The Influence of Injury Severity on Complication Rates After Primary Closure or Colostomy for Penetrating Colon Trauma

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The management of penetrating colon injury has been frequently debated in the literature, yet few reports have evaluated primary closure *versus* diverting colostomy in similarly injured patients. Diverting colostomy is the standard of care when mucosal penetration is present, but primary closure in civilian practice has generally had excellent results, although it has been restricted to less severely injured patients. Because the degree of injury may influence choice of treatment in modern practice, various indices of injury severity have been proposed for assessment of patients with penetrating colon trauma. As yet, however, there has been no cross-comparison of repair type *versus* injury severity. A retrospective study 76 patients who sustained penetrating colon trauma between January 1, 1979 and December 31, 1985 and who survived for at least 24 hours was conducted. Different preferences among attending surgeons and a more aggressive approach to the use of primary closure during the years of study led to an essentially random use of primary closure and diverting colostomy for moderate levels of colon injury, with mandatory colosomy reserved for the most serious injuries. Primary closure was performed in 37 patients (three having resection and anastamosis), and colostomy was performed in 39 patients. Severity of injury was evaluated by the Injury Severity Score (ISS), Penetrating Abdominal Trauma Index (PATI), and the Flint Colon Injury Score. Complications and outcome were evaluated as a function of severity of injury, and primary closure and colostomy were compared. Demographic profiles of the two groups did not differ regarding age, sex, mechanism of injury, shock, or delay between injury and operation. The mortality rate was 2.6% for each group. Major morbidity, including septic complications, occurred in 11% of the patients of the primary closure group and in 49% of those of the colostomy group. When PATI was < 25, the Flint score was ≤ 2, or when the ISS was < 25, primary closure resulted in fewer complications than did colostomy. Of the injury severity indices examined, the PATI most reliably predicted complications and specifically identified patients who whose outcome would be good with primary repair. These results suggest that the use of primary closure should be expanded in civilian penetrating colon trauma and that, even with moderate degrees of colon injury, primary closure provides an outcome equivalent to that provided by colostomy. In addition, the predictive value of the PATI suggests that it should be included along with other injury severity indices in trauma data bases.

THE MANAGEMENT OF penetrating colon injury continues to evolve slowly, and debate persists regarding the best course of treatment. The advent of mandatory colostomy during World War II is credited with a large decrement in mortality, but the circumstances surrounding battlefield management are substantially different than those of modern civilian practice. Perhaps most important in civilian systems are the marked decreases in the delay between injury and definitive treatment due to efficient transport systems and the occurrence of few high-velocity injuries. Scattered reports over the last 20 years have begun to define patients who are better managed with primary repair than with colostomy. Today there is little argument that patients suffering small colonic wounds without significant contamination can be safely treated with primary repair. Furthermore, most surgeons have little disagreement with the principle that serious injury with overwhelming contamination or prolonged delay between injury and surgery should be treated with resection of the injured segment and with colostomy.

What is missing from the literature is a definitive approach for deciding between these options based on objective criteria available at the time of surgery. The art and science of injury assessment is developing rapidly, and is being used in the development of trauma registries, as well as in the decision-making process of trauma management. Because of these factors, we decided to look retrospectively at the results of San Francisco General Hospital over the last 6 years for colostomy *versus* primary repair with stratification for injury severity by a battery of indices.

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TABLE 1. *Predictor Variables*

1) Age
2) Sex
3) Type of injury (stab wound, bullet wound, shotgun wound)
4) Intraperitoneal blood (ml)
5) Number of transfusions
6) Hematocrit on admission
7) Blood gasses
8) Number of concurrent injuries
9) Patients presenting in shock
10) Systolic pressure on admission
11) Fecal spillage
12) Delay between pick-up by ambulance and operation
13) Number of colon injuries
14) Amount and type of irrigation used intraoperatively
15) Location of colon injury (right, transverse, left, sigmoid)
16) Closure type
17) Drains
18) Antibiotics
19) Hyperalimentation

Materials and Methods

All patients sustaining penetrating colon trauma were included in the study if they survived for at least 24 hours and underwent either primary closure (closure of the defect or resection and primary reanastomosis), or colostomy (either with resection of the damaged segment or colostomy proximal to primary repair). Only one patient was treated with exteriorization of the injured segment during this period and was eliminated from the study because no meaningful conclusions could be drawn. Patients eliminated from the study included all who died within 24 hours of injury, all patients transferred to San Francisco General Hospital who had already undergone any operation related to the colon, any patient with rectal injury below the peritoneal reflection, and all patients who were transferred to another hospital during the initial hospitalization.

