at operation, with the finding of dilated bowel proximal to, and collapsed bowel distal to, a point of obstruction.

In phase I, 423 patients with the previously mentioned ICD-9 discharge diagnoses were identified. One hundred ninety were excluded because they lacked objective surgical or imaging evidence of small bowel obstruction, resulting in a cohort of 233 patients with partial or complete bowel obstruction. Of these, 60 had complete obstruction as determined at operation. In phase II, of the 328 patients with a presumptive diagnosis of obstruction, 60 lacked objective evidence of obstruction, 5 did not receive a definitive treatment, and charts were unobtainable for 2. Of the 261 eligible patients with small bowel obstruction, 81 had complete obstruction, resulting in a combined final sample of 141.

Phase I patients differed from phase II patients in bowel resection rates (35% versus 53%, respectively; $p = 0.03$), insurance coverage (Medicare: 40% versus 6%; $p < 0.0001$), commercial insurance (42% versus 70%; $p = 0.0001$), rebound tenderness (13% versus 2%; $p = 0.02$), having a CT scan (25% versus 64%; $p < 0.0001$), and the clinician's diagnostic impression of bowel obstruction (67% versus 41%; $p = 0.001$). These differences likely occurred because of the different sampling strategies, because phase I patients were randomly selected retrospectively from the entire cohort of bowel obstruction patients and phase II patients were identified prospectively. Because of these differences and the need to control for their potential effects, the phase of study was entered into multivariable models.

Date and time of symptom onset were obtained from the patient's initial examination after symptoms began. Time of symptom onset was based on the history taken during the first examination. Because 31% of patients had initial examinations outside the participating hospitals and emergency rooms, we tracked back to the site of initial care and abstracted those medical records in addition to the study hospital, clinic, and emergency room charts. We assigned specific times to those reported descriptively. For example, "AM" was coded as 8 AM, "middle of the night" as 3 AM, and "today" as halfway between 12 AM and the time of examination. To determine the times at which physicians performed physical examinations, data abstracted from the office- or hospital-based medical records, including physician notes, nursing notes documenting the physician examinations, and medication order forms were used. Exact times of examinations were recorded in 99% of patient charts. When the time of an event in the process of care was not specified, the midway point between documented times was used. For example, if the time of first examination was missing, but records showed that the patient was registered in the emergency department at 4 AM and transferred to the operating room at 8 AM, we estimated that the physician examination occurred at 6 AM. For office

examinations lacking data on time, we determined the physician office hours that day and took the midpoint.

The assessment portion of the initial examination note was reviewed to gauge the physician's diagnostic impression about bowel obstruction. "Diagnostic certainty" was assigned to patients for whom bowel obstruction or acute abdomen with intestinal obstruction was the first diagnosis. Diagnoses classified as certain included bowel obstruction, intussusception, volvulus, strangulated hernia, obstruction with adhesions, gangrenous or perforated bowel with obstruction, and nonmechanical obstruction. All other diagnoses were considered uncertain. Comorbidities were assessed using the Charlson Comorbidity Index.[12]

Time between symptom onset and definitive treatment was divided into patient time, ie, the time from symptom onset to first physician examination, and system time, ie, the time from first examination to operation. Total time was the sum of patient and system times. We differentiated between patient and system times because different patient demographic and health status factors and different health system factors could affect the duration of each.[13]

To assess the changing risk of resection with time, we used actuarial life table methods to obtain estimates of conditional risks.[14] This method allows assessment of the likelihood that a patient who has not been treated by designated times after symptoms begin will undergo resection within a specified period of time. Time was divided into intervals, initially of 24 hours, then 48 hours, and finally longer as the data became more sparse, and we assumed a constant risk of resection within the specified time intervals. We then estimated the probabilities that a patient who had not been treated by the beginning of each interval would undergo resection in the ensuing 24 hours, choosing this time period because clinically, this seemed a reasonable time period to assume treatment would be initiated. The starting time was the onset of first symptoms and time of resection was taken as the time of the operation during which resection was performed.

