THE SURGICAL MANAGEMENT OF COLON AND RECTAL INJURIES IN THE FORWARD AREAS

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THIRTY-NINE battle casualties sustaining injuries of the colon and rectum were operated upon initially by a general surgical team of an auxiliary surgical group functioning with the Fifth Army in Italy. Surgeons engaged in the initial management of intra-abdominal war injuries, particularly colon injuries, are cognizant of the fact that many patients fail to survive. Ogilvie[1] reported 107 injuries of the colon with 63 deaths. In a previous article, using a larger series of cases operated upon by surgeons of our group, the author[2] attempted an appraisal of numerous factors that exerted considerable influence upon mortality. Some of these factors were time-interval between wounding and operation, concomitant wounds, varying degree of peripheral circulatory collapse, and types of operations performed. During the past two years an intensive and comprehensive effort has been put forth by surgical consultants and surgeons in order that an effective decrease in mortality might be obtained in all war injuries. The purpose of this article is to present a brief description of those methods of management employed in a theater of war, and their application to the initial surgery of 39 injuries of the colon and rectum.

Colonel Edward D. Churchill,[3] Theater Consultant in Surgery, has suggested that the surgical care of a severely wounded soldier be divided into three phases—initial, reparative, and reconstructive.

For clarity, it is well to explain that the initial surgery of these colon and rectal injuries was performed in Field Hospitals. The "first-priority" surgical hospital (a platoon of a Field Hospital) is located in physical conjunction with the Division Clearing Station at the rear of the Division boundary. A platoon of a Field Hospital is a small mobile hospital under tentage, having a bed capacity of 30, which can be increased rapidly to 50, or more. It is divided into four sections—resuscitation, X-ray and small laboratory, surgery and surgical supply, and postoperative. When functioning under average conditions, each section can be adequately housed in a ward tent. Essential items of equipment necessary for the performance of major surgical procedures are provided. Administrative and departmental duties commensurate with the successful operation of a hospital are performed by the assigned personnel of the platoon. All professional duties, that is, resuscitation, surgery, and postoperative direction are performed by attached personnel. The attached personnel are members of general surgical and shock teams of an auxiliary surgical group—usually four or more teams depending on the demand and the tactical situation. A general surgical team consists of three medical officers—a general surgeon, an assistant surgeon, and an anesthetist, a surgical nurse and two enlisted men trained as surgical technicians.

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Patients not considered "first-priority" are transported from the clearing company to the evacuation hospital usually located five to 15 miles to the rear. The reparative phase of surgery is ordinarily a function of fixed hospitals located in the zones of communication. Those patients requiring reconstructive surgery over a prolonged period of time are evacuated to the Zone of the Interior (Z. I.) that is, the United States or the United Kingdom.

All of the patients underwent initial surgery during the Italian Campaign between the dates of October 1, 1943, and October 15, 1944. This series represents 39 unselected and consecutive hospital admissions sustaining colon and rectal injuries seen by a general surgical team of an auxiliary surgical group. All patients irrespective of multiplicity and severity of wounds, long time-interval, or severe peripheral circulatory collapse were given the benefit of surgery after maximal resuscitation. Most of the casualties were American soldiers. The remainder were British, French Colonials, and German prisoners of war. The youngest patient was 18 years of age, while the oldest was 38. The average age was 25 years.

Before proceeding further, the author wishes to offer an explanation for any statements that might be interpreted as original or positive. In the absence of complete works of reference, many statements are based upon the experience of surgical consultants and surgeons participating in this work.

WOUNDING AGENTS AND TIME-INTERVAL

Most enemy weapons encountered by soldiers of this theater employ the high explosive principle of fragmentation. The fragment wounds were caused by either artillery and mortar shells, grenades, antipersonnel bombs or mines. These agents frequently produced multiple severe wounds. Some of the concomitant wounds were intrapleural injury, traumatic extremity amputation, and compound comminuted fractures of the skull, long bones, and pelvis. Early, many of these concomitant wounds were complicated by hemorrhagic and traumatic shock, and, in some instances, followed by a long period of sepsis. Wounds caused by rifle, machine gun and machine pistol fire are usually single, and occurred in the ratio of approximately one to three, as compared to fragments (Table I).

TABLE I

WOUNDING AGENTS

Agents	No. of Cases	Per Cent
Fragment	30	76.9
Bullet	9	23.0

The time-interval is the time in hours that elapses between wounding and operation. The shortest time-interval was four hours while the longest was 102 hours. The average time-interval was 15 hours (Table II).

