# The Injured Colon

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**Controversy continues regarding the initial management of civilian colon injuries. The main issues are the safety of colostomy *versus* the desirability of primary repair and the role of exteriorized repair. From 1979 through 1984, 727 patients with injuries to the colon were treated at a large urban trauma center. Ninety-seven per cent of injuries were caused by penetrating wounds. Ten patients died in the operating room prior to repair of the colon wound. For patients who survived long enough to have their injury treated, 52.4% were treated by primary repair, 32.9% were treated with colostomies, and 14.6% were treated with exteriorized repair. Of the factors that have been stated to influence decision making, the extent of the colon injury was the most important. Location, number, and type of associated injuries, fecal contamination, and shock were less important. However, none of these latter factors mandated performance of a colostomy. The overall mortality rate for the series was 9.9%. Forty-one out of 70 deaths occurred within the first 48 hours and were due to shock and hemorrhage. The mortality rate for primary repair was significantly lower than that for colostomies ($p < 0.01$). The presence of shock and age greater than 40 were significant factors influencing mortality ($p < 0.01$). Mortality also was directly related to the number and type of associated abdominal injuries. Abdominal abscess also occurred significantly less often in patients treated with primary repair than in those with colostomies ($p < 0.01$). The use of exteriorized repair was successful in avoiding colostomy in 59% of patients. Primary repair can be performed with minimal morbidity and mortality and should be the mainstay of treatment for civilian colon injuries.**

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IN 1943, a proclamation went out over all the lands occupied by the Army of the United States that the proper treatment for wartime wounds of the colon would include performance of a colostomy.[1] This edict was predicated on the facts that: (1) there were many surgeons who did not have experience in the management of war wounds; (2) most war wounds of the colon resulted from high velocity missiles that destroyed significant segments of the colon, often surrounded by a severe blast effect; and (3) the patient often had to be transferred after the initial emergency therapy, and, if complications occurred en route, it might not be possible to manage them promptly. It is generally agreed that this edict resulted in a decrease in the mortality rate from colon wounds.

Historically, most of the information concerning treatment of traumatic wounds was generated from wartime experience, and the knowledge gained from this experience was frequently incorporated into the management of civilian wounds. The routine use of colostomy in the treatment of civilian colon injuries was questioned within a few years after the end of World War II[2] for several reasons: (1) civilian wounds of the colon often resulted from low velocity missiles or from small knife wounds without any blast injury and with relatively small perforations of the colon; (2) in many instances, treatment was by well-trained surgeons; and (3) the patient usually remained under the continued care of the operating surgeon and was not transferred.

Members of our department have advocated the individualized treatment of colon injuries for over 25 years.[3,4] Controversy continues, however, and to document the results of our current management principles, a review of our experience from 1979 through 1984 was undertaken.

## Clinical Material and Methods

From January 1, 1979, through December 30, 1984, 914 patients with injuries to the colon and rectum were

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TABLE 1. *Distribution of 797 Colon Injuries in 727 Patients According to the Mechanism of Injury*

| Location | Gunshot Wound % | Stab Wound % | Shotgun Wound % | Blunt % | Other % |
|---|---|---|---|---|---|
| Right colon N = 213 | 64.3 | 18.3 | 14.1 | 2.3 | 0.9 |
| Transverse colon N = 279 | 62.7 | 26.9 | 8.2 | 1.8 | 0.3 |
| Left colon N = 305 | 60.3 | 25.2 | 10.8 | 1.6 | 2.0 |
| Total 797 | 62.2 | 24.0 | 10.8 | 1.9 | 1.1 |

treated at Ben Taub General Hospital in Houston, Texas. One hundred nineteen patients had uncomplicated seromuscular injuries that would have healed without operative treatment and were excluded from this review; an additional 68 patients with injuries involving the rectum were also excluded. The remaining 727 patients with 797 colon injuries with perforation or devascularization causing necrosis constitute the subjects for this study. Males (89.1%) were injured more often than females (10.9%). The average age was 28.8 years, with a range of 4–88 years.

Penetrating injuries accounted for 97% of all injuries. There were 457 (62.9%) gunshot wounds, 58 (8.0%) shotgun wounds, 188 (25.8%) stab wounds, 15 (2.1%) injuries caused by blunt trauma (automobile accidents), and nine (1.2%) injuries caused by unusual sexual practices or complications of therapeutic abortions performed at other institutions.

For purposes of localization, the colon was grouped into the right, transverse, and left colons. The hepatic and splenic flexures were included with the right or left (respectively) and not the transverse colon. There were 213 injuries to the right colon, 297 injuries to the transverse colon, and 305 to the left colon. Sixty-eight (9.4%) patients had injuries to more than one location, resulting in a total of 797 colonic injuries. When all injuries to the colon are considered, the left colon rather than the transverse predominated. Wounding agents were rather evenly distributed throughout these three major locations (Table 1). Two subtle differences appear to be a slight decrease in the incidence of stab wounds and a slight increase in the incidence of shotgun wounds on the right side. The reason for these differences is not clear. Associated injuries were quite common, and, not surprisingly, the most commonly associated organ injured was the small intestine (Table 2). The number of associated major vascular injuries was remarkable, with a total of 146. There were nine associated cardiac injuries.