Chi-square analyses, *t*-tests, and Wilcoxon rank sum tests were used for bivariate comparisons. Statistical significance was represented by p values less than 0.05. We used logistic regression to assess the influence of the passage of time on risk of resection while controlling for other factors and linear regressions to determine factors that were associated with time to treatment. The outcomes variable of time was log-transformed to approximate a normal distribution. Models included a variable for the phase of the study to adjust for differences in the phases' patient populations. Finally, odds ratios were corrected to approximate relative risks using the method of Zhang and Yu.[15]

RESULTS

Table 1 shows the demographic and clinical characteristics of the study cohort. Patient mean age was 58 years. One-quarter had a history of malignancy, and 37% had an earlier history of bowel obstruction. Eighty-nine percent had previously undergone abdominal or pelvic surgery. Although vomiting and abdominal pain occurred at high frequencies (81% and 92% of patients, respectively), other classic signs and symptoms of obstruction were present in relatively few patients. Only 9% of patients had not passed flatus in the 24 hours before hospital admission, 60% had distention, 17% had guarding, and 6% had absent or high-pitched bowel sounds.

Of the 141 patients studied, 24% presented in a physician's office outside the hospital. Fifty-two percent of physicians conducting the patients' initial examinations listed intestinal obstruction as the first diagnosis.

Small bowel resection was performed in 45% (64 of 141) of patients. Patients who had a resection were less likely than those without resection to have reported nausea or vomiting before admission (87% versus 73%; $p = 0.04$). There were no significant differences between the two groups for clinical variables that physicians can use to determine a diagnosis of obstruction and its severity, including: history of earlier obstruction or abdominal or pelvic surgery, comorbidity, heart rate, temperature, blood pressure, distention, absent or high-pitched bowel sounds, guarding, rebound, or white blood cell count. Patients with obstruction caused by adhesions were less likely than those with other causes, such as volvulus, incarcerated hernia, malignancy, or Crohn's disease, to undergo resection (36% versus 71%; $p < 0.001$). Patients tended to be less likely to undergo bowel resection when their physicians listed obstruction as the first diagnosis (diagnostic certainty: 60% versus 44%; $p = 0.06$). In a multivariable logistic analysis that adjusted for age, gender, and study phase, neither nausea and vomiting nor diagnostic certainty remained statistically significant.

Table 1. Characteristics of Patients With and Without Intestinal Resection

Characteristics	Total (n = 141)	No resection (n = 77)	Resection (n = 64)	p Value
Demographics				
Mean age, y (SD)	58.0 (21.9)	57.5 (21.9)	58.5 (22.0)	0.77
0–17, n (%)	6 (4)	3 (4)	3 (5)	
18–64, n (%)	71 (50)	42 (55)	29 (45)	
≥ 65, n (%)	64 (45)	32 (42)	32 (50)	
Women, n (%)	87 (62)	48 (62)	39 (61)	0.86
Race/ethnicity				0.79
African American, non-Hispanic, n (%)	26 (18)	16 (21)	10 (16)	
Caucasian, non-Hispanic, n (%)	80 (57)	41 (53)	39 (61)	
Hispanic, n (%)	20 (14)	11 (14)	9 (14)	
Other, n (%)	15 (11)	9 (12)	6 (9)	
Non-English speaker, n (%)	27 (18)	16 (21)	10 (16)	0.43
Insurance type*				0.86
Medicare, n (%)	28 (20)	15 (20)	13 (21)	
Medicaid/self-pay, n (%)	29 (21)	17 (21)	12 (19)	
Private, n (%)	81 (59)	43 (57)	38 (60)	
Medical history				
Chronic obstructive lung disease, n (%)	5 (4)	1 (1)	4 (6)	0.18
Congestive heart failure, n (%)	10 (7)	4 (5)	6 (9)	0.51
Dementia, n (%)	5 (4)	3 (4)	2 (3)	1.00
Diabetes mellitus, n (%)	12 (9)	5 (6)	7 (11)	0.38
Inflammatory bowel disease, n (%)	17 (12)	10 (13)	7 (11)	0.71
Malignancy, n (%)	35 (25)	18 (23)	17 (27)	0.66
Myocardial infarction, n (%)	10 (7)	6 (8)	4 (6)	1.00
Obesity, n (%)	17 (12)	9 (12)	8 (13)	0.88
Psychiatric illness, n (%)	8 (6)	5 (6)	3 (5)	0.64
Prior intestinal obstruction, n (%)	52 (37)	27 (35)	25 (39)	0.62
Prior surgery, abdominal/pelvic, *n (%)	126 (89)	68 (88)	58 (91)	0.77
Present illness				
Nausea/vomiting, n (%)	114 (81)	67 (87)	47 (73)	0.04
No flatus in past 24 h, n (%)	12 (9)	4 (5)	8 (13)	0.14
Abdominal pain, n (%)	130 (92)	68 (88)	62 (97)	0.45
Analgesic before first exam, n (%)	24 (17)	10 (13)	14 (22)	0.16
Site of initial exam				
Clinic/physician's office, n (%)	34 (24)	18 (23)	16 (25)	0.10
Emergency room, n (%)	91 (65)	53 (69)	38 (60)	0.10
Transfer from different hospital or nursing home, n (%)	15 (11)	6 (8)	9 (15)	0.23
Findings at initial exam				
Heart rate (beats/min), mean	91	92	90	0.51
Systolic blood pressure (mmHg), mean	134	133	135	0.68
Diastolic blood pressure (mmHg), mean	78	77	78	0.95
Temperature (°C), mean	36.8	36.8	36.7	0.46
Abdominal exam				
Distention, n (%)	84 (60)	47 (61)	37 (58)	0.70
No bowel sounds, n (%)	9 (6)	5 (6)	4 (6)	1.00
Tenderness, n (%)	90 (64)	49 (64)	41 (64)	0.96

