

The Injured Colon

Relationships of Management to Complications

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One hundred thirty-seven patients who sustained intraperitoneal colon wounds were admitted to the University of Louisville Hospital during the three-year period ending December 31, 1979. One hundred twenty penetrating wounds and 17 blunt injuries were treated. An intraoperative classification system was employed, in which Grade 1 injuries were characterized by minimal contamination, the absence of associated organ injuries, minimal shock, and no significant delay between injury and definitive operation. All of these were managed by single-layer closure. More severe wounds were treated by colostomy or exteriorization. The overwhelming majority of the patients (116) sustained Grade 2 injuries. Twenty-two patients (16%) died. Nine deaths (6% of the patients) were directly attributable to the colon wounds. Twenty-five Grade 1 injuries were treated by primary suture closure with a single complication (3% of the patients). Nine wounds were exteriorized for later reinsertion into the peritoneal cavity, but only two patients were spared colostomy by this method. Right colon injuries were, clearly, more severe than left or sigmoid colon wounds. Intraoperative classification allowed selection of a group of patients in whom suture repair was safe. Colostomy was associated with the lowest complication rate for Grade 2 and 3 wounds.

IINTRAPERITONEAL COLON INJURY challenges the surgeon because of far-reaching implications of this type of injury for complications due to short-term septic complications and long-term problems of colostomy, particularly the need for reoperation for closure. While the appropriate administration of perioperative antibiotics and delayed wound closure have lowered the incidence of postinjury wound infection,^{8,12} it has not lowered the incidence of intra-abdominal abscess, indicating the difficulty in quantitating the balance between contamination and intraperitoneal defenses.

Management plans to avoid colostomy have been proposed,^{2,10} specifically primary closure of selected colon wounds and exteriorization of the sutured colon

wound, with later return of the sutured colon to the peritoneal cavity.

We have reviewed our experience with intraperitoneal colon injury to ascertain whether an intraoperative classification of injury severity could allow accurate selection of patients for primary closure, and to assess the usefulness of various other management techniques.

Materials and Methods

During the period from January 1, 1976 to December 31, 1979, 137 patients who sustained intraperitoneal colon injuries were admitted to the trauma service. There were 120 men and 17 women; 75 patients were between the ages of 20 and 34 years. Only four patients were over 60 years of age. One hundred twenty penetrating wounds and 17 blunt injuries were treated. The modes of injury are given in Table 1.

In our institution, all injured patients are admitted directly to a resuscitation area where, after acquisition of an airway and assurance of oxygenation, restoration of intravascular volume deficit is initiated. Multiple large-bore intravenous catheters were inserted into extremity veins and, when shock was present, an initial bolus of balanced salt solution (2,000 ml in adults) was infused rapidly as a diagnostic and therapeutic challenge. Response of the cardiac output was assessed using arterial pressure, pulse rate, and urine output as indicators of hemodynamic changes. A broad-spectrum antibiotic, usually cefazolin 1.0 g, was administered intravenously to all patients suspected as having intraperitoneal injuries. The diagnosis of intraperitoneal injury was made on the basis of clinical signs of peritoneal irritation in conscious, cooperative patients. In clinically negative patients with stab wounds, surgical exploration of the entry wound, under local anesthesia,

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TABLE 1. *Modes of Injury*

Injury	Number of Patients	Per Cent
Gunshot wounds	101	72
Blunt trauma	21	15
Stab wounds	12	8
Shotgun blasts	7	5

allowed diagnosis of depth of penetration. Penetration beyond the level of the internal oblique fascia indicated probable peritoneal penetration and in such patients, diagnostic peritoneal lavage was used, as suggested by Thal and associates,¹¹ to diagnose serious intraperitoneal bleeding and to reduce the frequency of negative laparotomy.

Peritoneal lavage was liberally employed in patients sustaining blunt injuries, where head injury or drugs precluded a dependable physical examination. All patients with gunshot wounds proximal to the peritoneal cavity underwent exploratory laparotomies.

Intraoperative classification of colon injury was achieved according to the system indicated in Table 2. Grade 1 injuries are characterized by minimal contamination, the absence of associated organ injuries, minimal shock and no significant delay between injury and definitive operation. They are managed by single-layer suture closure of the perforation. Grades 2 and 3 wounds are more severe. The presence of through-and-through perforation, laceration and associated injury characterize the former. Severe tissue loss, heavy contamination and deep shock indicate a Grade 3 injury. Both Grades 2 and 3 are managed by exteriorization with or without subsequent colostomy, resection and colostomy with mucous fistula, or Hartman closure of the distal colonic segment. Exteriorized wounds are sutured and supported over a glass rod. End colostomies are closed with a colostomy clamp. Colostomies and exteriorized wounds are brought out through separate transverse incisions lateral to the midline laparotomy incision. The selection of the appropriate procedure is made by the operating surgeon, on the basis of the grading system and the anatomic characteristics of the wound. Following definitive repair of the colon injury, all particulate material is lavaged from the peritoneal cavity with 4 L of warmed, normal saline solution, and abdominal wall closure is accomplished with single-layer fascial sutures of heavy monofilament material. Skin and subcutaneous tissue are left open for delayed closure or healing by secondary intention.

