Independent risk factors of morbidity in penetrating colon injuries

Penetran kolon yaralanmalarında morbiditeye etkili bağımsız risk faktörleri

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BACKGROUND

The present study explored the factors effective on colon-related morbidity in patients with penetrating injury of the colon.

METHODS

The medical records of 196 patients were reviewed for variables including age, gender, factor of trauma, time between injury and operation, shock, duration of operation, Penetrating Abdominal Trauma Index (PATI), Injury Severity Score (ISS), site of colon injury, Colon Injury Score, fecal contamination, number of associated intra- and extraabdominal organ injuries, units of transfused blood within the first 24 hours, and type of surgery. In order to determine the independent risk factors, multivariate logistic regression analysis was performed.

RESULTS

Gunshot wounds, interval between injury and operation ≥6 hours, shock, duration of the operation ≥6 hours, PATI ≥25, ISS ≥20, Colon Injury Score ≥ grade 3, major fecal contamination, number of associated intraabdominal organ injuries >2, number of associated extraabdominal organ injuries >2, multiple blood transfusions, and diversion were significantly associated with morbidity. Multivariate logistic regression analysis showed diversion and transfusion of ≥4 units in the first 24 hours as independent risk factors affecting colon-related morbidity.

CONCLUSION

Diversion and transfusion of ≥4 units in the first 24 hours were determined to be independent risk factors for colon-related morbidity.

Key Words: Colon/injuries; penetrating colon injury; risk factor; morbidity.

AMAÇ

Penetran kolon yaralanmalı hastalarda, kolon ile ilişkili morbiditeye etkili faktörler değerlendirildi.

GEREÇ VE YÖNTEM

Hastaların (n=196) medikal kayıtlarından yaş, cinsiyet, travma etkeni, travma operasyon entervali, şok, ameliyat süresi, Penetran Abdominal Travma İndeksi (PATİ), yaralanma şiddeti ölçeği (ISS), yaralanan kolon segmenti, kolon yaralanma skoru, fekal kontaminasyon, ilk 24 saat içinde yapılan kan transfüzyonu, intra ve ekstra-abdominal yandaş yaralanan organ sayısı ve cerrahi şeklini içeren değişkenler incelendi. Bağımsız risk faktörlerini saptamak amacıyla bu değişkenlere multivaryant lojistik regresyon analizi uygulandı.

BULGULAR

Ateşli silah yaralanması, travma ameliyat entervalinin ≥6 s, şok varlığı, ameliyat süresi ≥6 s, PATİ ≥25, İSS ≥20, kolon yaralanma skoru ≥3, majör fekal kontaminasyon, karıniçi yandaş yaralanan organ sayısı >2, ekstra-abdominal yandaş yaralanan organ sayısı >2, multipl kan transfüzyonunun yapılması ve diversiyon uygulanmış olması morbiditeyle ilişkisi anlamlı bulundu. Multivaryant analiz, ilk 24 saat içinde yapılan kan transfüzyon sayısının ≥4 olması ve diversiyon uygulamasının penetran kolon yaralanmalarında kolon ilişkili morbitite gelişimi üzerine etkili bağımsız risk faktörleri olduğunu gösterdi.

SONUÇ

Kolon ilişkili morbidite gelişimi üzerine etkili bağımsız risk faktörleri; ilk 24 saat içinde yapılan kan transfüzyon sayısının ≥4 olması ve diversiyon olarak belirlendi.

Anahtar Sözcükler: Kolon/yaralanma; penetran kolon yaralanması; risk faktörü; morbidite.

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Penetrating injuries of the colon (PIC) have an important place among abdominal traumas, with high rates of morbidity and mortality.[1] The intestines occupy the abdominal cavity and thus are more likely to be injured by penetrating abdominal injuries. The colon is a common abdominal organ that is injured by gunshot wounds along with the small bowel and stomach.[2] Many studies in recent years have reported a colon-related abdominal complication (CRC) rate between 15-50%.[3,4] The major adverse outcomes after operation for colon injury are abdominal infectious complications: intra-abdominal abscess (IAA), peritonitis, wound infection, sepsis, necrotizing fasciitis, facial dehiscence, anastomotic leak, and missile tract infection. Though other complications may occur, they are attributed to the magnitude of the overall trauma and not specifically to the colon injury.[5] Moreover, organ injuries apart from the colon are not associated with a high rate of septic complication.