All morbidity and mortality figures for the colostomy group include complications encountered during the initial hospitalization and after takedown of the colostomy when this information was available (31 of 39 colostomy patients, 79%). Patients who underwent colostomy, but who were readmitted for colostomy takedown at another hospital were included in the study, and only the results from the first hospitalization were compiled (8 of 39 patients).

Morbidity was defined as follows: *major morbidity* was defined as a septic or nonseptic complication that resulted in significant changes in treatment, outcome, or hospital stay; *colon-related morbidity,* a subset of major morbidity, was defined as septic morbidity, including intra-abdominal abscesses, systemic sepsis, colonic fistula, major wound infection, dehiscence, or major ostomy infection, but excluding pneumonia or urinary tract infection.

Most authors have used colon-related morbidity to gauge the risks and effectiveness of colonic procedures, citing it as the most likely to have arisen from difficulties in colonic repair. We believe, however, that major complications, as defined above, are more important indicators of clinical outcome, despite the fact that some were not direct consequences of surgery, but of the initial injury. Both major and colon-related complications are addressed in this report.

Patients were stratified according to the clinical parameters shown in Table 1 in order to detect the contribution of various predictor variables to outcome. Stratifications were also performed according to three injury severity indices, which include the Penetrating Abdominal Trauma Index (PATI),[1] Injury Severity Score (ISS),[2] and the Flint Injury Score.[3]

The PATI is a score based on the combined severity of injury of individual abdominal viscera diagnosed by operative examination. Each organ is assigned a number from one to five based on the severity of injury, but because injuries to different viscera carry different complication risks, this number is multiplied by a coefficient corresponding to the likelihood of morbidity and mortality resulting from injury to that organ. The resultant scores from each viscus are added together to give the final PATI. Previous studies have shown that postoperative morbidity and mortality increase sharply with a PATI of ≥ 25.[1] Advantages to the use of PATI are that it is one of the most detailed indices relating specifically to abdominal trauma and that it has been shown to reliably predict outcome. Its major disadvantage is that it does not take into consideration the physiologic impact of injury from other regions of the body.

The Abbreviated Injury Score (AIS) is a system of scoring based on severity of injury to each of six different anatomic regions of the body. The ISS is a frequently used index derived from the AIS, and is computed by summing the squares of the largest scores in each of the three highest scoring regions. The major strengths of ISS scores are the consideration of the aggregate effect of total body injury on ultimate outcome, and their established widespread use in the literature pertaining to injury of all types. The ISS is very nonspecific when tabulating complex intra-abdominal injury, however, and less useful in stratifying subtle differences.

The Flint Severity Score has the advantage of marked simplicity. All colonic injuries are divided into three groups of increasing severity that are easily remembered by surgeons at the time of operation. The groups are divided as follows:

Flint 1) Isolated colon injury, minimal contamination, no shock, minimal delay

Flint 2) Through-and-through perforation, lacerations, moderate contamination

Flint 3) Severe tissue loss, devascularization, heavy contamination.

TABLE 2. *Distribution of Repair Types*

Repair Type	Number of Patients	Percentage of Patients
Primary repair		
Simple oversew	34	45%
Resection with 1° anastomosis	3	3.9%
Total	37	49%
Colostomy		
With resection	38	50%
Proximal to 1° repair	1	1.3%
Total	39	51%

Its disadvantage is that it does not include the contributions of other intra-abdominal injuries and ignores injury to other regions of the body entirely.

Demographic and morbidity and mortality statistics were calculated, and predictors of morbidity analyzed. Treatment groups (colostomy *vs.* primary repair) were then analyzed for comparability, and cross-comparisons were made between treatment groups stratified according to injury severity in order to examine outcome in terms of both morbidity and cost.

Results

Seventy-six patients fulfilled criteria for admission into the study, 66 of whom were men (86.8%). Average age was 33 ± 15 years. Injuries to these patients included 42 stab wounds, 33 bullet wounds, and one shotgun wound. No distinction was made between low- and high-velocity gunshot wounds because such information was not reliably available, although the majority of these wounds were handgun injuries.

Thirty-four patients underwent simple oversew of the colonic injury (45%); resection with primary anastomosis was accomplished in three patients (3.9%); colostomy with resection was performed in 38 (50%); and colostomy proximal to a primary repair was performed in one patient (1.3%), accounting for a total of 39 colostomy (51%) and 37 noncolostomy (primary repair) patients (49%) (Table 2).

Ninety-two per cent of the patients were brought to surgery within 4 hours of injury. The average time from pick-up by the ambulance to incision was 1.9 hours, excluding one patient who presented 56 hours postinjury.

There were two deaths in the series, one in each group, accounting for a total mortality of 2.6%. One death was due to *Staphylococcal* sepsis after postoperative aspiration and pneumonia in a patient who had undergone colostomy after sustaining a bullet wound. The other death occurred in a patient undergoing primary repair who had a progressively worsening course, ending in multiple organ system failure. Both deaths occurred in patients with cirrhosis (confirmed at operation), and constituted all patients with documented cirrhosis in our series. Neither patient had evidence of anastomotic breakdown.

