
Management of Penetrating Colon Injuries

A Prospective Randomized Trial

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Fifty-six patients with penetrating colon injuries were entered into a randomized prospective study. Management of the colon injury was not dependent on the number of associated injuries, amount of fecal contamination, shock, or blood requirements. Twenty-eight patients were treated with primary repair or resection and anastomosis and 28 patients were treated by diversion (24 colostomy, 3 ileostomy, 1 jejunostomy). The average Penetrating Abdominal Trauma Index score was 23.9 for the diversion group and 26 for the primary repair group. There were five (17.9%) septic-related complications in the diversion group. This included four intra-abdominal abscesses and one subcutaneous wound infection. There were six (21.4%) septic-related complications in the primary repair group. This included one wound infection, two positive blood cultures, and three intra-abdominal abscesses. There were no episodes of suture line failure in the primary repair/anastomosis group. The authors conclude that, independent of associated risk factors, primary repair or resection and anastomosis should be considered for treatment of all patients in the civilian population with penetrating colon wounds.

THE MANAGEMENT OF the colon injury remains controversial in spite of a number of divergent reports during the past decade. Argument continues over the propriety of ostomy to divert such injuries *versus* primary repair without stoma.

Most recent retrospective investigations favor an aggressive approach with primary repair.¹⁻³ Only one prospective, randomized study analyzing diversion *versus* primary repair has been published, however.⁴ That study showed an advantage to primary repair in selected cases. The study was flawed, however, by inclusion of criteria for obligatory diversion before randomization, thereby eliminating 48% of patients from the study.

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Civilian injuries resulting in colonic perforation continue to represent a significant problem in the United States, particularly in the urban sector. With the psychological, financial, and physical drawbacks of an ostomy and subsequent takedown, the question of the superiority of diversion over primary repair of colon injury is worthy of further research.

With this in mind, we initiated a prospective, randomized study, without exclusion of any patients, evaluating the treatment of intraperitoneal large bowel injury by diversion *versus* primary repair. Patients with extraperitoneal rectal injuries in association with intraperitoneal injuries were excluded. This report describes the results in the first 56 patients.

Materials and Methods

Between August 1987 and June 1990, all patients with a potential penetrating intraperitoneal large bowel injury admitted to the Louisiana State University trauma service at Charity Hospital at New Orleans were considered eligible for entry into the study. Standard resuscitative measures were performed on all patients according to Advanced Trauma Life Support (ATLS) protocol. Nasogastric and urinary catheters were placed. Depending on the response to resuscitation, patients were evaluated with indicated radiographic and endoscopic tests in selected cases. All patients received perioperative broad-spectrum systemic antibiotics. At the time of laparotomy, those patients found to have one or more penetrating colon injuries were randomized to either 'diversion' or 'primary repair.'

Randomization was accomplished with a table of random two numbers. Diversion was defined as (1) exteriorization of the injury; (2) resection of the injury with exteriorization of the proximal segment and either exteriorization or closure of the distal line of resection; or (3) debridement, if indicated, and simple closure of perforations with formation of a loop or end stoma proximal to the injury. Primary repair was defined as (1) debridement, if indicated, with simple closure of the perforations or (2) resection of a segment of large bowel containing perforations followed by anastomosis. All perforations were closed using accepted suture or staple methods. Patients with multiple colon injuries were included in the study. The peritoneal cavity in all patients was irrigated with sterile saline solution before fascial closure. Skin wounds were left open to heal by secondary intention or by delayed primary closure at approximately 5 days after operation. Administration of systemic antibiotics beyond 48 hours was permitted only when other extra-abdominal injuries dictated, for example, open fracture. Patient care was by surgical residents with close supervision by attending staff throughout the hospital course. Patient data were collected with the emphasis on success or failure of the method of management of the colon injury and the subsequent effect on the patient's clinical course. Similar data were retrieved for those patients treated with diversion who later underwent stoma closure.