TABLE 2. *Associated Injuries*

| | | | |
|---|---|---|---|
| Small bowel | 328 | Spinal cord | 8 |
| Liver | 153 | Renal vein | 6 |
| Lung | 120 | Iliac vein | 6 |
| Stomach | 113 | Uterus | 5 |
| Kidney | 112 | Neck | 5 |
| Extremity | 101 | External iliac artery | 4 |
| Diaphragm | 95 | Head | 4 |
| Duodenum | 69 | Renal artery | 3 |
| Pancreas | 56 | Ovary | 3 |
| Inferior vena cava | 46 | Testis | 3 |
| Spleen | 39 | Trachea | 3 |
| Gall bladder | 33 | Portal vein | 2 |
| Ureter | 31 | Internal iliac artery | 2 |
| Aorta | 19 | Esophagus | 2 |
| Common iliac vein | 19 | Urethra | 2 |
| Bladder | 18 | Adrenal | 2 |
| Superior mesenteric vein | 11 | Appendix | 2 |
| External iliac vein | 10 | Brain | 2 |
| Heart | 9 | Common bile duct | 1 |
| Chest wall | 8 | Fallopian tube | 1 |
| Common iliac artery | 8 | Penis | 1 |
| Iliac artery | 8 | Innominate artery | 1 |
| Superior mesenteric artery | 8 | Innominate vein | 1 |

Shock was defined as being present when the blood pressure was recorded as below 80 mmHg systolic. Specifically excluded were patients who had a transient drop in blood pressure with the induction of anesthesia. Time from wounding to operation was defined as the time from when the injury occurred to the time the knife cut the skin in the operating room. Statistics were performed with the chi square test.

## Treatment

Initial patient management was usually performed by emergency medical technicians of the Houston Fire Department. Balanced saline solution was administered intravenously during transfer. Obtunded or unconscious patients had airway protection and oxygen administration. On arrival in the emergency center, history and physical examination were performed expeditiously; chest, abdomen, and single exposure intravenous (I.V.) pyelogram radiographs were obtained. Blood was drawn for complete blood count and blood typing. All patients sustaining truncal gunshot wounds, shotgun wounds, or penetrating stab wounds below the fifth intercostal space underwent prompt exploration. All patients received tetanus prophylaxis and preoperative antibiotics. During the last 5 years of this study, antibiotics were administered on the basis of a randomized protocol.

Operations were performed by the resident staff under the supervision of senior faculty. The abdomen was explored through a long midline incision. All liquid blood and clots were promptly evacuated and hemorrhage controlled. Prevention of additional contamination from colon injuries was the next priority, and the colon wound was occluded with either sutures or clamps. The peritoneal cavity frequently was irrigated with warm saline to remove fecal contamination before further surgery was performed.

TABLE 3. *Treatment of Colon Injuries in 727 Patients*

| Treatment | No. | % |
|---|---|---|
| Primary repair | 376 | 51.7 |
| Simple closure | 346 | 47.6 |
| Resection and ileocolostomy | 21 | 2.9 |
| Resection and colocolostomy | 9 | 1.2 |
| Colostomy | 236 | 32.5 |
| Exteriorized repair | 105 | 14.4 |
| None | 10 | 1.4 |
| Total | 727 | 100 |

If simple suture of the colon injury was selected as the treatment, the wound was debrided as necessary. In many cases debridement was not required. An attempt was made to close all wounds in a transverse fashion to prevent narrowing of the lumen. Virtually all wound closures were performed in two layers, using 3-0 polyglycolic acid suture through all layers and interrupted 3-0 silk seromuscular sutures.

At the completion of the operation, the abdomen was irrigated with large quantities of warmed saline until the effluent was clear. This frequently required 5–10 liters. The last liter of irrigation solution contained 1 gram of kanamycin and 50,000 units of bacitracin. Colon injuries or repairs were never drained, although drainage was selectively used for other organ injuries (*e.g.*, liver, pancreas, duodenum, and urologic injuries). Most abdominal wounds were closed using a running #1 polypropylene suture; retention sutures were used selectively. The skin was closed selectively with a running 2-0 nylon suture or a running 3-0 polyglycolic acid subcuticular suture. The skin was closed primarily in 64% of patients; delayed primary closure was performed rarely. Perioperative antibiotics were administered by protocol for 48 hours and then discontinued.

A wide variety of techniques were used to treat colon injuries (Table 3). "Primary repair" is used to describe three methods of treatment: simple closure, resection and ileocolostomy, and resection and colocolostomy. The term colostomy is used to describe a variety of procedures, including resection with end colostomy and mucous fistula, ileostomy and mucous fistula, exteriorization of the injury, repair with proximal colostomy, and Hartmann's procedure. Exteriorized repairs were performed with standard suture techniques and suspended on the abdominal wall with a nylon rod. An effort was made not to use this technique with injuries of the mesenteric border because leakage may be more likely to contaminate the peritoneal cavity. The repair was kept moist with saline dressings. If leakage occurred, a loop colostomy was created. If leakage had not occurred by the tenth postoperative day, the repair was replaced beneath the fascia and the fascia closed. The skin was always left open.