TABLE 3. *Major Complications* Versus *Repair Type**

Complication	Colostomy (%)	1° Repair (%)	Combined (%)
Colon-Related			
Intra-abdominal abscess	8 (21%)	1 (2.7%)	9 (12%)
Wound infections	6 (15%)	0 (0%)	6 (7.9%)
Systemic Sepsis	6 (15%)	0 (0%)	6 (7.9%)
Ileus (>7 days)	6 (15%)	0 (0%)	6 (7.9%)
Bowel obstruction	3 (7.8%)	1 (2.7%)	4 (5.3%)
Multiple organ failure	2 (5.1%)	1 (2.7%)	3 (3.9%)
Wound dehiscence	3 (7.8%)	0 (0%)	3 (3.9%)
Colonic fistula	0 (0%)	1 (2.7%)	1 (1.3%)
Total combined colon-related complications	34	4	38
Noncolon-Related:			
Pneumonia	3 (7.8%)	1 (2.7%)	4 (5.3%)
Noncolonic fistula	3 (7.8%)	0 (0%)	3 (3.9%)
Cardiac arrest (resuscitated)	0 (0%)	1 (2.7%)	1 (1.3%)
Combined total complications	40	6	46
Total number of patients suffering from major complications	19 (49%)	4 (11%)	23 (30%)

* Morbidity is stratified according to colon-related and noncolon-related complications, but not by injury severity. Raw comparisons reveal clearly increased complication rates with colostomy as opposed to primary repair.

Table 3 shows morbidity statistics stratified according to repair type. In addition to the increase in complication rate seen in colostomy patients unstratified for severity of injury, major complications were seen more frequently in patients who received a transfusion of greater than 4 units of blood (a complication rate of 13.5% for patients who had 0–4 transfusions as opposed to 81% for patients who had ≥ 5 transfusions; $p \leq 0.001$), and were more prevalent in patients with high degrees of fecal spillage (minimal to minor spillage was associated with a 19.6% complication rate as opposed to a 63.6% rate in patients

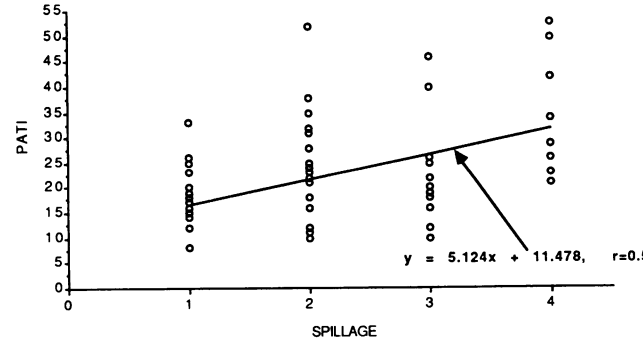

FIG. 1. Graph showing the correlation between fecal spillage and PATI.

TABLE 4. *Major Morbidity as a Function of Location of Injury and Closure Type**

Injury Location and Closure Type	Number (%)	Complications	
		Major	Wound
Location of injury			
Right colon	12	25%	
Transverse colon	45	28%	
Left colon	13	46%	
Sigmoid colon	11	18%	
Closure type			
Primary closure	35 (46%)		17%
Delayed primary closure	23 (31%)		13%
Secondary closure	18 (24%)		11%

* Differences in complication rates were not significant for any combination of the above risk factors.

with moderate to major spillage; $p \leq 0.001$). Spillage was poorly correlated to PATI ($r = 0.51$) (Fig. 1).

There were twelve right, 45 transverse, 13 left, and eleven sigmoid colon injuries (Table 4). No correlations