Nasogastric decompression is maintained for a minimum of five full days and colostomies are not matured before the fifth postoperative day. Colostomy appli-

ances are prefitted, so that contamination of open wounds is minimized after colostomy function begins. Antibiotic therapy is discontinued after three postoperative doses have been given at six-hour intervals.

Results

The locations of the colon wounds were evenly distributed throughout the length of the intraperitoneal colon, with 42 wounds located in the right colon, 55 wounds located in the transverse colon, 28 wounds located in the left colon, and 31 wounds located in the sigmoid colon. Forty patients presented in shock (systolic arterial pressure less than 80 mmHg or clinical signs of massive blood loss) on arrival.

The results of the intraoperative classification are given in Table 2. The overwhelming majority of the patients sustained Grade 2 injuries. Ninety-three patients (70%) had injuries associated with at least one other major organ system. Eighty-four patients had associated small intestine injuries, ranging from simple perforation to extensive tissue loss. Forty-eight patients had injuries to the pancreas, stomach, liver, or spleen. Twenty-one patients had colon injuries associated with major intra-abdominal vascular injuries. Twenty of the patients presented with injuries to five or more organ systems associated with their colon wound.

Twenty-two patients died (16%). Thirteen deaths occurred as a result of exsanguination or severe neurologic trauma, all within the first 24 hours. Nine late deaths (6%) were directly attributable to persistent peritonitis and sepsis resulting from fecal contamination of the peritoneal cavity following the colon wound. Of the 40 patients presenting in shock, 17 (42%) subsequently died. Twenty-five patients (14%) sustained major nonfatal septic complications. These included intra-abdominal abscesses (23 patients), wound infections (seven patients), wound dehiscence (three patients),

TABLE 2. *Grade of Injury*

	Injuries	Per Cent
Grade 1 isolated colon injury, minimal contamination, no shock, minimal delay	25	(16%)
Grade 2 through-and-through perforation, lacerations, moderate contamination	116	(74%)
Grade 3 severe tissue loss, devascularization, heavy contamination	16	(10%)

and enterocutaneous fistulas (two patients). All complications eventually resolved, and these patients were discharged from the hospital in good condition.

Complications and deaths were examined as functions of wound locations. For right colon injuries, there were nine complications (20%) and four colon-related deaths (9%). With transverse colon injuries there were 12 complications (21%) and three deaths (5%), while left colon injuries accrued a complication rate of 10%, and one patient died (3%). Sigmoid injuries were associated with a 9% complication rate and one death (3%). Table 3 indicates mortality and morbidity rates relative to injury grades. The mortality rate rose progressively with the severity of the injury (4% for Grade 1, 31% for Grade 3), while septic complication rates were similar for Grades 2 and 3 (20 and 25%, respectively). The outcome was assessed for each repair technique. Suture repair was used only in Grade 1 injuries, and a wound infection was noted in a single patient (3%). Resections and colostomies were associated with a 20% septic complication rate. Primary anastomosis was used only in right colectomies and was associated with a 33% complication rate. Many of these complications, such as anastomotic leak, persistent peritonitis, and intra-abdominal abscess leading to remote organ system failure, were major sources of morbidity. Although only 10% (14) of our patients had their colon wounds exteriorized, this method was fraught with complications. The overall complication rate was 50%, with suture line breakdown and wound infection characterizing the results in this group. Of nine patients who had their wounds sutured and exteriorized for later replacement in the peritoneal cavity, seven were eventually converted into colostomy; only two patients were spared the formation of a colostomy and a reoperation for later closure.

There was an apparent influence of preoperatively-administered antibiotics on the overall incidence of infectious complications (wound infection and intra-abdominal abscess). Those patients receiving a first dose of antibiotics before or during operation had a 14% frequency of infectious complications, while in 34 patients receiving antibiotics postoperatively we observed infectious complications in 13 patients (38%).

Discussion

Primary suture repair of colon perforations due to penetrating injury is most frequently possible following low velocity injuries (particularly stab wounds), where associated organ systems are uninjured and contamination is minimal. The presence of hemorrhagic shock and the length of time between injury and definitive repair are also important influences which,

TABLE 3. Injury Grade versus Complication

	Injuries	Deaths	Complications
Grade 1	25	1 (4%)	0
Grade 2	116	3 (20%)	23 (20%)
Grade 3	16	4 (25%)	5 (31%)

when present, predispose the patient to infection and suture-line dehiscence after operation. Haygood and Polk,⁵ reporting the experience of our trauma service with colon gunshot wounds between 1969 and 1974, observed that 51% of the patients had suture closure of their colon wounds, with a 33% major complication rate. In 1976, a more conservative selection process for wounds amenable to suture was begun, and our observations confirm the safety of suture closure for Grade 1 injuries. The proportion of our patients (16%) deemed suitable for suture closure is smaller than that reported by Matolo and Wolfman.⁷ These authors accomplished successful primary closure of colon wounds in 75% of 57 patients. Nearly half of their patients sustained stab wounds. In comparison, 77% of our patients were injured by either gunshot or shotgun, and this factor probably accounts for the lower incidence of favorable wounds in our series. Steele,⁹ reporting the experience of San Francisco General Hospital Trauma Unit in 1976, observed wounds suitable for primary closure in only 20% of patients.