TABLE 4. *Location of Wound According to Treatment in 651 Patients with Injuries to Only One Area of the Colon*

| Treatment | Right Colon N = 186 % | Transverse Colon N = 223 % | Left Colon N = 242 % |
|---|---|---|---|
| Primary repair | 78.5 | 61.8 | 32.2 |
| Simple closure | 64.5 | 60.5 | 31.8 |
| Resection and ileocolostomy | 11.3 | 0.0 | 0.0 |
| Resection and colocolostomy | 2.7 | 1.3 | 0.4 |
| Colostomy | 15.6 | 27.8 | 40.9 |
| Exteriorized repair | 5.9 | 10.3 | 26.9 |

Factors potentially related to the treatment of colon wounds were evaluated. These include location of the injury, the presence of shock, the time from wounding to treatment, the number and type of associated injuries, the extent of the colon injury, and the degree of fecal contamination; each of these will be dealt with separately. Because of the complexity and paradoxes of multiple wounds requiring multiple treatments in divergent areas, a simplified table was constructed to describe the 651 patients with injuries to only one colonic location (Table 4). Primary repair was performed in all locations, although there was a distinct difference between the right colon (78.5%) and the left colon (32.2%). In part this is due to the fact that resection and ileocolostomy was not performed in the left colon. There was also an increase in the number of exteriorized repairs on the left side. No location, however, was considered a contraindication to simple closure. Stab wounds were far more frequently treated by simple closure than any other type of injury, and blunt injuries were most often treated by colostomy (Table 5). Gunshot wounds, by far the most common cause of colonic injury, were treated with primary repair in 47.4% of cases. Shotgun wounds were treated by primary repair in 42.9% of cases.

TABLE 5. *Incidence of Wounding Agent According to Treatment in 727 Patients*

| Treatment | GSW N = 449 % | SW N = 188 % | SGW N = 56 % | Blunt N = 15 % | Other N = 9 % |
|---|---|---|---|---|---|
| Primary repair | 47.4 | 70.2 | 42.9 | 28.7 | 33.3 |
| Simple closure | 42.5 | 69.1 | 35.7 | 13.3 | 33.3 |
| Resection and ileocolostomy | 3.8 | 0.0 | 5.4 | 7.7 | 0.0 |
| Resection and colocolostomy | 1.1 | 1.1 | 1.8 | 7.7 | 0.0 |
| Colostomy | 37.0 | 13.3 | 53.6 | 60.0 | 66.7 |
| Exteriorized repair | 15.6 | 16.5 | 3.6 | 13.3 | 0.0 |

TABLE 6. *Treatment of Colon Injuries in 171 Patients with Shock*

| Treatment | Preoperative Only N = 72 % | Intraoperative Only N = 30 % | Preoperative and Intraoperative N = 69 % |
|---|---|---|---|
| Primary repair | 58.3 | 23.3 | 40.6 |
| Simple closure | 55.6 | 20.0 | 34.8 |
| Resection and ileocolostomy | 2.8 | 3.3 | 5.8 |
| Resection and colocolostomy | 0.0 | 0.0 | 0.0 |
| Colostomy | 33.3 | 66.7 | 52.2 |
| Exteriorized repair | 8.3 | 10.0 | 7.2 |

One hundred seventy-one patients experienced shock in the preoperative or intraoperative period or both (Table 6). Although the frequency of primary repair varied in these critically ill patients, it was nevertheless performed commonly in all three shock categories. There were 533 patients treated within 6 hours of wounding, 148 patients treated between 6–24 hours, and 13 patients treated greater than 24 hours after wounding (Table 7). Excluding the 10 patients who never received treatment and 23 in whom this time could not be accurately determined, there was virtually no difference in the distribution of the various repairs between the <6-hour group and the >6-hour group. The ">24-hour" patients are interesting in that they did not attempt to seek medical treatment for at least 24 hours after an injury had occurred. In some cases, this was as long as 4 days. All patients in this group presented with signs and symptoms of feculent peritonitis. In spite of this delay, three patients were still treated with primary repair.

The severity of the colon injury was graded 1, 2, and 3, using a grading system described by Flint et al.[5] In addition, another category was created for those injuries that devascularized the colon or nearly transected it (Table 8). There were 153 patients in this category of "extensive" colon injuries. Only 3.9% could be treated by simple closure and 76.5% required colostomy. Resection and ileocolostomy as a form of primary repair was performed in 10.5% of these patients.

TABLE 7. *Time from Wounding to Operation for Various Treatments in 694 Patients**

| Treatment | <6 Hours N = 533 % | 6–24 Hours N = 148 % | >24 Hours N = 13 % |
|---|---|---|---|
| Primary repair | 52.3 | 58.8 | 23.1 |
| Simple closure | 48.4 | 54.7 | 15.4 |
| Resection and ileocolostomy | 3.0 | 3.4 | 0.0 |
| Resection and colocolostomy | 1.1 | 0.7 | 7.7 |
| Colostomy | 33.6 | 23.0 | 53.8 |
| Exteriorized repair | 13.9 | 18.2 | 23.1 |

* See text.

TABLE 8. *Management of "Extensive" Colon Injuries in 153 Patients*

| | % |
|---|---|
| Primary repair | 17.6 |
| Simple closure | 3.9 |
| Resection and ileocolostomy | 10.5 |
| Resection and colocolostomy | 3.3 |
| Colostomy | 76.5 |
| Exteriorized repair | 5.9 |

Fecal contamination was very difficult to grade because of its subjectivity. Nevertheless, there were 97 patients in whom the surgeon stated that extensive fecal contamination was present (Table 9). This group includes all 13 patients who sought medical treatment greater than 24 hours after wounding. Primary repair was employed in 22.6% of these patients with simple closure, accounting for 8.2%, and resection in ileocolostomy 11.3%. In addition, 56 (57.7%) of these patients also had colon injuries described as "extensive."