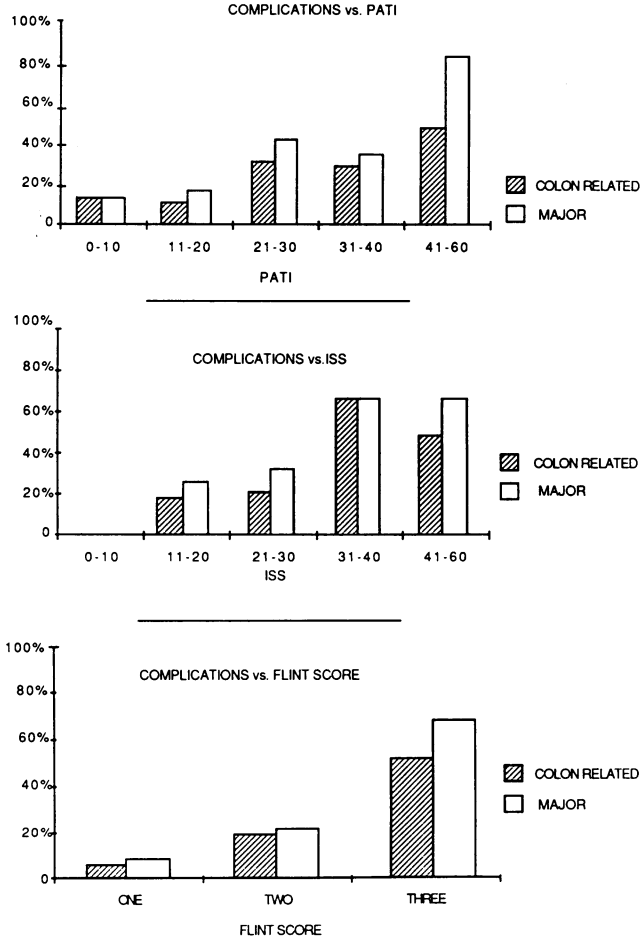

FIG. 2. Percentage of morbidity *versus* degree of injury as measured by PATI, ISS, and Flint injury severity indices. In each case, both major complications and colon-related complications were seen to increase with increasing index scores.

TABLE 5. *Predictor Variables That Revealed Significant Differences Between Treatment Groups*

Predictor Variables	Colostomy	Primary Repair	Significance
Intraperitoneal blood (ml)	1423 ± 935	602 ± 664	$p < 0.05$
No. of transfusions	7.2 ± 9.2	2.2 ± 3.3	$p < 0.001$
No. of concurrent injuries	4.6 ± 3.4	2.9 ± 2.3	$p < 0.05$
Fecal spillage	47.6%	14.7%	$p < 0.01$

could be found between location of injury and major complications (right 25% and transverse 28% *vs.* left 46% and sigmoid 18%, $p > 0.8$, NS), age greater than or less than 40 years (53.8% *vs.* 32.3% respectively, NS), or stab wound versus bullet wound (30.9% *vs.* 42.4%, NS).

Skin closure consisted of primary closure in 35 patients (46%), (usually with either staples or steristrips), delayed primary closure (DPC) in 23 patients (31%), and secondary closure in 18 (24%). Wound complications were noted in 17% with primary closure, 13% with DPC and 11% with secondary closure (NS). No patients had placement of superficial drains in the wound. Nine patients had intra-abdominal drains placed, but only one of those was for drainage of colonic wounds; the remainder were for duodenal/pancreatic (4) and liver/biliary injuries (1).

Of the 39 patients who underwent colostomy, 31 (80%) subsequently returned an average of 91 ± 45 days later for colostomy takedown, a rate that is high for the county hospital setting. Colostomy takedown itself resulted in a major complication rate of 13%, which compares favorably with that of other studies.[5] There was one intraperitoneal abscess with prolonged ileus, one dehiscence, one wound infection, and one case of pneumonia. Minor complications were seen in 16% of the patients.

Figure 2 shows histograms of complication rate *versus* severity index, independent of repair type, showing the expected increasing morbidity in all indices with increasing scores. This supports the results of previous studies pertaining to each index[1-3,6] (although the PATI and Flint scales were shown by chi square analysis to be statistically more accurate than the ISS in predicting subsequent morbidity).

Differences Between Treatment Groups

All predictor variables were examined between patients treated with colostomy *versus* primary repair to assess comparability between groups (Table 1). The significant differences are reviewed in Tables 5 and 6, each of which supports the assertion that, on the whole, colostomy patients had more severe injuries.

Figure 3 shows the distribution of patients with respect to the three injury severity indices. Most patients presented with mild to moderate injury scores in each index. High

scores in all indices were associated more frequently with the colostomy patients than those who underwent primary repair, as would be expected in a retrospective study of this type.

Morbidity Versus *Repair Type According to Index of Injury Severity*

Because higher degrees of trauma were seen in the colostomy patients, comparisons were stratified according to index of injury severity to reduce this bias.

Figure 4 shows stratified comparisons of morbidity and repair type for the three indices of injury severity examined. These results show clearly decreased morbidity for patients undergoing primary repair in the mild to moderate injury category. Patients with a PATI of less than 25 showed a major complication rate of 6% with primary repair as opposed to the 47% rate associated with colostomy ($0.001 \leq p \leq 0.01$). The results were similar for the ISS, showing complication rates for ISS of less than 25 at 12% and 44%, respectively ($0.01 \leq p \leq 0.05$). The Flint scale was not adequate for stratification in this series because there were not enough colostomy patients in the Stage 1 category and not enough primary repair patients in the Stage 3 category. For Stage 2, however, there was a statistical advantage to primary repair for major complications, showing a morbidity rate of 10% *versus* that of 38% for colostomy patients ($0.01 \leq p \leq 0.05$). If Stages 1 and 2 are combined, the morbidity rates are 9% versus 42%, respectively ($0.001 \leq p \leq 0.01$).