There have been refinements in the methods used to quantify the magnitude of factors predicting the development of CRC. The risk factors schemed by Stone and Fabian[2] in the late 1970's, which require obligatory colostomy (shock, major blood loss, number of organs injured, degree of contamination, and so forth), overlap with those described in more recent reports, including the Penetrating Abdominal Trauma Index (PATI) and hypotension on admission,[6] severe fecal contamination, transfusion of >4 units of blood within the first 24 hours (h), and single-agent antibiotic prophylaxis.[3]

The present report was performed retrospectively to define and discuss the factors that could affect the morbidity in PICs.

MATERIALS AND METHODS

Dicle University Hospital (DUH), a tertiary referral center and the largest hospital in the southeast of Turkey, cares for the vast majority of patients with traumatic injury who are referred from other hospitals. Using a standardized data collection instrument, case records of all patients with PIC diagnosed between January 1996 and December 2005 at DUH were reviewed. A total of 226 patients with PIC without rectal and/or serosal involvement were evaluated. Thirty patients died within two days of their injuries, and 196 patients survived at least 48 h after injury. Statistical analyses for evaluating morbidity were performed on patients with CRC. All patients who had emergency laparotomy after sustaining gunshot wounds (GSW) and stab wounds (SW) were included in the study.

Epidemiological and clinical features were evaluated as probable risk factors for morbidity in PIC. Findings for risk factors included: patient characteristics (age and gender), mechanism of trauma (GSW/SW), interval between injury and operation (IBIO), presence of shock during admission (PSDA) (systolic blood pressure ≤90 mmHg), duration of operation, PATI score, Injury Severity Score (ISS), and site of colon injury (right colon defined as being to the right of middle colic vessels, left colon to the left of the vessels). Patients with combined injury were included in the left colon group because they had left colon injury. Colon Injury Score (CIS) (Table 1)[1] was based on fecal contamination (minor, moderate, major),[7] number of associated intra-abdominal organ (IAO) injuries, number of associated extra-abdominal organ (EAO) injuries, transfused blood units (TBU) within the first 24 h, and type of surgery (primary repair or diversion).

Fecal contamination was classified as minimum (confined to the area of injury), moderate (confined to one quadrant of the abdomen), or major (contamination of more than one quadrant). Minor and medium fecal contaminations were included in the statistical analysis as medium contamination.

Management of colon injury was classified as primary repair (debridement with simple closure and resection with anastomosis) and diversion (loop, end stoma with Hartmann's pouch, or end stoma with mucous fistula).

Standard advanced trauma life support resuscitation protocols were used in all patients. All patients received preoperative combined antibiotics and were

Table 1. Colon Injury Score

Grade	Type of injury	Description of injury
I	Hematoma	Contusion or hematoma without devascularization
	Laceration	Partial thickness, no perforation
II	Laceration	Laceration <50% of circumference
III	Laceration	Laceration >50% of circumference without transection
IV	Laceration	Transection of the colon
V	Laceration	Transection of the colon with segmental tissue loss
	Vascular	Devascularized segment

Table 2. Postoperative CRC

CRC	n (%)
Wound infection	50 (22.1)
Intra-abdominal abscess	33 (14.6)
Facial dehiscence	18 (7.9)
Anastomotic leak	10 (4.4)
Sepsis	9 (3.9)

CRC: Colon-related complications.

maintained on antibiotics for at least 24 h postoperatively. Outcome was evaluated based on complications directly related or possibly related to the colon injury.

All data were entered into a statistical model for analyzing morbidity factors for PIC and were performed using SPSS (SPSS 10.0 for Windows, SPSS Inc.). For all univariate analyses, a chi-square test was used for binary variables. To assess predictors of morbidity, multivariable analysis using logistic regression was performed. Candidate variables either of biological importance or those with a p value <0.1 were entered, using an entry approach. Predictor variables were kept in the final model if p<0.05.

RESULTS

During the study period, of the 196 eligible patients included in the study, 176 (89.8%) were males and 20 (10.2%) were females, and the mean ± Standard Error Mean (SEM) age was 29±0.86 years (12-73). While 158 (80.6%) of patients were exposed to GSW, 38 (19.4%) had SW. The mean IBIO was 3.60±0.19 h (1-14). Before the operation, 136 (69.4%) patients were in shock. The mean duration of operation, PATI score, ISS score, IAO, EAO and TBU were 3.13±0.11 h (1-8 h), 26.6±1.04 (4-81), 19.33±0.89 (3-50), 1.61±1.30 (0-5), 0.41±0.69 (0-2) and 2.03±0.24 U (0-26 U), respectively. Primary repair was performed in 178 (90.8%) patients and diversion in 18 (8.2%) patients. One hundred seventeen (59.7%) patients had injury to the left colon, while 79 (40.3%) had right colon injury.