The number of associated abdominal organ injuries is a reflection of the overall seriousness of the wound and has been considered to be a factor determining the appropriateness of primary repair or colostomy (Table 10). Each abdominal organ was counted once, and each major abdominal vascular injury was counted once. There was a clear trend showing a decrease in the frequency of primary repair accompanied by an increase in the frequency of colostomy with increasing numbers of associated organs injured. Nevertheless, primary repair was still accomplished in all categories. Exteriorized repair was performed with a fairly equal distribution. The incidence with which specific organs were injured relative to treatment was also evaluated (Table 11). In each organ category, there was a slight increase in the frequency with which colostomy was performed compared to primary repair; however, there were no specific associated organ injuries that mandated colostomy.

TABLE 9. *Management of Colon Injuries Associated with Extensive Contamination in 97 Patients*

| | % |
|---|---|
| Primary repair | 20.6 |
| Simple closure | 8.3 |
| Resection and ileocolostomy | 11.3 |
| Resection and colocolostomy | 1.0 |
| Colostomy | 63.9 |
| Exteriorized repair | 15.5 |

TABLE 10. *Treatment of 717 Patients According to Number of Associated Abdominal Injuries**

| | 0 N = 149 % | 1 N = 265 % | 2 N = 159 % | 3 N = 90 % | 4 N = 39 % | 5 N = 7 % | 6 N = 7 % | 7 N = 1 % |
|---|---|---|---|---|---|---|---|---|
| Primary repair | 61.7 | 54.3 | 50.9 | 46.7 | 30.8 | 28.6 | 42.9 | 0.0 |
| Colostomy | 24.2 | 27.5 | 35.8 | 41.1 | 61.5 | 57.1 | 57.1 | 100.0 |
| Exteriorized repair | 14.1 | 18.1 | 13.2 | 12.2 | 7.7 | 14.3 | 0.0 | 0.0 |

* See text.

## Results

### *Mortality*

Mortality rate is the ultimate determinant for success or failure of a given treatment. Therefore, the results of mortality have been studied in detail and correlated with suspected risk factors. Of the 727 patients treated, there were 70 deaths. Ten patients exsanguinated in the operating room prior to repair of the colon wound but after a colon injury was identified. Twenty-one patients were transferred to other hospitals prior to completion of their care at this institution. All of these patients had minimal injuries and were stable at the time of transfer. It is reasonable to presume that they all survived; however, follow-up was not available, and they are excluded from calculations of mortality and complications. The overall mortality rate in the remaining 706 patients was 9.9%. Mortality was further subdivided into two groups, early and late. By definition, early deaths were said to occur within 48 hours of admission. All of these patients died of shock and exsanguination and are excluded from calculations of complications. There were 41 patients in this group for a mortality rate of 5.8%, and 29 patients in the late death category for a mortality rate of 4.1%.

The mortality rate for each type of repair was tabulated (Table 12). The most significant difference in this table is the comparison of the late mortality rate for primary repair, 1.6%, and that for colostomy, 9.2% ($p < 0.01$). Since the existence or treatment of a colon wound has little bearing on whether a patient dies of shock or hemorrhage, a detailed analysis of the late deaths is of paramount importance (Table 13). There were four patients who appeared to die from irreversible shock following massive hemorrhage during this time, two at 2 days and two at 3 days after admission. There were only 19 patients who possibly died of complications related to the colon injury or its treatment. Three occurred in the primary repair group, 15 in the colostomy group, and in one with an exteriorized repair. This yields a mortality rate of 2.7% for colon injury related deaths.

The location for a particular injury also had a bearing on the mortality rate. Most fatalities (79%) had injuries in or around the right upper quadrant or were associated with injuries to the sigmoid colon. These 55 patients had associated major vascular injuries in 67% of cases.

Mortality rates were determined relative to repair for

TABLE 11. *Incidence of Specific Organ Injuries According to Type of Repair in 717 Patients**

| | Liver % | Vascular % | Kidney % | Duodenum % | Pancreas % |
|---|---|---|---|---|---|
| Primary repair N = 376 | 20.7 | 12.5 | 12.5 | 8.5 | 6.4 |
| Simple closure N = 346 | 19.9 | 12.4 | 12.1 | 8.1 | 6.4 |
| Resection and ileocolostomy N = 21 | 23.8 | 19.0 | 23.8 | 19.0 | 4.8 |
| Resection and colocolostomy N = 9 | 44.4 | 0.0 | 0.0 | 0.0 | 11.1 |
| Colostomy N = 236 | 22.5 | 20.3 | 18.2 | 11.9 | 11.4 |
| Exteriorized repair N = 105 | 16.2 | 7.6 | 20.0 | 5.7 | 2.8 |

* See text.

TABLE 12. *Mortality Rates According to Type of Repair in 696 Patients**

| Treatment | Total % | Deaths Early % | Deaths Late % |
|---|---|---|---|
| Primary repair N = 368 | 4.9 | 3.3 | 1.6 |
| Simple closure N = 340 | 5.0 | 3.5 | 1.5 |
| Resection and ileocolostomy N = 19 | 0.0 | 0.0 | 0.0 |
| Resection and colocolostomy N = 9 | 11.1 | 0.0 | 11.1 |
| Colostomy N = 228 | 17.5 | 8.3 | 9.2 |
| Exteriorized repair N = 100 | 2.0 | 0.0 | 2.0 |
| Total N = 696 | 8.6 | 4.5 | 4.2 |

* See text.