(continued)

Table 1. (continued)

Characteristics	Total (n = 141)	No resection (n = 77)	Resection (n = 64)	p Value
Guarding, n (%)	24 (17)	11 (14)	13 (20)	0.34
Rebound, n (%)	10 (7)	5 (6)	5 (8)	1.00
Mass, n (%)	6 (4)	3 (4)	3 (5)	1.00
Initial WBC (per μL), mean	10,907	10,563	11,320	0.42
Diagnostic certainty, n (%)	75 (52)	46 (60)	28 (44)	0.06

Chi-square or *t*-test.
*The insurance and prior surgery variables are missing data from 3 patients.

Association between time and risk of bowel resection

Patient and system times varied widely, with a median duration of 24.0 hours and 38.5 hours, respectively (Table 2). Patient time, the time between symptom onset and first physician examination, was not significantly associated with resection. System time, the time from hospital admission to definitive operation, tended to be longer for patients who had resection compared with those who had surgery without resection. In a logistic regression model that adjusted for age, gender, presence of adhesions, diagnostic certainty, and study phase, longer system time was associated with an increased risk of resection (adjusted relative risk 1.003 per hour; 95% CI 1.00 to 1.005, p = 0.03) (Table 3). Because system time affected the risk of resection, we examined factors associated with prolonged or reduced system time.

Factors associated with system time

Prolonged system time occurred in patients with a history of malignancy (median time: 54 hours versus 30 hours; p = 0.001) and those treated initially with a tube (median time: 41 versus 10 hours; p = 0.001). Although patients treated with tubes had longer times to operation, they were no more likely to undergo resection than patients who did not have a tube placed. System time was shorter for patients who presented to an emergency department rather than a clinic or office (29 hours versus 62 hours; p = 0.0001) and in cases where the physician had diagnostic certainty of obstruction (31 hours versus 49 hours; p = 0.02). System time was also shorter for patients with physical signs suggestive of more severe illness: nausea (31 hours versus 71 hours; p = 0.002), persistent abdominal tenderness (25 hours versus 55 hours; p = 0.0001), guarding (13 hours versus 41 hours; p = 0.003), rebound tenderness (12 hours versus 41 hours; p = 0.006), and those with abnormal white blood cell counts (17 hours versus 44 hours; p = 0.003).

A multivariable linear regression model predicting system time found that patients with abdominal tenderness ($\beta = -0.51$; p = 0.005), guarding ($\beta = -0.54$; p = 0.02), elevated white blood cell counts ($\beta = -0.41$; p = 0.02), those first seen in the emergency department ($\beta = -0.63$; p = 0.001), and those for whom the first examining physician diagnosed the obstruction ($\beta = -0.56$; p = 0.002) had shorter times between first examination and treatment. Those treated first with a tube had longer system times ($\beta = 0.99$; $p < 0.0001$; model $R^2 = 0.41$; $p < 0.0001$).