A short time-interval is desirable, particularly in the presence of increasing peritoneal contamination and continuing hemorrhage. In our experience, a

TABLE II

TIME-INTERVAL—WOUNDING TO OPERATION

Time in Hours	No. of Cases	Died	Per Cent
0– 6	5	2	40.0
6–12	20	5	25.0
12–18	6	2	33.3
18–24	1	1	100.0
Over 24	7	3	42.8

Average time-interval—15 hours.

short time-interval has not contributed materially toward a decreased mortality in intra-abdominal injuries because some of the most severely wounded came to surgery who would have died had the time-interval been longer.

SHOCK—RESUSCITATION THERAPY—PREOPERATIVE PREPARATION

For the surgeon working in forward hospitals, battle casualties offer inexhaustible opportunities for observing hemorrhagic and traumatic shock, with varying degree of peripheral circulatory failure. For convenience, shock has been arbitrarily classified as suspected, moderate, and severe. This classification was prepared from recorded blood pressure, pulse, color, extensiveness of wounds and condition of the skin. Blood pressure was the most consistent recorded finding. Those patients with a systolic pressure of 100 mm. Hg. plus were put in the suspected group. In our experience, this group of patients developed varying degree of peripheral circulatory failure during surgery whenever preoperative resuscitation was omitted. Those exhibiting a systolic pressure between 80 and 100 mm. Hg. were put in the moderate group and those between 0 and 80 mm. Hg. in the severe group. Certainly, errors in classification have occurred, particularly in the suspected and moderate groups. For example, a patient might have been admitted in incipient hemorrhagic and traumatic shock with a systolic pressure in excess of 100 mm. Hg. and yet he was put in the suspected group. Of 39 patients, 12 arrived at the hospital in suspected hemorrhagic and traumatic shock (Table III). Two of the 12 patients died; one of bilateral lobar pneumonia on the seventh postoperative day and the other of peritonitis on the tenth postoperative day. Ten of the 39 patients fell into the severe group. Eight of the ten patients failed to survive the initial phase of surgery in spite of vigorous replacement therapy.

TABLE III

DEGREE OF SHOCK IN RELATION TO TIME ELAPSED BETWEEN WOUNDING AND HOSPITAL ADMISSIONS—DEATHS

	Hours						
Degree of Shock	0–6	6–12	12–18	18–24	Over 24	Total Cases	Died
Suspected	1	8	1	—	2	12	2
Moderate	3	9	2	—	3	17	3
Severe	1	3	3	1	2	10	8

The majority of patients in severe shock responded within a three-hour period to 2,000 cc. of whole blood, as indicated by a restored systolic blood

pressure of or above 100 mm. Hg. Those patients whose response was slow, or *nil,* received 2,500 to 4,500 cc. of blood within three hours. Five of the eight patients died within the 24th postoperative hour of peripheral circulatory collapse. This observation only confirms the substantiated fact that simple restoration of effective blood circulatory volume does not necessarily alleviate peripheral circulatory collapse. Three patients died after the 24th postoperative hour. Sepsis was the dominant cause of death in this group.

Most plasma was administered before the patient arrived at the hospital. Whenever possible, blood was used to elevate the lowered circulatory volume (Table IV). The total volume of blood administered was approximately three times that of plasma.

TABLE IV

UNITS OF PLASMA AND BLOOD USED IN RESUSCITATION

Agent	Rgt. Colon	Transverse	Left	Rectum	Total Cases	Total Units	Average
Plasma	27	7	31	9	30	74	2.4
Blood	45	13	57	14	37	129	3.4

One unit of plasma is equivalent to 250 cc.
One unit of blood is equivalent to 500 cc.
Maximum units of plasma to one patient were six.
Maximum units of blood to one patient were nine.

Immediately after admission to the hospital, the patients were examined by the resuscitation officer and, as soon as possible, by the surgeon and assistant surgeon. The patients admitted in severe shock were given low titer "o" blood rapidly until cross-matching was completed, and oxygen by mask. As soon as the patients exhibited a favorable response to resuscitation therapy, other preoperative measures were instituted. These measures consisted of nasogastric intubation, urinary bladder catheterization for possible genito-urinary tract damage, and skin preparation. Nasogastric intubation is most important since aspiration of vomitus into the respiratory tract during anesthesia might suddenly, or eventually, become disastrous. It has been our policy to pass the Levine tube into the stomach, and, if the gastric contents was free of macroscopic blood, moderate gastric lavage was performed before the induction of anesthesia.