TABLE 13. *Treatment and Cause of Death in 29 Patients who Expired 48 Hours or More after Admission*

| | Primary Repair | Colostomy | Exteriorized Repair |
|---|---|---|---|
| | 1 Fistula and sepsis (colocolostomy) | 14 Multisystem failure and sepsis | 1 Shock (2 days) |
| | 1 Pulmonary aspiration | 1 Myocardial infarction | 1 Necrosis of transverse colon |
| | | 2 Shock (3 days) | |
| | 1 Cecal necrosis (blunt trauma) | 1 Shock (2 days) | |
| | 1 Hemorrhagic pancreatitis | 1 Brain injury | |
| | 1 Missed injury | 1 Pulmonary embolus | |
| | 1 Midgut infarction | 1 Necrosis of colostomy | |
| Total | 6 | 21 | 2 |

shocked patients (Table 14). The overall mortality rate for patients with preoperative shock was only 5.6%. This is in striking but not unexpected contrast to a mortality rate of 26.7% for those with intraoperative shock, or the mortality rate of 58.0% for those with shock occurring both before and during the operation. In all three shock categories, the mortality rates were lower for those patients treated by primary repair.

Mortality rates were also consistently lower in those patients treated by primary repair, regardless of the elapsed time between wounding and operation (Table 15). Surprisingly, no deaths occurred in the patients treated with primary repair who were operated upon greater than 6 hours after wounding.

As has been consistently shown previously, mortality is directly related to the number of associated injuries (Table 16). Finally, patients over the age of 40 years had a mortality rate of 20.7%, almost three times that of younger patients, 7.4% ($p < 0.01$).

*Complications*

Complications related to the pulmonary system were the most commonly encountered (Table 17). Four complications considered to be potentially related to the colon wound were analyzed separately (Table 18). These include abdominal abscess, fever of unknown origin, wound infection, and fecal fistula. For the purpose of this study, the term, "fever of unknown origin," is not used in the usual sense but used rather to define the complication in a group of individuals who had prolonged fever with no identifiable source, such as atelectasis, phlebitis, urinary tract infection, or other discernible cause. These patients had a prolonged hospital stay and were treated with antibiotics. It is most likely that this diagnosis represented a degree of peritoneal cellulitis that never developed into an abdominal abscess. The overall rate of abdominal abscess formation was 9.0%, fever of unknown origin occurred in 4.8% of patients, wound infection in 4.7%, and fecal fistula in 1.1%. Abdominal abscess occurred almost three times as often in patients treated by colostomy as compared to those with primary repair ($p < 0.01$), and more than twice as often in patients with shock, 15.4%, compared to those without shock, 7.4% ($p < 0.01$). Wound infections were distributed relatively equally throughout the patients, with the notable exception of a very high incidence in those treated by ileocolostomy, 31.6% ($p < 0.01$).

Of great interest is the low frequency of fecal fistula in patients treated by simple closure. This occurred in only three (0.9%) patients. This rate is actually lower than the incidence of fecal fistula in patients treated by colostomy (1.4%). Of the three patients who developed fecal fistula following simple closure, two appeared after the drainage of an intra-abdominal abscess and closed spontaneously. The third occurred in a patient who received a gunshot wound to the midtransverse colon, liver, and lung. This patient was in shock before and during surgery, lost 14

TABLE 14. *Treatment of Colon Wounds in 171 Patients with Shock and Associated Mortality Rates*

| | Preoperative Only | | Intraoperative Only | | Preoperative and Intraoperative | | Total | |
|---|---|---|---|---|---|---|---|---|
| Treatment | No. | Mortality Rate % | No. | Mortality Rate % | No. | Mortality Rate % | No. | Mortality Rate % |
| Primary repair | 42 | 2.4 | 7 | 14.3 | 28 | 53.6 | 77 | 22.1 |
| Colostomy | 24 | 12.5 | 20 | 35.0 | 36 | 63.9 | 80 | 41.3 |
| Exteriorized repair | 6 | 0.0 | 3 | 0.0 | 5 | 40.0 | 14 | 14.3 |
| Total | 72 | 5.6 | 30 | 26.7 | 69 | 58.0 | 171 | 30.4 |

TABLE 15. *Mortality Rates for Various Treatments According to Time from Wounding to Operation in 696 Patients**

| Treatment | <6 Hours % | 6–24 Hours % | >24 Hours % |
|---|---|---|---|
| Primary repair | 6.4 | 0.0 | 0.0 |
| Simple closure | 6.6 | 0.0 | 0.0 |
| Resection and ileocolostomy | 0.0 | 0.0 | 0.0 |
| Resection and colocolostomy | 16.7 | 0.0 | 0.0 |
| Colostomy | 18.4 | 5.9 | 14.3 |
| Exteriorized repair | 2.7 | 0.0 | 0.0 |

* See text.

liters of blood, received autotransfusion of contaminated blood, and required a right hepatic lobectomy for control of hemorrhage from the liver. After operation, this patient developed an abdominal abscess and the fistula was discovered during the re-exploration; it was treated with colostomy. Although hospitalization was prolonged (27 days), the patient survived and subsequently had his colostomy closed.

Special complications are associated with the construction of a colostomy (Table 19). Of the eight patients who developed stomal necrosis, five occurred in a mucous fistula and did not require reoperation. Three patients with necrotic colostomies did require reoperation; one of these patients developed an abdominal abscess and died of sepsis and multisystem failure. All other colostomy complications required reoperation. The overall complication rate related to performing colostomies was 6.2%.

Unique complications also occurred in the patients treated with exteriorized repair (Table 20). The most common complication was obstruction, occurring in six patients. Three of the six patients with obstruction had relief of obstruction with replacement of the exteriorized repair and did not require colostomy. Remarkably, seven out of the 11 patients with complications of the exteriorized repair were able to have the repair replaced within the abdominal cavity and avoided colostomy. Failure of the exteriorized wound to heal was not considered a complication. The overall success rate of the exteriorized repair was 59 out of 100 cases (59%).