Results

Of the 56 patients, 28 were randomized into each group. Data were collected concurrently and complications and outcome recorded.

The majority of patients in each group were young men. The average age for the primary repair group was 26 years (range, 17 to 58 years); and for the diversion group, 23 years (range, 14 to 61 years). There were 27 men and 1 woman in the primary repair group and 25 men and 3 women in the diversion group. All patients were from the New Orleans area and were brought to the Charity Hospital accident room shortly after sustaining injury. Average time from arrival at the Accident Room to operation was 116 minutes for primary repair *versus* 91 minutes for the diversion group. There was a single patient in the primary

TABLE 1. Mechanism of Injury

Mechanism	Primary Repair	Diversion
Gunshot wound	24	27
Stab	4	0
Shotgun	0	1

TABLE 2. Transfusions

Number Units PRBC	Primary Repair	Diversion
0	15	17
1-4	8	3
>4	5	8

PRBC, packed red blood cells.

repair group whose stab wound to the abdomen was treated nonoperatively at first. This patient's time to operation was 705 minutes. Both groups had a preponderance of gunshot wounds as the cause of penetrating injury (Table 1). In the diversion group, there was one patient with a shotgun wound.

At the time of arrival in the accident room, the majority of patients were hemodynamically stable. Shock, defined by a systolic blood pressure less than 80 mmHg, was present in three patients in the diversion group and one patient in the primary repair group. No blood transfusions were required in 32 patients. Packed red blood cell (PRBC) administration to others is shown in Table 2. More than 4 units of PRBC were required in eight patients in the diversion group and five patients in the primary repair group.

All patients were explored through midline incisions. Colon wounds and associated injuries were evaluated and graded according to the Penetrating Abdominal Trauma Index (PATI).⁵ All associated abdominal organs injured were evaluated and treated accordingly. The small bowel was the other organ injured most commonly (Table 3). The number of injuries, including colon injury, was similar in both groups (Table 4). The average PATI score for the primary repair group was 26, with a range of 8 to 77, and for the diversion group the score was 23.9, with a range of 12 to 55.

There was no difference between the two groups with respect to the grade of colon injury according to the colon

TABLE 3. Associated Intra-abdominal Injuries

Organs	Primary Repair	Diversion
Small bowel	15	21
Duodenum	7	4
Stomach	6	4
Liver	6	4
Major vascular	5	4
Kidney	4	3
Pancreas	2	2
Ureter	1	3
Diaphragm	2	—
Gallbladder	1	—
Spleen	1	—

TABLE 4. Total Number Organs Injured

Number	Primary Repair	Diversion
1	3	2
2-3	19	19
>4	6	7

injury severity scale (Table 5) or location of injury (Fig 1). There was a single colon injury in 25 patients in the primary repair group and in 20 patients in the diversion group. Multiple colon injuries were found in 11 patients (Table 6). Of particular note is the presence of a similar number of left-sided injuries in each treatment group. The majority of injuries were grades III and IV. There were no grade I colon injuries in either group.

Of the 28 patients in the diversion group, 21 were diverted by a colostomy (12 end and 9 loop) and 6 by ileostomy (3 end and 3 loop). One patient had a shotgun wound requiring resection of a large portion of small bowel and colon and underwent an end jejunostomy.

Of the patients in the primary repair group, 11 underwent resection with anastomosis, (10 stapled functional end to end, 1 sutured) and 17 underwent debridement and closure (5 stapled, 12 sutured). There were no anastomotic leaks in the primary repair group.

Complications developed with equal frequency in both groups (Table 7). Eighteen patients in the diversion group and 19 patients in the primary repair group had no complications and an uneventful recovery and discharge. In the diversion group, there was one patient who developed a soft tissue infection in the anterior abdominal wall. This patient had a shotgun wound and developed a subcutaneous abscess between the incision and stoma. In the primary repair group, there was one wound infection that occurred after the wound was closed by delayed primary closure. There were two fistulas (one pancreatic and one duodenal) in the diversion group. Both healed by non-operative treatment with total parenteral nutrition.