It was impossible to compare therapies for patients in the Severe Injury category because almost all of the patients in this category had colostomies. Only five patients who underwent primary repair had a PATI of ≥ 25 as opposed to 19 patients who underwent colostomy.

Cost Statistics

Financial data were tabulated, where available, in order to examine the cost-effectiveness of individual procedures. Included in the analysis were hospital costs, operating room costs, and professional surgical fees for each operation performed. Not included were the costs of clinic visits, out-patient visiting nurses, and stoma care devices (all of which would be more expensive for colostomy patients).

Patients who underwent colostomy had a significantly longer hospital course of 33 ± 30 days *versus* 12 ± 11 days ($p \leq 0.001$) for those patients treated with primary repair (these statistics include hospitalization for takedown of colostomy in colostomy patients). Cost data were available for 44 patients, 21 of whom underwent colostomy and 23 of whom underwent primary repair. Combined average cost for colostomy patients was \$28,559.50 *versus* \$10,295.60 in the primary repair group ($Z = -4.194$, $p \leq 0.001$, Mann Whitney U-Test). After stratification, the average cost difference was still significantly less for the primary repair group, both for PATI of < 25 ($Z = -3.683$, $p \leq 0.001$), and PATI of ≥ 25 ($Z = -1.8$, $0.01 \leq p \leq 0.05$) although the differences were narrowed (Table 7). Because hospital costs rose precipitously during the 6 years studied, *paired* comparisons were also done according to the year that the injury was sustained, in an attempt to eliminate time-related changes in hospital cost as a contributing variable. Because there were more colostomy patients than primary-repair patients, the pairings were not strict, but the differences appeared to remain highly significant nonetheless.

TABLE 6. *Mean Scores for Each Index Stratified According to Treatment Group, Showing Generally Increased Injury Severity in Colostomy Patients*

Index	Colostomy	Primary Repair	Significance
PATI	26.6 ± 12.4	17.0 ± 5.7	$p < 0.001$
ISS	22.2 ± 10.6	18.2 ± 5.0	$p < 0.05$
Flint	2.3 ± 0.61	1.7 ± 0.58	$p < 0.001$

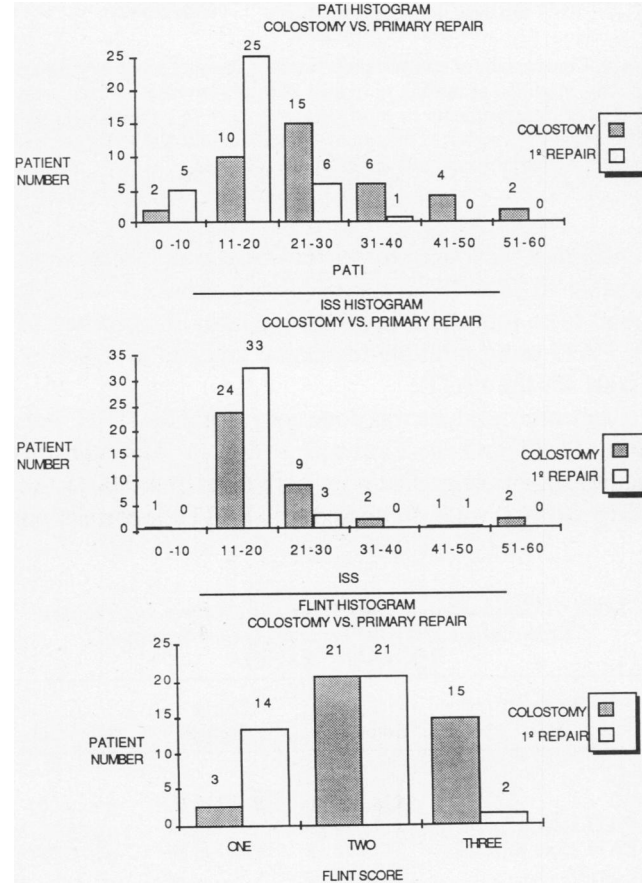

FIG. 3. Number of patients *versus* degree of injury as measured by PATI, ISS, and Flint injury severity indices. Most patients fell into the Moderate Injury categories, and only a few patients in the Severe Injury categories were treated with primary repair.