A CRC developed in 58 patients (29.6%). Wound infection (22.1%) and IAA (14.6%) were the most frequent CRC (Table 2).

Fifty patients had wound infection, which was generally minor and managed by removal of involved sutures, wound dressing, use of suitable antibiotics after the culture/sensitivity, and secondary suturing.

Of 33 patients in whom IAA developed, primary repair was performed in 26 (78.7%) and diversion in 7 (22.3%) patients. The most common abscess localizations were left subdiaphragmatic (42.3%), rectovesical (25.6%), and left paracolic sites. Of these patients, there were both rectovesical and left paracolic abscess in 3 patients. Percutaneous drainage was applied in 23 patients with IAA, whereas re-operation was done in the remaining 10 patients with IAA. Of these 10 patients developing anastomotic leak, 3 patients underwent re-operation due to clinical worsening, fecal material within the wound or abdominal drain, or severe peritonitis. Two patients underwent end colostomies, while the other patient underwent end stoma with mucous fistula. Seven patients developing enterocutaneous fistula were conservatively treated. However, none of these anastomotic leaks led to lethal complications.

Long IBIO (≥6 h), GSW, PSDA, long duration of the operation (≥6 h), high PATI score (≥25), high ISS (≥20), high CIS score (grade ≥3), major fecal contamination, high IAO (>2), high EAO (>2), high TBU (≥4 units in 24 h) and diversion (colostomy) were found to be significantly associated with morbidity (Table 3).

The results of multivariate logistic regression analysis using selected variables are shown in Table 4. Diversion (colostomy) [Odds Ratio (OR) =0.034, 95% Confidence Interval (CI) =0.004-0.297, p=0.002] and high TBU (OR=0.275, CI=0.104-0.726, p=0.009) were defined as independent risk factors affecting morbidity. The two independent risk factors related to CRC identified are shown in Figure 1.

DISCUSSION

Penetrating abdominal injuries caused by GSW or SW are common in urban areas. They affect mainly a younger age group, resulting in considerable morbidity and loss of working time. Penetrating abdominal injuries cause significant morbidity and mortality, and their numbers are likely to increase in the future; infections in these patients can raise the morbidity and mortality.[8] Recent studies have determined a CRC rate between 15-50%, while in our study, the CRC rate was 29.6%. IAA and wound infection were the reported common CRCs, and both complications were also common CRC in our study.

Many studies have been carried out to determine the predictive factors that affect morbidity, since the

Table 3. Univariate analysis of potential predictors of morbidity in patients exposed to penetrating injuries of the colon

Variables	Morbidity rate n (%)	p value
Age		
<30	35/120 (29.1)	p=0.87
≥30	23/76 (30.2)	
Gender		
Male	50/176 (28.4)	p=0.28
Female	8/20 (40)	
Mechanism of trauma		
SW	4/38 (10.5)	p=0.004*
GSW	54/158 (34.1)	
IBIO		
<6 h	37/155 (23.8)	p=0.001*
≥6 h	21/41 (51.2)	
PSDA		
≤90 mmHg	28/136 (20.5)	p<0.0001*
>90 mmHg	30/60 (50)	
Duration of operation		
<6 h	25/131 (19)	p<0.0001*
≥6 h	33/65 (50.7)	
PATI Score		
<25	24/109 (22)	p=0.009*
≥25	34/87 (39)	
ISS		
<20	24/122 (19.6)	p<0.0001*
≥20	34/74 (45.9)	
Site of colon injuries		
Right	25/79 (31.6)	p=0.60
Left	33/117 (28.2)	
CIS		
<3	24/119 (20.1)	p<0.0001*
≥3	34/77 (40.1)	
Fecal contamination		
Moderate	19/112 (16.9)	p<0.0001*
Major	39/84 (46.4)	
IAO		
≤2	18/110 (16.3)	p<0.0001*
>2	40/86 (46.5	
EAO		
≤2	48/174 (27.5)	p=0.08
>2	10/22 (45.4)	
TBU		
<4	32/154 (20.7)	p<0.0001*
≥4	26/42 (61.9)	
Type of surgery		
Primary repair	41/178 (23)	p<0.0001*
Diversion	17/18 (94.4)	

GSW: Gunshot wounds; SW: Stab wounds; IBIO: Interval between injury and operation; PSDA: Presence of shock during admission; PATI: Penetrating Abdominal Trauma Index; ISS: Injury Severity Score; CIS: Colon Injury Score; IAO: Number of associated intra-abdominal organ injuries; EAO: Number of associated extra-abdominal organ injuries; TBU: Transfused blood units within the first 24 hours.
*Statistically significant.

morbidity developing in PIC causes extended hospitalization, higher health care costs, prolonged antibiotic coverage, length of utilization of intensive care services, negative impact on patient's life, and higher mortality.