The length of stay for patients who survived treatment, excluding those transferred to other institutions, was different for the three major groups of repairs. For those patients treated by primary repair, this averaged 13.0 days, for colostomy, 21.5 days, and for exteriorized repair, 17.5 days. The length of stay for primary repair patients was significantly shorter compared to the other two groups of patients ($p < 0.01$).

The creation of a colostomy in a trauma patient requires its subsequent closure. Failure to include morbidity and mortality for this second operation minimizes these factors for what is, in its own right, a morbid procedure. Of the 227 patients with colostomies or unsuccessful exteriorized repairs, some have had colostomy closures at other institutions, some have never returned for closure, and others are awaiting closure. Of the 99 colostomies closed at this time, there were 55 loop colostomies, 39 end colostomies with mucous fistulae, and 5 Hartmann procedures. There were no deaths. One patient developed a fecal fistula and four wound infections occurred. The fecal fistula required colostomy for treatment and has subsequently been closed successfully. The average postoperative stay was 6.8 days.

Changes occurred in the frequency with which various procedures were performed during the study period (Table 21). In general, the frequency of primary repair increased and the frequencies of colostomies and exteriorized repairs decreased. From 1980 through 1984, the mortality rate decreased each year from 12.5% in 1980 to 6.7% in 1984.

## Discussion

British military surgeons during the first World War and in the early part of the second World War were advocates of primary repair of colon injuries.[6] Nevertheless, it was a British surgeon[7] as well as the Surgeon General of the United States[1] whose powerful statements proclaimed the necessity for colostomy in the treatment of colon injuries during wartime. These dicta clearly and for many years had an impact on the treatment of civilian injuries in spite of studies such as that of Woodhall and

TABLE 16. *Mortality Rates According to Number of Associated Abdominal Injuries in 706 Patients**

| Number of Associated Injuries | | | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 0 N = 146 | | 1 N = 260 | | 2 N = 156 | | 3 N = 88 | | 4 N = 38 | | 5 N = 9 | | 6 N = 7 | | 7 N = 1 | | 8 N = 1 | |
| No. | % | No. | % | No. | % | No. | % | No. | % | No. | % | No. | % | No. | % | No. | % |
| 1 | 0.7 | 10 | 3.8 | 21 | 13.5 | 14 | 15.9 | 13 | 34.2 | 6 | 66.7 | 3 | 42.9 | 1 | 100 | 1 | 100 |

* See text.

TABLE 17. *Miscellaneous Complications in 665 Patients**

| | No. | % |
|---|---|---|
| Atelectasis | 126 | 18.9 |
| Adult respiratory distress syndrome | 26 | 3.9 |
| Acute renal failure | 26 | 3.9 |
| Pneumonia | 19 | 2.9 |
| Phlebitis | 18 | 2.7 |
| Small bowel obstruction | 18 | 2.7 |
| Postoperative abdominal hemorrhage | 16 | 2.4 |
| Urinary tract infection | 15 | 2.3 |
| Acute cardiac failure | 6 | 0.9 |
| Dehiscence | 6 | 0.9 |
| Diffuse gastric hemorrhage | 5 | 0.8 |
| Catheter sepsis | 4 | 0.6 |
| Ileus | 4 | 0.6 |
| Acute hepatic failure | 3 | 0.5 |

* See text.

Ochsner.[2] The civilian literature has seen the pendulum swing from disapproval for primary repair[8,9] to enthusiasm[10,11] several times. In spite of over 50 articles published on this subject since the end of World War II, the controversy seems no closer to resolution today. Although some devastating injuries must be treated, the majority of civilian injuries bear little resemblance to those that occur in the military theater.[12] In this series, the complication rate directly related to the injury or its treatment was higher in the colostomy group. Furthermore, the late mortality rate was also higher in this group. These patients had, in general, more severe injuries, as evidenced by more blood loss (3.3 *vs.* 1.4 L), and required longer operations

TABLE 18. *Complications Possibly Related to the Treatment of the Colon Wound**

| Treatment | Abdominal Abscess % | Fever of Unknown Origin % | Wound Infection % | Fecal Fistula % |
|---|---|---|---|---|
| Primary repair N = 356 | 5.3 | 3.3 | 4.5 | 1.1 |
| Simple closure N = 328 | 5.2 | 3.0 | 3.0 | 0.9 |
| Resection and ileocolostomy N = 19 | 5.3 | 5.3 | 31.6 | 0.0 |
| Resection and colocolostomy N = 9 | 11.1 | 11.1 | 0.0 | 11.1 |
| Colostomy N = 209 | 16.7 | 7.2 | 5.3 | 1.4 |
| Exteriorized repair N = 100 | 6.0 | 5.0 | 4.0 | 0.0 |
| Total N = 665 | 9.0 | 4.8 | 4.7 | 1.1 |

* See text.

TABLE 19. *Stomal Complications Occurring in 209 Patients Treated by Colostomy**

| Complication | No. | % | Reoperation Required No. | Reoperation Required % |
|---|---|---|---|---|
| Stomal necrosis | 8 | 3.8 | 3 | 37.5 |
| Peristomal evisceration | 3 | 1.4 | 3 | 100 |
| Stomal obstruction | 1 | 0.5 | 1 | 100 |
| Peristomal abscess | 1 | 0.5 | 1 | 100 |
| Total | 13 | 6.2 | 8 | 61.5 |

* Excludes 19 patients who died of shock and exsanguination and eight patients transferred to other hospitals.