Patients who developed intra-abdominal abscesses were evaluated for known risk factors (Table 8). The length of time from arrival in the accident room to operation was not different from the overall group for the seven patients

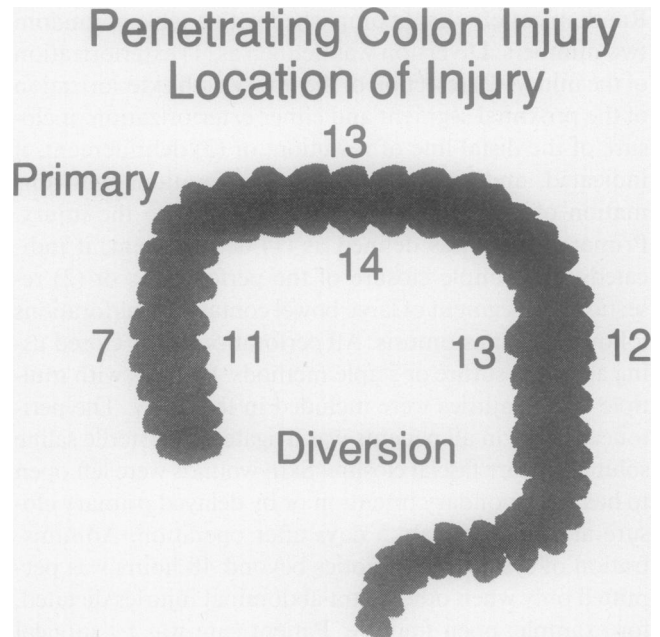


FIG. 1. Location of injuries, primary repair versus diversion.

who developed intra-abdominal abscesses. One patient was 61 years old (older than average), but the remaining six patients were all between the ages of 17 and 33. Penetrating Abdominal Trauma Index score was less than 25 in four patients and more than 25 in three. Blood transfusion was required in six of the seven patients, but shock was only present in one of the seven patients. There was no difference in the incidence of abscess between the diversion and primary repair groups. Two of the three patients with intra-abdominal abscess in the primary repair group had resection and anastomosis. The number of associated injuries, number of colon injuries, and grade of the worst colon injury were similar.

All dehiscences occurred in the diversion group (Table 9). One patient was 61 years old, received 10 units of PRBCs, and developed an intra-abdominal abscess. In the other two patients, no contributing factors could be identified that predisposed the patient to dehiscence.

Drains were used as indicated for associated injuries; no colon repair was drained.

To date stoma closure has been performed on 22 pa-

TABLE 5. Colon Injury Severity Scale

Worst Grade Injury	Primary Repair	Diversion
I	0	0
II	4	3
III	13	17
IV	7	5
V	4	3

TABLE 6. Number Colon Injuries

Number	Primary Repair	Diversion
1	25	20
2	2	6
3	1	2

TABLE 7. *Complications*

Complication	Primary Repair	Diversion
Intra-abdominal abscess	3	4
Dehiscence	0	3
Repeat operation	2	3
Duodenal leak	0	1
Pancreatic fistula	0	1
Ureteral stenosis	0	1
Wound infection	1	1
IVC thrombosis	1	0
BC+—no source	2	0
Respiratory failure	0	1
Phlebitis	0	1
Catheter sepsis	0	1
Atelectasis	1	1

IVC, inferior vena cava; BC+, blood culture positive without identifiable source.

tients. One patient with a colostomy had a spinal cord transection with paralysis and there is no plan for closure. Of the 22 patients closed, the average length of stay was 7.4 days (range, 4 to 11 days) for closure. The average interval from creation to closure of stoma was 120 days (range, 51 to 264 days). Twenty-one of twenty-two stomas were closed without complication. One patient with an ileostomy developed an enterocutaneous fistula after ileostomy closure. The fistula closed spontaneously after 18 days of hyperalimentation. Comparing length of stay for each group, including admission and readmission for colostomy closure, shows a longer stay for the diversion group than the primary repair group (18.8 days *versus* 12.8 days).