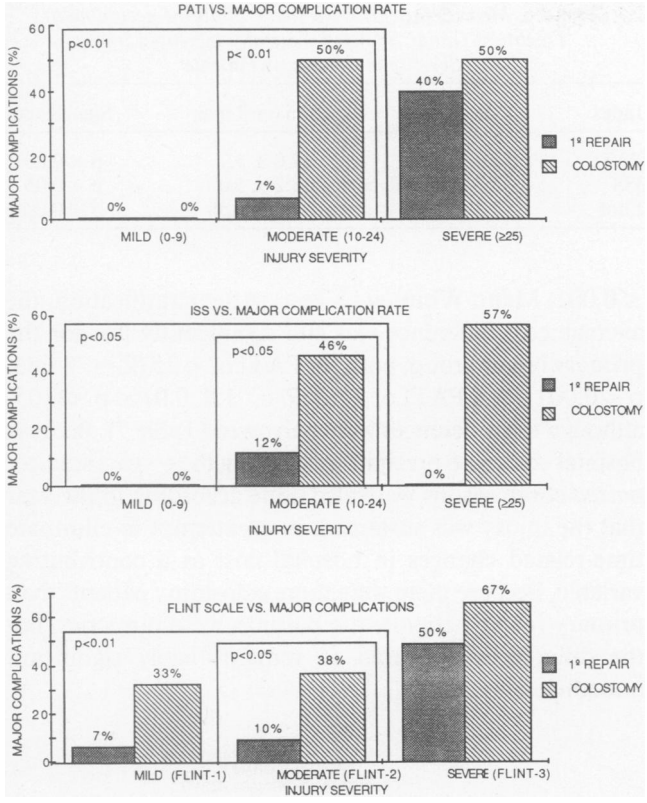

FIG. 4. Comparison of complication rates for primary repair *versus* colostomy, stratified according to indices of injury severity. In each case, significant improvements in morbidity were seen in patients who underwent primary repair in the mild to moderate injury severity groups. p values represent the results of chi square analyses.

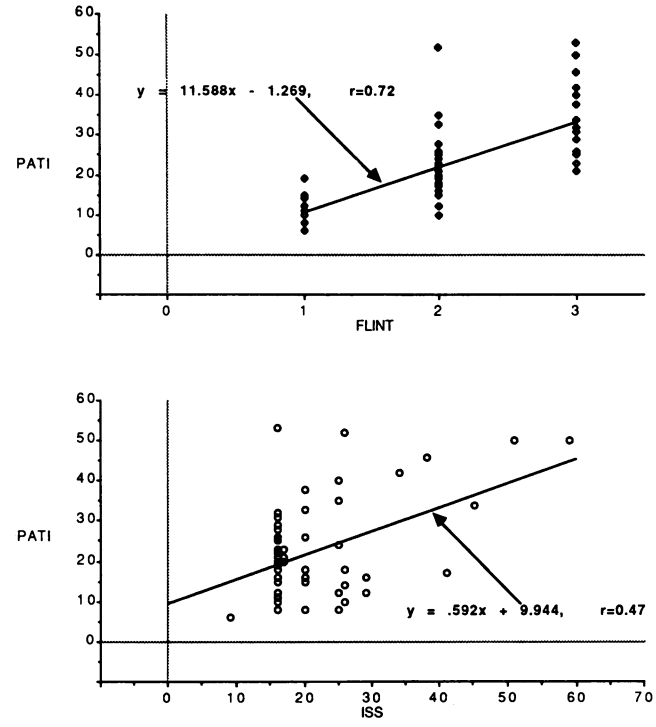

FIG. 5. Linear regression analysis of the PATI *versus* both the Flint Scale and the ISS, showing a better correlation coefficient with the Flint scale than with the ISS.

Although fecal spillage was found to be an independent variable in predicting major complications, it was not found to be important in predicting cost, independent of the PATI using multiple regression analysis ($p = 0.4$ *vs.* 0.0001 for the PATI).

Regression analysis was done comparing the PATI with both the ISS and the Flint scales (Fig. 5). Although the relationship was significant for both Flint ($p \leq 0.001$) and ISS ($p \leq 0.001$) when compared with PATI, the correlation coefficient was much better for the Flint scale ($r = 0.72$) than for the ISS ($r = 0.47$).

Multiple regression analysis was done to establish the independent contributions of PATI and ISS to ultimate cost. The results show that the contribution of the ISS ($p = 0.06$) is far less than that of the PATI ($p = 0.0001$) for patients with colon injury.