Ivatury et al.[9] carried out a prospective study on 252 patients with PICs. Their protocol emphasized definitive management of the colonic wound by repair, resection, and anastomosis or exteriorized repair. Colostomy was reserved for left colon injuries requiring resection or for delayed treatment. IAA occurred in 17.1%. A multiple regression analysis identified the Abdominal Trauma Index and the presence of colostomy as significant independent factors associated with IAA, which is a colon- related morbidity.

In the single level 1 trauma center experience to date, Bulger et al.[6] retrospectively analyzed 181 patients with PICs, including 20 patients with rectal injuries. Their total complications rate was 49.1%. They performed multivariate analysis to determine independent predictive factors in patients with IAA. Eventually, they described the predictors of IAA as hypotension and PATI score >25. When adjusted for injury severity and hypotension, the type of operation performed was found not to increase colon-related morbidity.

In a multicenter study, Demetriades et al.[3] prospectively evaluated 297 patients with PIC. CRC occurred in 24%. Multivariate analysis identified three independent risk factors for abdominal complications: severe fecal contamination, TBU >4 units within the first 24 h, and single-agent antibiotic prophylaxis. The authors, therefore, suggested that PIC requiring resection should be managed by primary repair, irrespective of risk factors, and antibiotic prophylaxis should be considered again. We apply combined antibiotic prophylaxis in patients with colon injuries and recommend this application routinely in all patients with colon injuries.

Dente et al.[10] reported a large retrospective series of 350 patients with PIC. They reported that a total of 78 (25%) patients developed 152 infectious complications. These infections were classified as traumatic or nosocomial in nature. They studied CRC under the title of traumatic infections (46%). The five most significant risk factors, using all infections as an outcome, were as follows: PATI >30, presence of an ostomy, number of per operative blood transfusions, ISS >16, and Revised Trauma Score <7.8.

Table 4. Predictors of colon-related morbidity by "Enter Logistic Regression"

Variables	Odds Ratio (Lower-Upper)	95% Confidence Interval	p value
Diversion	0.034	(0.004-0.297)	0.002*
High TBU	0.275	(0.104-0.726)	0.009*
High ISS	0.546	(0.237-1.258)	0.155
GSW	0.550	(1.171-1.771)	0.316
High PATİ	1.456	(0.534-3.974)	0.463
High CİS	1.194	(0.472-3.019)	0.708
Major fecal contamination	0.436	(0.170-1.115)	0.083

TBU: Transfused blood units within the first 24 hours; ISS: Injury Severity Score; GSW: Gunshot wounds; PATI: Penetrating Abdominal Trauma Index; CIS: Colon Injury Score.
*Statistically significant.

Multivariate analysis for traumatic infections revealed only two of the above to be independent risk factors: presence of an ostomy and a PATI >30. The authors failed to identify a high-risk group of patients in whom an ostomy prevented septic complications.

It is shown in many studies that operation technique, which is still a controversial matter in penetrating colon traumas, affects the CRC ratio significantly. For this reason, this study was planned as two stages, adding the applied operation technique to risk factors previously determined for CRC. In the first stage, univariate analysis was applied to determine the meaningful variables. Then, in the second stage, multivariate analysis was performed on six variables that were selected among from the variables, which had p<0.1 values. Through logistic regression analyses, two risk factors, such as TBU ≥4 within the first 24 h and diversion, were identified to have independent effects.

The need for multiple blood transfusions reflects

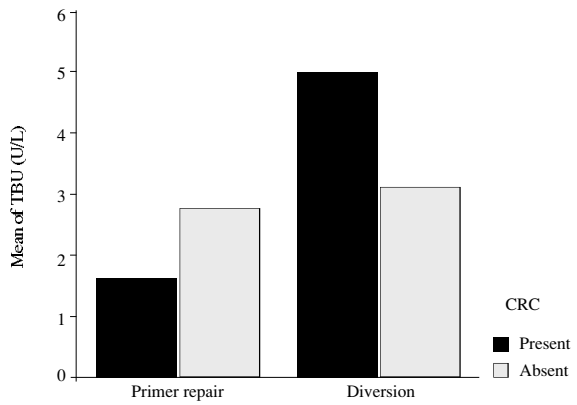

Fig. 1. Independent risk factors related to CRC.
TBU: Transfused blood units within the first 24 hours; CRC: Colon-related complication.

the overall extent of injury, and additionally, blood transfusions are thought to be immunosuppressive.[10] Long-lasting hypotension and altered perfusion facilitate development of sepsis and increase morbidity and mortality by causing bacterial translocation and disrupting the immune system.[3,6,11,12] It has been shown that transfusion of 4-6 units of blood resulted in an increase in the complication rate.[3,13] We also determined that blood transfusion within the first 24 h is an independent risk factor for colon-related morbidity.