Discussion

Trends in the management of colonic injury in this century have been summarized by Nance.⁶ Primary repair was favored early in the century until World War II, when Ogilvie's classic paper describing the British experience

TABLE 8. *Intra-abdominal Abscess*

Time to Surgery (min)	Age	PATI	Number Units PRBC	Shock
Diversion				
75	61	30	10	No
75	19	32	2	No
90	29	19	0	No
120	22	22	6	No
Primary repair				
105	33	24	4	Yes
58	32	77	8	No
58	31	18	2	No

PATI, Penetrating Abdominal Trauma Index; PRBC, packed red blood cells.

TABLE 9. *Wound Dehiscence: Diversion*

Time to Surgery (min)	Age	PATI	Number Units PRBC	Shock
24	30	22	0	No
35	22	20	0	No
75	61	30	10	No

PATI, Penetrating Abdominal Trauma Index; PRBC, packed red blood cells.

in the African desert and the mandate by the Surgeon General of the Armed Service Forces of the United States made colostomy proximal to or at the site of large bowel trauma the standard of care.^{7,8} Woodhall and Ochsner⁹ in 1951 suggested the safety of primary repair in selected patients with civilian colon injury. Diversion remained the standard of care during the period from 1950 to 1980, however. In the last 10 years, primary repair has assumed an increasing role in the treatment of colon injuries.¹⁻³

Stone and Fabian,⁴ in a 1979 prospective randomized study of perforating colon injuries, clearly demonstrated that, in select patients, primary repair was effective when compared with colostomy. Moreover in some patients the colon-related morbidity rate of primary repair was less than that of diversion. As a 'randomized, prospective' study, this important paper was criticized on several points. A large number of patients (48%) were eliminated from randomization and assigned obligatory colostomy on the basis of parameters indicating severe injury (shock, excessive blood loss, more than two abdominal organs injured, excessive fecal contamination, delay in operation, colon injury requiring resection, major abdominal wall loss). In addition randomization was on the basis of the patient's hospital number, not the ideal method of blinding the surgeon obtaining consent of the patient.

Despite the criticisms of the report by Stone and Fabian, the importance of their investigation cannot be underestimated. The past decade has ushered in a number of

TABLE 10. *Comparison of Retrospective Studies*

Author		Wound Infection (%)	Intra-abdominal Abscesses (%)	Deaths (%)
Jurisich unpublished data	Colostomy	23	6	8.5
	Primary repair	9.4	3	2.6
George ³	Colostomy	29	10	6.4
	Primary repair	8.6	5.5	1.4
Shannon ¹	Colostomy	12	25	2*
	Primary repair	7	14	1
Burch ²	Colostomy	5.3	16.7	9.2
	Primary repair	4.5	5.3	1.6

* Septic-related death.

retrospective studies from major trauma centers on the treatment of the injured colon. These studies and those of our institution's retrospective data (unpublished) tend to agree with Stone and Fabian (Table 10). These retrospective data have shown that patients often can be treated successfully with primary repair even in the presence of the adverse conditions that mandated obligatory colostomy by Stone and Fabian.⁴

George and colleagues prospectively performed primary repair in 95 of 102 patients (93%) with colon injury.¹⁰ The incidence of wound infection was 14.8% and intra-abdominal abscess/peritonitis was 13.6%. There was one suture line failure in the anastomosis group.