(3.9 *vs.* 2.9 hours) as compared to the simple closure group. Because of these factors, we analyzed our data to identify deaths that could be the result of the modality of treatment. Excluding the missed injury, we could find only three such deaths in the entire series. There was no such patient in the simple closure group. There was one death among the patients treated by resection and colocolostomy, one in the colostomy group, and one in the exteriorized repair group.

We disagree with those who maintain that suture closure should not be used in the presence of shock. To the contrary, we recognize a group of patients with severe injuries who have massive hemorrhage, hypothermia, and coagulopathy in whom it is important to close the abdomen as rapidly as possible in order to rewarm and to correct the coagulopathy. Simple suture of small wounds may be the most appropriate therapy for avoidance of another incision and may save blood loss and time.

The most important prognostic factor was shock ($p < 0.01$); 62 of 70 (89%) of all patients who died were in shock at some time before or during their operation. The other important identifiable factors were age over 40 years ($p < 0.01$) and the number and complexity of associated injuries.

Comparisons between morbidity and mortality of this series and other series are difficult because exclusions or

TABLE 20. *Complications of the Exteriorized Repair in 100 Patients**

| Complication | No. | % | Successfully Replaced No. | Successfully Replaced % |
|---|---|---|---|---|
| Obstruction | 6 | 6.0 | 3 | 50 |
| Abscess | 2 | 2.0 | 2 | 100 |
| Evisceration | 2 | 2.0 | 2 | 100 |
| Necrosis | 1 | 1.0 | 0 | 0.0 |
| Total | 11 | 11.0 | 7 | 63.6 |

* Excludes five patients transferred to other hospitals.

TABLE 21. *Change in the Incidence of Treatments during the Study Period*

| Treatment | 1979 N = 117 % | 1980 N = 120 % | 1981 N = 130 % | 1982 N = 147 % | 1983 N = 137 % | 1984 N = 76 % |
|---|---|---|---|---|---|---|
| Primary repair | 40.2 | 38.3 | 45.4 | 55.8 | 66.4 | 65.8 |
| Simple closure | 35.9 | 35.8 | 40.8 | 49.7 | 62.8 | 63.2 |
| Resection and ileocolostomy | 4.3 | 1.7 | 3.8 | 3.4 | 1.5 | 2.6 |
| Resection and colocolostomy | 0.0 | 0.8 | 0.8 | 2.7 | 2.2 | 0.0 |
| Colostomy | 36.8 | 44.2 | 33.8 | 31.3 | 21.2 | 27.6 |
| Exteriorized repair | 23.1 | 16.7 | 20.0 | 10.2 | 9.5 | 5.3 |
| None | 0.0 | 0.8 | 0.8 | 2.0 | 2.9 | 1.3 |

inclusions of patients are not always clearly defined. For example, when patients who sustained injuries to the seromuscular layer of the colon are included, the mortality rate will be low. Furthermore, many studies elect to exclude all patients who die of shock or hemorrhage producing an artificially low mortality rate.

Some studies do invite comparison. Flint et al.[5] developed a grading system for colon injuries based on the degree of contamination, the number of associated organ injuries, shock, and time between injury and operation. Using these criteria, we had only 5% grade 1 injuries (the least severe), 66% grade 2, and 29% grade 3 (the most severe), compared to 16% grade 1, 74% grade 2, and 10% grade 3 reported in their series. These differences could reflect error in interpretation of the grading scheme or reflect true differences in the nature of the injuries in our patients. The mortality rates in these groupings for our patients were 0.0%, 5.4%, and 17.8%, respectively, compared to 4%, 3%, and 25% reported in their series. The septic complication rates in our patients were 6%, 14%, and 23% for grades 1–3 and were 0%, 20%, and 31%, respectively, for those same complications reported by Flint et al. Grade 2 injuries in their study were considered a contraindication to primary repair; however, 67% of the grade 2 patients in our study were treated by primary repair.

An important prospective study was reported by Stone and Fabian.[11] These authors selected a group of good risk patients for randomization for primary repair or colostomy. Criteria for entry into the randomized study included the following: the absence of preoperative shock, less than 1000 ml intraperitoneal blood loss, less than two intra-abdominal organ systems injured, insignificant peritoneal soilage by feces, less than 8 hours between injury and treatment, absence of such an extensive colon injury as to require resection, and no major abdominal wall loss requiring mesh replacement. In this group, Stone and Fabian reported a 1% mortality rate and an intraperitoneal infection rate for primary repair of 15% and for colostomy of 29%. In our study, we were able to identify 252 such patients. In our patients, the mortality rate was 0.8%. If we include all patients with intra-abdominal abscesses, those with fever of unknown origin, and those with fecal fistulae, the comparable intraperitoneal infection rate was 6%. In these patients, we performed 70% primary repair, 16% colostomies, and 14% exteriorized repairs. Of even greater interest is the fact that, in the group Stone and Fabian identified for mandatory colostomy, 42% of our patients were treated with primary repair.

## Conclusions

Mortality in patients sustaining injuries to the colon is related to the presence of shock, number and type of associated injuries, and the age of the patient. Barring technical errors, the mortality rate is not related to the type of repair. The overall mortality and morbidity for patients treated with primary repair is lower than that for those treated with colostomy. Exteriorized repair in selected patients remains a useful technique, but only when the colon can be closed primarily and the surgeon is concerned about the security of the repair. Primary repair should be the mainstay for the treatment of civilian colon injuries.