Our data indicate that selective primary repair may be used in a significant proportion of colon wounds, based on a classification system that employs an assessment of the extent of tissue injury, degree of fecal contamination, assessment of associated injuries; and estimates of the influences of delay between injury and definitive therapy and hemorrhagic shock. The system also identifies more severely injured patients, in whom careful use of colostomy or exteriorization yield similar outcomes. Successful use of injury-severity classification systems has been reported previously.^{4,6} In our patients, it has provided an excellent means of identifying favorable lesions for primary closure.

For more extensive colon wounds, Grades 2 and 3, with moderate-to-severe contamination, colostomy gave the most favorable complication rate (20 and 25%, respectively). Exteriorization was used in only 10% of our patients, but this method accrued a 50% complication rate. We have not successfully selected patients for exteriorization and later reinsertion of colon wounds. Suture of the colon wound with exteriorization for later replacement in the peritoneal cavity was used in only nine of our patients, but was unsuccessful in seven of these. In all but two patients, there was spontaneous development of suture line leakage, with conversion to colostomy or planned formation of colos-

tomy. By contrast, Steele and associates⁹ were able to successfully reinsert the colon intraperitoneally in 66% of 27 patients. Mulherin and Sawyers⁸ reported a similar experience with 78% successful interiorization of the sutured colon wounds.

We have confirmed the observation of Mulherin and Sawyers⁸ that right colon injuries clearly are not more favorable than left colon or sigmoid injuries. We recorded a 9% mortality rate and a 20% complication rate in right-sided lesions. While right-sided perforations of the colon have often been considered more favorable for primary repair, our data indicate the opposite. Complications observed after right colon injuries are frequently life-threatening anastomotic dehiscences and intraperitoneal sepsis. Arango and associates¹ reported that proximal diversion was possible in 57% of their patients with right colon wounds, and that deferring anastomosis contributed to lower mortality rate (3.2%) for these lesions. In a study that examined right colon perforations in the combined experience of our institution and the San Francisco General Hospital,³ we could not confirm a significant advantage for proximal diversion (ileostomy) over primary anastomosis, due to the high incidence of peristomal complications, when ileostomy was performed in the presence of peritonitis.

Perioperative antibiotic therapy has proved to be effective in reducing the incidence of septic complications following elective colon operations. In our patients who received antibiotics prior to or during the definitive operation, infectious complications were observed less frequently (14 versus 38%) than in those patients who received their first dose of antibiotics postoperatively. The patient groups are not comparable, however, and these observations do not conclusively prove the value of preoperative antibiotics in emergency abdominal surgery. Extrapolation of the data gathered in elective surgical patients strongly suggests,

however, that these drugs are valuable adjuncts when operations are necessary in contaminated fields. Thus, the distressing fact is that even in a unit where interest in trauma is high, 34 of 137 patients (24%) failed to receive adjunctive treatment considered valuable by most practitioners.

From these data we have concluded that intraoperative classification of colon wounds identifies a patient group in which suture closure is safe. Exteriorization of colon wounds incurs a high complication rate and does not provide an adequate substitute for colostomy. For most severe wounds, colostomy remains the most dependable method of treatment.

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DISCUSSION

DR. H. HARLAN STONE (Atlanta, Georgia): In a prior study of patients at Grady Hospital (slide), we randomized a select group of patients with only a relatively minor colon injury. In other words, 70% of these patients could be randomized into either having the wound of the colon exteriorized as a colostomy or having a proximal colostomy performed if the colon wound had been repaired, versus a primary closure of the colon wound. Because of massiveness of contamination, massiveness of injury, shock, and the like, 30% of patients were excluded.

(slide) The most striking difference between the randomized groups was that, whenever a drain had been inserted, the incidence of intra-abdominal sepsis was much greater than if no drain had been used. These differences were highly significant on statistical analysis. Thus, in those patients who can be managed by a primary closure of their colon wound and yet in whom a peritoneal drain must be inserted, the subsequent intra-abdominal infection rate is much lower than if a combination of drain and colostomy is present.

(slide) Secondly, we felt we noted considerable savings in hospitalization time with respect to carrying out a primary closure versus performance of a colostomy between these equivalent, randomized patients.

(slide) In addition, there was no longer a need for the added hospitalization for colostomy closure. The difficulty, however, has been in the establishment of a system which will reliably dictate which of the patients have the minimal injury.

Dr. Flint has presented concrete aids for making this assessment, rather than our being forced to take some figures out of the sky. He has come to grips with the real problem, *i.e.*, definition of the severity of the colon injury. Such can thereby lead us to make the proper decision.

DR. LLOYD M. NYHUS (Chicago, Illinois): On the basis of the study of 124 colon injury patients by Drs. Abcarian and Lowe of our department, I wish to make the following observations.

(slide) Here you see listed the controversies. It is important to highlight the role of external drainage.