Many advances in prehospital care, resuscitation, blood banking, and critical care have changed the natural course of the patient with civilian colon injury as compared with 50 years ago. When victims of colon trauma die in the early postinjury period, death is usually due to other injuries, such as great vessel perforation or head injury. The usual problems associated with colon injury are infections with subsequent complications and, sometimes, death. The purported advantage of diversion over primary repair is the avoidance of a suture line leak as a potential source of intra-abdominal sepsis. In this study the incidence of colon-related complications did not differ between the two groups. The incidence of intra-abdominal abscess was 14% in the diversion group and 11% in the primary repair group. There was no suture line leak in the primary repair group.

It has been suggested that the PATI is a reliable basis for prediction of complications and a gauge for comparison of colon injury management. Moore and coworkers⁵ found that when the PATI was 25 or less, the morbidity rates after stab wounds and gunshot wounds to the abdomen were 5% and 7%, respectively. A PATI of greater than 25 was associated with morbidity rates of 50% and 46%, respectively. Retrospectively, Nelken and Lewis¹¹ evaluated PATI, the Injury Severity Score (ISS), and the Flint Colon Injury Score. They concluded that PATI was superior to ISS and the Flint Score and recommended that the use of primary repair be expanded in civilian colon trauma. In our review the average PATI scores were 26 for the primary repair group and 23.9 in the diversion group. The number of patients with a PATI score greater

than 25 or less than 25 was similar in each group (Table 11). For those patients in either group who developed colon-related complications, however, a PATI score greater than 25 was not an accurate predictor of complications in either group.

Exteriorized repair continues to be used in some centers as a method of management of colon trauma.¹² It requires a perforation, ideally on the antimesenteric border, amenable to suture closure rather than resection and capable of mobilization to the abdominal wall without excessive tension. Meticulous postoperative care is needed in the form of dressing changes. Despite enthusiastic proponents it never has been widely practiced. For these reasons we have not adopted the technique and did not think it appropriate for inclusion in this study.

The treatment of colon injury cannot be addressed satisfactorily without discussion of the psychological, financial, and physical consequences of colostomy and subsequent closure. Few would debate the psychological adjustments needed to adapt to life with a stoma, even if temporary. Similarly there is no doubt about the added expense of a second procedure for colostomy takedown, which involves not only the hospital and physician fees, but also the potential loss of work time during the hospitalization and recovery.

There is a wide variation in the recorded morbidity of stoma closure. Parks and Hastings¹³ found a 36% complication rate and no deaths in a review of 83 patients subjected to colostomy closure at our institution after stoma formation for a variety of diagnoses, including injury. In contrast other reviews addressing colostomy closure after colon injury have found a much lower morbidity rate.¹⁴⁻¹⁶ Crass et al.¹⁵ studied 75 patients with colostomy takedown after colon injury and found a 5% overall complication rate, which correlates with the 5% morbidity rate in this study. Even though stoma closure after trauma can be done with a low morbidity rate, we agree with Jordan¹⁷ that any operation, regardless of complication rate, is a potential cause of complications for the patient and that a colon injury should be managed with primary repair, avoiding colostomy and subsequent takedown, if it is judged safe to do so.

In addition to the morbidity rate of colostomy closure, the added time of hospitalization must be evaluated. Patients in this study who had colostomy closure had an average total length of hospital stay of 18.8 days *versus* 12.8 days for the primary repair group.

This review describes the results of a randomized prospective study of penetrating colon injury with no exclusion criteria. Evaluation of previously identified risk factors including PATI score greater than 25, number of transfusions, shock, and the time interval to operation

TABLE 11. Comparison of PATI

PATI	Primary Repair	Diversion
<25	18	20
>25	10	8

PATI, Penetrating Abdominal Trauma Index.

was not beneficial in predicting increased morbidity rate from primary repair. The results suggest that virtually all patients with penetrating civilian colon trauma can be managed safely by primary repair.