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## Discussion

DR. J. DAVID RICHARDSON (Louisville, Kentucky): We presented a series of colon injuries at this meeting 4 years ago, and in that meeting Lewis Flint from our institution presented a method of grading patients with colon injuries in which we tried to make the same point, I think, that Dr. Jordan has made today. That is that it is possible to individualize patients with colon injuries for different types of treatment.

We did feel that primary repair was a good thing to be done for some patients, but we must admit that we were much more conservative than the Houston group in the use of primary repair. I think we used primary repair on actually a little bit less than 15% of the patients whom we treated.

We chose not to do primary repair if the patient was unstable. By unstable we meant if they were in shock on the operating table or had had a difficult preoperative resuscitation, if they had significant multisystem injuries that needed to be treated, or if they had a mesenteric injury. Furthermore, we wanted to treat the injury promptly, and we used a time frame of around 6 hours and specified that there be no severe fecal contamination. Basically, we held all of these things to be important as criteria that we could teach our residents to apply in some kind of uniform fashion.

We see in the report from Ben Taub that a number of the principles we espoused do not seem to be as important as we might have believed. We had no morbidity and no mortality from doing primary repair in what I would call a very conservative situation. It may be that we were too conservative, and I do think, in fact, that we probably have liberalized our use of primary repair somewhat.

The only problem that I had with this excellent manuscript was trying to get a handle on what are the elements of good judgment that allowed you to do a primary repair in some patients with severe fecal contamination and do colostomy in another group. What are the elements that allowed you to do exteriorization *versus* primary repair *versus* colostomy in patients who had delayed treatment? I would be interested in some details about your extensively injured group as well.

I want to comment briefly on our experience with exteriorization of the colon. I think that there is no question that this will work with many patients who have colon injuries. I must say, though, that we really have not been satisfied with it because of issues regarding the timing of when one returns the colon to the abdomen. Many of these patients develop serositis, the colon really does not appear healthy, and many patients develop obstructive symptoms before we really feel that it is time to drop the colon back in. Because of these factors, we have almost abandoned the use of exteriorization. I noted from the manuscript that you wait 10 days before returning the colon to the abdomen. I am surprised that this works. I would take issue with one statistic related to exteriorization. In the cases that broke down and were converted to a colostomy, I would have to consider that a failure of the method.

I enjoyed this excellent paper. Thank you for the privilege of the floor.

DR. M. VICTORIA GERKEN (Jackson, Mississippi): The charts of 2000 patients admitted to the University of Mississippi Medical Center Trauma Service since 1980 were reviewed with findings of 147 large bowel injuries for an occurrence rate of 7.4%. One hundred six of these injuries, or 72%, were incurred as a result of gunshot wounds. Nine patients had been injured by shotguns and one by a high-speed rifle. Fifteen patients were the victims of stab wounds, yielding a total penetrating trauma rate of 89% of our colon injuries. Twelve colon injuries were the result of motor vehicle accidents. The remaining four cases were the result of falls and blunt instrument injuries.

In 36 cases, or 25%, the colon was the only intra-abdominal organ injured. There were associated small bowel injuries in 49% of our cases, stomach injuries in 20%, and liver injuries in 11%. Associated splenic injuries occurred in only 5% of our patients. Urologic injuries were found in 20% and neurologic injuries were associated in 6% of our cases. Bony fractures were seen in 13% and associated thoracic injuries were noted in 27 of our 147 patients.

In 44 of our patients or 31%, a colostomy was performed proximal to a repaired or resected injury. In 64 patients (44%), the injured segment was exteriorized. Thirty-three patients underwent colon resection without colostomy. Five patients died on the operating table before the colon injury could be definitively treated.

Only one of the 142 patients surviving the initial operation required drainage of a subphrenic abscess. This patient had sustained a gunshot wound to the abdomen and had other intra-abdominal injuries including small bowel injuries necessitating resection. This patient ultimately survived.

Of the 147 patients in this series sustaining colon injuries, 14 died, for a total mortality rate of 9.46%.

The factors that enter into the decision regarding primary repair *versus* colostomy are numerous. The degree of fecal contamination, the location of the injury, and the general condition of the patient all require critical judgment by the surgeon.

In our institution, we have been much more conservative in our decision either to perform a colostomy or to exteriorize the wound. We have been rewarded with a lower incidence of intra-abdominal abscesses; however, our mortality rate is essentially the same as that of the authors.

I have two questions for the authors. First, does the type of associated intra-abdominal injuries influence your decision to perform a colostomy? For example, in the presence of a major pancreatic or duodenal injury where there is a significant incidence of postoperative fistulas, would you be more likely to exteriorize?

In the patient with multisystem injuries, would you now be more likely to repair primarily a simple colon injury in an attempt to expedite the surgery?

I thank the Association for the privilege of discussing this clinically significant paper.

DR. H. HARLAN STONE (Baltimore, Maryland): This, indeed is a marvelous manuscript. It is a great review of probably the largest series of colon wounds that has ever appeared and hopefully that will ever appear.

Today, the major question to be answered is: When and when not can a primary repair of the colon wound be done? Experience has suggested that there are perhaps seven crucial factors. However, on more detailed review, I would have to agree with Doctor Jordan that probably the single most significant factor is the presence of already established infection. A massive fecal contamination of short duration, such as only a few hours, is equal to a major fecal contamination that has been present for a day or two.

We also could find no correlation whatsoever with outcome of the colon wound alone with respect to other factors such as number of organs injured, amount of hemorrhage, depth or duration of shock, or how destructive the colon wound happened to be. However, as Dr. Jordan