Because there was little correlation between PATI and ISS scores, the sum of both scales was used to determine a new group of patients with intermediate injury in order to incorporate features of both indices. A sum between

TABLE 7. *Comparison of Costs Between Colostomy and Primary Repair Before and After Stratification for Severity of Injury Using the PATI*

	Colostomy	Primary Repair	Significance
Mean			
All	$28,559.50	$10,295.60	$p \leq 0.001$
PATI score of < 25	$17,059.99	$7,378.72	$p \leq 0.001$
PATI score of ≥ 25	$43,892.18	$20,796.39	$p \leq 0.05$
Minimum	$7,315.25	$3,594.64	
Maximum	$100,183.05	$47,555.74	

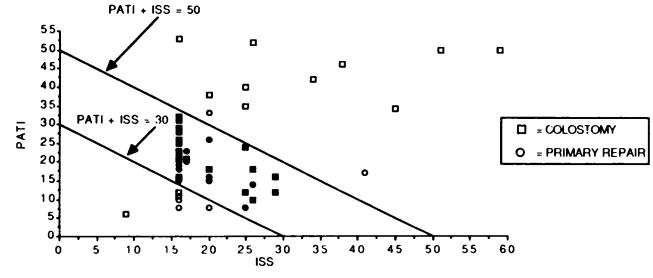

FIG. 6. Combined scale including PATI and ISS scores. Filled-in points show those patients whose scores (PATI + ISS) were between 30 and 50, defining an intermediate injury group with influences of both the PATI and the ISS. This group also revealed a significant decrease in morbidity for patients who underwent primary repair.

30 and 50 defined patients in this intermediate group (Fig. 6). Chi square analysis showed that major complications were again seen more frequently in the colostomy group than in the primary-repair group [42% *vs.* 12%, respectively ($0.01 \leq p \leq 0.05$)] and that cost differences closely approached significance ($10,921.00 *vs.* $5,421.00 $p = 0.07$, Mann Whitney U-test).

Discussion

The repair of penetrating injury to the colon has undergone a progressive evolution since World War I, in which colon injury was fatal in 60% of patients, most of whom were treated with primary repair. During World War II, with the introduction of colostomy, a consequent reduction in mortality to approximately 30% was seen.[7] Mandatory colostomy or exteriorized repair, antibiotics, fluid replacement, electrolyte monitoring, and improved evacuation techniques reduced the mortality rate to 12% during both the Korean and Vietnamese conflicts. Given the dramatic improvement in battlefield mortality figures, colostomy was understandably adopted much more frequently in civilian practice, and in many institutions, it became required treatment for all cases of colonic mucosal penetration. Woodall and Ochsner[4] published the first reference re-examining primary closure in 1951. They argued that colostomy was more effective in battle conditions because of the prevalence of high-velocity injury and also because surgeons are often unable to examine their patients after operation. In civilian practice, however, their own mortality rate decreased from 23% to 9% with the use of primary repair. Since that time, the use of primary repair for colon injuries has gained favor with some authors for injuries of limited severity or degree of fecal spillage[3,6,7,8-12]. With improvement in shock management, prehospital care, and antibiotics, the risk of anastomotic breakdown has diminished significantly. High-velocity missile injury is much less common in civilian practice than on the battlefield, further reducing the likelihood of extensive soft tissue damage and risk for anastomotic breakdown. In agreement with the results of Demetriades et al.,[11] there was no important difference in this study between stab wounds and gunshot wounds in predicting morbidity, undoubtedly due to the fact that most gunshot wounds were from low-velocity firearms. Recent overall mortality in civilian practice for patients with penetrating colon injury has fallen to less than 5%, but the major complication rate is still high, ranging from 15% to 50%, depending on injury severity and repair type.[6,11]

Primary closure has been shown to be preferable to colostomy in a widening group of circumstances. Various groups have eliminated the requirement for colostomy in cases of left colon injury. An in-depth review of this subject by Thompson and Moore in 1982[13] showed that there is no statistical increase in complications after repair of the left colon as opposed to that of the right colon for either internal or exteriorized repair, or in elective or traumatic situations—an observation supported by our own results.

The degree of fecal spillage has been correlated with complication rates in many studies and was highly associated in our own, despite its poor correlation with the PATI. Adkins et al.,[12] however, have eliminated fecal spillage as an independent determinant for colostomy formation if associated injuries are not extensive. In their series, no anastomotic breakdowns or intra-abdominal abscesses were seen in any patients who underwent primary repair, who comprised 64% of their total patient population and included many patients with gross spillage. The patients in their series who underwent colostomy were those who required major colon resections, repair of associated injuries, and prolonged operations. Our results would not support this approach and continue to show a higher complication rate with greater amounts of spillage, although quantitation of this variable may often be questioned.

Colostomies have risks and costs of their own[5]: a second hospitalization for takedown, increased care in the interim between colostomy and takedown, training of the patient in management, and frequently, psychologic problems in adjusting to the presence of the colostomy. Although complication rates for trauma patients are less than for others undergoing colostomy takedown, they are still significant, ranging from 5%[14] to 46%,[15] with a low but real mortality.[4,15]

The problem with many studies is that the criteria for selecting patients for different treatments have been limited, inexact, and diversified, and all studies except one have been retrospective.[10] Selection criteria need to be assessable at the time of initial surgery to be useful.