Table 4 shows the probability of undergoing bowel resection at specific intervals of total time (time from symptom onset to surgery). If a patient did not have surgery in the first 24 hours after admission, then the probability of bowel resection in the next 24 hours was 4%. The risk of resection increased from 4% to 14% for individuals who did not have surgery within the first 72 hours of symptoms. The risk of resection remained greater than 10% for patients with 4 days of unresponsive

Table 2. Median Time for Patients With and Without Intestinal Resection

Time, h	All patients (n = 141)	No resection (n = 77)	Resection (n = 64)	p Value
Total (range)	76.5 (5.3–1,109)	75.6 (5.3–480)	77.1 (13.5–1,109)	0.35
Patient (range)	24.0 (0.5–624)	24.0 (0.5–456)	24.0 (0.5–624)	0.60
System (range)	38.5 (1.0–653)	32.9 (1.0–336)	43.3 (2.1–653)	0.09

Patient time = time of first examination–time of symptom onset.
System time = time of surgery –time of first examination.

Table 3. Multivariable Model of Factors Affecting Resection

Factor	Relative risk	95%CI	p Value
System time (per h)	1.003	1.00–1.005	0.03
Age (per y)	1.001	1.00–1.006	0.68
Female gender	1.02	0.63–1.41	0.94
Presence of adhesions	0.45	0.23–0.75	0.0003
+ Diagnostic certainty	0.80	0.48–1.15	0.27

Model c statistic = 0.73. Model adjusted for study phase (study phase odds ratio = 0.53 [95% CI 0.24–1.15]).
System time, time between first physician examination and surgical treatment.

symptoms, then declined, with some variability. The variability is likely from decreasing numbers of patients who remained without surgical treatment for longer than a week. Risk of resection did not disappear despite patient access to care and receipt of conservative treatment.

Complications

Patients with bowel resection tended to have a longer and more complicated hospital course than patients without resection. Patients undergoing resection had longer lengths of stay (median 11 days versus 8 days; $p = 0.03$); an increased risk of ICU admission (31% versus 14%; $p = 0.02$); and a greater, but not a statistically significant, risk of mortality (13% versus 4%; $p = 0.06$) during the admission. Resection remained significantly associated with ICU admission after adjustment for age, comorbidity, and study phase (relative risk = 2.30; 95% CI 1.02 to 4.09; model c = 0.86; $p < 0.0001$).

DISCUSSION

Time between symptom onset and treatment is a risk factor for resection among patients with complete small bowel obstruction. Our data indicate resection risk continues to rise after 24 hours, remains higher than 10% up to 96 hours after onset of symptoms, and then declines but remains ever present. These findings suggest that early intervention for patients suspected of having complete obstruction might reduce the need for bowel resection.

Research in the last 2 decades has produced conflicting findings about the benefit of early surgical intervention for treatment of suspected bowel obstruction. Resolution of symptoms with conservative management has been observed in about 65% of patients with suspected small and large bowel obstructions.[6,8] Yet others show

Table 4. Risk of Resection

Total time from symptom onset to surgery, h	Sample size at risk	Probability of resection in ensuing 24 h, %
<24	141	4
24–48	124	10
48–72	102	14
72–96	73	12
96–120	54	6
120–144	43	7
144–168	34	6
168–192	26	4
192–216	24	9
216–336	20	7
336–1,110	13	4

This is the risk of resection in a 24-hour period during each designated time interval among patients who had not undergone surgery by that amount of time after symptom onset. These risks are conditional upon time of treatment receipt. Sample size at risk is the number of untreated patients at that time.