Several reports suggest that risk factors of hypotension, massive blood transfusions, more than two associated injuries, PATI >25, major fecal contamination, or delay to operation increase the risk of CRC after PIC, and therefore, should be considered factors favoring diversion.[3,14-19] However, in many studies carried out recently, whether prospectively or retrospectively, when the morbidity rates of patients undergoing diversion and primary repair were compared, it was reported that the morbidity rate was higher in those patients undergoing diversion than in patients undergoing primary repair.[3,7,9,20-23] Some authors have suggested that all civilian penetrating colon injuries should be managed by primary repair.[3,20,24]

Georgi et al.[25] reported intra-abdominal injuries to be more frequent in patients with bullet injuries. Patients injured by shrapnel had significantly more associated IAO injuries. This finding was explained by the greater destructive force of high-velocity bullets. Small-caliber handgun injuries are characterized by much less primary tissue destruction than wounds caused by military weapons.[26] In addition to permanent cavity, temporary cavity of variable size generated by a bullet from the weapons (such as Kalashnikov AK-47 rifle, etc.) is usually used for

assaults, especially in our region of Turkey compared to other regions, due to socio-cultural status. Thus, most of our patients with gunshot injuries were high-velocity missile injuries and these injuries should be regarded as war injuries. Some authors do not recommend primary closure for high-velocity missile injuries of the colon as they are usually surrounded by contused and devitalized tissue that extends beyond the visible injury.[27,28] Hudolin et al.[29] suggested that primary closure could be employed selectively for these types of injury. We suggest primary repair for PICs sustained during war or among civilians.

In the first prospective randomized trial of colostomy versus primary repair, Stone and Fabian[2] excluded patients with any criteria that they deemed high risk. They included patients with hypotension, delayed operation, multiple associated injuries, and destructive colon injuries requiring resection. These criteria were noticed in the literature as contraindications to primary repair.

In the 1980s, the notion that military and civilian injuries should be assessed independently was introduced, with a resultant increase in treatment with primary repair techniques.[3,20,30] In 1988, George et al.[7] reported that treating patients, who were not excluded for shock or associated injuries, with resection and anastomosis for the management of the colon wound did not significantly affect the rate of septic morbidity. They concluded that all civilian injuries could be repaired primarily.

In the 1990s, on the other hand, it was suggested that primary repair could be used in any case. Chappuis et al.,[21] Sasaki et al.[20] and Gonzales et al.[23] subsequently carried out prospective studies to show the results following selective treatment of colon injuries. The consensus of these reviews was that primary repair of the colon was better than diversion and their comment was widely accepted among surgeons and ushered in a new wave of prospective randomized studies that form the basis for modern management.

There is an ongoing debate on surgical methods and factors that affect the choice of these methods despite injuries caused by low velocity shotguns among civilians and surgeons being experienced in these injuries, rapid transport of the patients to hospitals, absence of requirement for transport after surgery, advances in antimicrobial drugs, and improvements in intensive care units. Even though the mortality rates have decreased to the level of 5%, complication rates vary between 15-50%, depending on the surgical method and the severity of the injury.[3,4]

When the colostomy is performed on patients who have undergone major traumas, morbidity and mortality rates may be higher. Furthermore, surgeons may mistakenly prefer colostomy, based on their experience, to primary repair in spite of such evidence-based medicine and class I-II-III confirmation about primary repair. The surgeon should take adverse conditions such as requirement of a second operation, cost, stoma necrosis, retraction, stenosis, stomal prolapse, parastomal infection, increase in abdominal septic complication, and psychological trauma into account in patients for whom colostomy is considered.[20] However, this should not lead surgeons to give up colostomy. They should decide operation type in the operating room since the decisions are complicated due to multiple factors, not all measurable, which affect the gain-loss balance. However, in patients with PIC, we recommend primary repair as long as the surgeon has sufficient evidence that the bowel wall (especially with bowel edema and ischemia) is suitable for anastomosis.

In conclusion, we determined in our retrospective study that TBU ≥4 within the first 24 h and diversion are independent risk factors affecting morbidity. We believe that further comprehensive studies, prospective and multi-center in nature and including a large number of patients, are needed.

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