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DISCUSSIONS

DR. ARTHUR C. BEALL, JR. (Houston, Texas): I rise to note that at this meeting in this hotel 20 years ago, I presented the Baylor experience on primary repair of colon injuries. I can well remember I was severely taken to task at that meeting by people who pointed out the experience in World War II, the Surgeon General's dictum regarding exteriorization, and so forth.

Obviously civilian colon injuries are different. They are usually stab wounds or low-velocity missiles as compared to high-velocity missiles in war time. The contamination is different. The time from injury to treatment is different. The follow-up is different. The treating surgeons are usually well-trained residents under supervision by experienced staff.

You cannot compare the two, but people have done that now for 40 years since Dr. Ochsner presented the Tulane experience on primary repair of colon injuries. People have quoted "Those who cannot remember the past are condemned to repeat it." However there are times that the past is different from the present. I hope we no longer have papers on primary repair of colon injuries in civilian practice introduced by saying there is still considerable controversy. I think it's time to lay that controversy to rest.

DR. TIMOTHY C. FABIAN (Memphis, Tennessee): I congratulate the authors on a very well-constructed prospective randomized study. It was very well controlled; the patients were well matched relative to location and grade of injury. Their data corroborate studies that I have been involved with in the past. And it certainly is convincing that primary repair is preferable to diversion for nondestructive colon wounds. I agree with Dr. Beall that there is little question that those wounds are appropriate. But I would still like to sound a word of caution about more injurious injuries that require resection and anastomosis. I think the jury is still out relative to those patients.

I would like to take a second and put some of this into perspective. In addition to Dr. Beall's work at Baylor 20 years ago, Woodall and Ochsner in New Orleans in 1951 were the first in the post-World War II period to suggest that civilian wounds were different and half of their patients could be repaired primarily. Regardless of that, it fell pretty much on deaf ears throughout the country, and most people began diverting most of these patients.

I would next like to refer to the study that Dr. Cohn mentioned, the perspective randomized study that was designed by Dr. Harlan Stone,

and I was fortunate enough to participate in, presented at this meeting 12 years ago.

At that time primary repair was not a popular thing to do, as Dr. Beall suggested. Most people still were pretty skeptical that it could be done, safely, and at that time it was elected not to do it on everybody because there were no data available. Therefore certain patients were eliminated. Those who were in shock, who had more than two units of blood loss, significant delays in operation greater than 6 hours, multiple associated organ injuries, and excessive fecal contamination were not considered. If they had those, the patients underwent obligatory colostomy, which was 48% of the total population of 268 patients. The other 52% then were randomized to primary closure *versus* colostomy. As you can see, the intraperitoneal infection rate was significantly ($p = 0.05$) higher with colostomy. So that data demonstrated certainly that primary repair was not only as good but better for selected cases.

Two year ago we presented a study that was prospective but not comparative. It became fairly clear to us that the vast majority of colon injuries could be repaired primarily and did not require resection. At that time we had 83 patients with primary repair. We had 12 patients who had anastomoses. I would like to focus on the intra-abdominal sepsis rate, which was very similar to that data presented today. Our rate was 12% with primary repair. And, very importantly, there were no failures of repair in that study. Zero of 83.

Currently we are finding about a 1% failure rate with primary repair. However, with anastomosis, although there was a small number of patients, there was one failure. A patient leaked his anastomosis.

Subsequently we have had a fairly large series of colectomies with anastomosis and currently we're finding a 10% failure rate. It is clear to me that not all patients can be primarily anastomosed safely, and I think that is our next great challenge. Our risk factors have been major contamination and transfusions.

With that said, I would like to ask the following questions to the LSU group. First you noted that you only administer perioperative antibiotics for 48 hours. What is the rationale for using that limited amount of therapy in these patients, although that does satisfy my bias? I do not think there are any data available.

I would like to know about the 10% dehiscence rate in the resected patients. Was this due to necrotizing fascia or was this technical failure?

And finally are there any patients on whom you would not do a primary anastomosis today? I suspect that we will get a little more conservative as more data are available on that in the future.