that 54% to 87% of patients fail conservative management and require operations; those with delayed surgery experience higher complication rates, such as mortality or wound infection, and increased length of stay.[3,4,7,11] Fevang and colleagues[4] found that patients who died had a median treatment delay of 72 hours, significantly longer than the 36 hours among those surviving their obstruction. Fevang and associates[4,8,9] and Bizer and coworkers[10] evaluated the relationship between duration of untreated symptoms and nonviable bowel, but did not find a significant association. Differences in methodology may partly explain the wide range of complication rates associated with delayed surgery observed in previous studies on bowel obstruction. These studies included patients with both partial and complete obstruction, clouding the effect of time on surgical outcomes.[4,9] In addition, these studies did not focus on resection as an outcomes measure. Clinically, resection is an important outcome because it increases patients' risk of postoperative sepsis, prolongs recovery,[1,4] and, as demonstrated here, increases risk of ICU admission, longer lengths of stay, and a nonsignificant higher mortality risk.

The challenge of determining the optimal timing of surgery for patients with suspected bowel obstruction may be from the complex nature of obstruction. Obstruction results from a variety of mechanisms, may involve full or partial obstruction, and can involve different areas of the bowel, producing a range of symptoms and clinical findings. To limit the complexity of potential clinical presentations, we focused on patients with

complete small bowel obstruction at the time of operation. Despite this approach, we did not identify clinical factors associated with resection risk. The limited utility of commonly used clinical parameters to predict the risk of resection strengthens the importance of other measurable risk factors such as time.

How can these findings be helpful to physicians examining patients with suspected complete small bowel obstruction? Time, as a risk factor for resection, may provide a guide to physician action. If a patient has signs of complete obstruction that are unresponsive to conservative measures, such as bowel rest and decompression, surgeons, emergency, and primary care physicians should be alert to act sooner rather than later. Of note, the reduction in risk after 96 hours of symptoms may represent a somewhat more indolent course and provide a longer window of conservative therapy. But physicians should not be lulled by this window of time. Even though the risk of resection decreases, despite access to care and conservative therapies, the risk does not disappear.

Several limitations to this study deserve mention. First, because of a relatively small sample size with symptoms beyond 5 days, we had limited power to obtain a stable estimate of risk of resection. Second, the combined retrospectively and prospectively identified patients in these groups differed by several clinical characteristics and resection rates. The differences may have occurred from different approaches to patient finding or, less likely, from secular trends in bowel obstruction and its management. To control for potentially unobserved differences between phase I and II patients, we used a variable for study phase in all of our multivariable analyses.

We did not examine the risk of resection among patients presenting with abdominal pain, distention, nausea, and vomiting from causes other than obstruction because we sought to ascertain the effect of time on risk of poorer outcomes in patients with small bowel obstruction. This approach limits the applicability of our findings to patients with obstruction. The data do provide a time frame to help guide physician intervention for patients with complete small bowel obstruction. Some might argue that risk of resection depends on the underlying cause of obstruction. But we found a similar distribution of cancer and inflammatory bowel diseases, conditions that might result in a higher rate of resection, between patients who underwent resection and those whose surgical treatment did not entail resection. Because there was no difference in these diseases between the groups, we did not include the cause of obstruction in the models predicting resection. Last, we included only surgically treated patients for whom we had a reliable, objective assessment of complete obstruction, and we might have excluded some patients with complete obstruction whose condition resolved with conservative management. So our findings should be used with caution to prospectively identify patients who will require bowel resection.

In conclusion, prolonged time from symptom onset to definitive treatment may increase the need for bowel resection among surgically treated patients with complete small bowel obstruction. Bowel resection is associated with worse clinical outcomes, including the need for intensive care and mortality. Yet, reliably identifying patients who may safely undergo conservative management remains difficult. Pending additional prospective studies that identify clinical factors that reliably predict which patients can safely be managed conservatively, physicians should be cautious about postponing surgical treatment beyond 24 hours of unresponsive symptoms in patients with complete obstruction. For patients with sympt oms beyond 96 hours, physicians should remain vigilant because the risk of resection declines but does not disappear.

Author Contributions

Study conception and design: Bickell, Aufses
Acquisition of data: Bickell, Aufses
Analysis and interpretation of data: Bickell, Federman, Aufses
Drafting of manuscript: Federman, Bickell
Critical revision: Bickell, Federman, Aufses
Statistical expertise: Bickell, Federman
Obtaining funding: Bickell, Aufses
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