We chose to examine the PATI, ISS, and Flint scales because each is standardized, and each demonstrates its own individual strengths by emphasizing different aspects of injury. The PATI was chosen for its in-depth analysis of intra-abdominal injury, the ISS for its comprehensive assessment of total body injury, and the Flint scale for its simplicity and specific applicability to colon injury.

Although the Flint scale was excellent at predicting complications, it was not useful in our study for distinguishing differences in complication rates between treatment options because it appeared to be too restrictive. There were only three colostomies performed at Stage 1 and only two cases repaired primarily for Stage 3 injury. Moderate injury (Stage 2) was observed in 21 patients in each treatment group and showed a clear advantage of primary repair (10% *vs.* 38% major morbidity; $0.01 \leq p \leq 0.05$). Dang[16] suggested conveniently assigning treatment according to stage, with primary repair for all Stage

1 injuries, exteriorization for all Stage 2 injuries, and colostomy for all Stage 3 injuries. Because we observed in our series only two major complications (only one of which was colon-related) in a total of 21 Stage 2 patients who underwent primary repair (10%) as opposed to seven of 24 (29%) Stage 2 patients who underwent exteriorization in Dang's study[16], we believe that his Stage 2 patients might have benefited from primary repair. It seems reasonable, given our statistics, to combine patients from both Stage 1 and Stage 2 in the low to moderate injury group and perform primary repair, reserving colostomy for Stage 3 patients.

The index that we found to be the most useful was the PATI. Not only was it helpful in identifying patients with low to moderate injury who were clearly better served with primary repair (as opposed to those with very severe injury), but it was excellent in predicting complications and cost, independent of repair type despite its inability to account for extra-abdominal injury.

Although the ISS was found to correlate loosely with the same factors, correlations were weak, as was correlation of ISS to the PATI itself. Statistical analysis reveals that the ISS adds little useful information to the PATI in predicting cost or morbidity in cases of colon injury. Even when combined with the PATI, the predictive value was no better than that of the PATI alone. This is no doubt due to the fact that nearly all patients in this study had penetrating trauma and that the major damage was usually restricted to the abdomen. Thus, the ISS would not be expected to diverge from the PATI. This is not to say that the ISS is not useful, but it appears that, in most patients with colon injury, intra-abdominal factors play a dominant role in predicting morbidity when compared with this index of total body injury.

Dellinger et al.[17] determined a list of risk factors for morbidity that occurs after laparotomy for penetrating abdominal injury of all varieties. Using stepwise discriminant analysis, a numeric function was derived that yielded the probability of infection, depending on transfusion requirement, PATI, length of operation, and age of the patient. Of these, only the PATI and the age of the patient are known at the time of surgery, when operative decisions must be made.

After examining results stratified according to all three indices of injury severity, these retrospective data do not support the use of colostomy in treating mild and moderate injury. In other series, exteriorization has been advocated as an alternative to colostomy and a means of protecting the patient from intra-abdominal sepsis that obviates this need for a major second operation. Because of a high incidence of breakdown associated with this option[8] and because the resulting colostomy is suboptimal in terms of construction and management, we have chosen to avoid this alternative and have had little experience with it. Others have not had such poor results, although even the most optimistic series report a 25–35% incidence of suture line breakdown when the bowel is extra-abdominal.

Our results indicate that patients with a PATI of < 25, an ISS of < 25, or a Flint score of ≤ 2 define a group that is probably better treated with primary repair than colostomy unless spillage is large or unless there is a long delay between injury and surgery, or a large transfusion requirement. Adherence to these guidelines for the patients in this study would have mandated primary repair in 67% of our patients, a percentage even higher than in the Adkins study.[12]

Considerable care needs to be exercised, however, before these data can be extrapolated to the general population of trauma patients. Although treatment with primary repair has received increasingly favorable results in retrospective trials, the weakness of retrospective analysis is well-known, especially in light of the catastrophic results of anastomotic breakdown in these patients. By using objective scoring systems, we have made every effort to compare the equivalent populations in evaluating primary repair *versus* colostomy. In a retrospective study, however, it is impossible to be certain that the patients selected for colostomy did not represent a more severely injured group, despite our inability to show any differences by the criteria tested. There may have been other factors observed at the time of surgery that led to the performance of colostomy that were not detectable by chart review. To the extent that this might be the case, our conclusions will be invalid.

It seems clear, however, that the good results associated with the use of primary repair in civilian practice, which have been reported consistently since 1951, warrant a more aggressive approach to its use, including the objective evaluation of different therapies by prospective, randomized trials. For evaluation purposes, the wartime experiences of 40 and 70 years ago do not currently apply, and an objective reappraisal of colon injury management is warranted.

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