INJURIES OF THE COLON AND RECTUM

All injuries of the colon included in this series resulted in fecal peritoneal contamination of varying degree. Intraperitoneal injuries of the rectum were placed in the colon group. All of the injuries in the rectal group were extraperitoneal.

The types of colon injuries were single or multiple mesenteric, lateral, and antimesenteric perforations; hemisection; transection; and longitudinal tears. Contusions, lacerations not involving the mucosa, injuries to the mesocolon interfering with blood supply, and posterior wall perforations without peritoneal soiling were not included.

Table V is included to emphasize a moderately high incidence of injury to certain related viscera. Some of the factors that determined the likelihood

of injury to related viscera were: Location of the wound of entry; size, contour, and velocity of the missile; and the surface area of the related viscus. The influence of a vast surface area was corroborated by the fact that 13 of the 39 patients sustained injury to the small bowel.

TABLE V

INCIDENCE OF INJURY TO RELATED VISCERA

	No. of Cases	Small Bowel	Liver	Diaph.	Stomach	L. Kid.	R. Kid.	Spleen	Bladder	2nd Part of Duodenum
R.C.....	14	3	1	1	—	—	1	—	—	2
T.C.....	4	1	1	3	3	—	—	1	—	—
L.C.....	15	8	2	1	—	2	—	1	—	—
Rectum.....	6	1	—	—	—	—	—	—	3	—

Five of the 33 colon injuries were complicated by injury to the diaphragm: that is, they were thoraco-abdominal wounds. The second part of the duodenum was involved in two of four cases with injuries of the hepatic flexure. Such a high incidence necessitates exposure of this part of the duodenum whenever the hepatic flexure is injured.

ANESTHESIA

Ether, open-drop or in a closed system, was used for all operations. Among the anesthetic agents used for induction, excluding ether, were nitrous oxide-oxygen and ethyl chloride. Nitrous oxide-oxygen-ether, using the closed absorption, endotracheal technic was the most frequently used anesthesia. Endotracheal anesthesia was employed in all thoraco-abdominal and separate intrapleural injuries.

TYPES OF OPERATIONS PERFORMED UPON THE COLON AND RECTUM

For obvious reasons, primary suture of the unprepared colon in the presence of peritoneal contamination has always been condemned in this theater. Consequently, all initial operations were designed to divert the fecal current outside the peritoneum. The only exception to this rule has been in those patients sustaining injury between the sigmoid and the extraperitoneal rectum. These perforations were closed by suture and supplemented by proximal colostomy (Table VI). The type and severity of the injury occurring between the terminal ileum and sigmoid colon usually determined whether a loop or double-barrel colostomy with spur was to be performed. Single or closely associated multiple anterior and lateral wall perforations and antimesenteric hemisections were exteriorized as loop colostomies. Mesenteric hemisections, transections, and extensive injuries necessitating resection of the colon were exteriorized as double-barrel with spur colostomies. We have endeavored to perform an initial operation that not only diverts the fecal current extraperitoneally, but also leaves the patient with a simple stoma which can be closed secondarily without entering the peritoneal cavity. Since the extraperitoneal closure of a loop colostomy of the right colon is impractical, a single perforation of the right colon was treated by tube colostomy or cecostomy. The tube and about two centimeters of adjacent tissue around the tube were extraperitonealized through a stab

incision to prevent any subsequent leakage into the peritoneal cavity. At secondary operation, this extraperitonealized portion of colon could be utilized to close the colonic fistula without entering the peritoneal cavity. Three patients were treated successfully by this procedure.

TABLE VI

TYPES OF OPERATIONS PERFORMED ON THE COLON AND RECTUM

Type of Operation Performed	Right Colon	Left Colon	Trans. Colon	Rectum	Total	Deaths	
						Number	Per Cent
1. Exteriorization	4	12	4	—	20	10	50.0
2. Resection of terminal ileum, cecum, ascending colon and double-barrel ileo-transverse colostomy	4	—	—	—	4	1	25.0
3. Tube cecostomy or colostomy	3	—	—	—	3	0	—
4. Resection and exteriorization	—	1	—	—	1	0	—
5. Suture of perforation and proximal cecostomy or colostomy	1	2	—	—	3	0	—
6. Proximal colostomy and coccygectomy	—	—	—	6	6	0	—
7. None (died during surgery)	2	—	—	—	2	2	100.0

Injuries of the splenic flexure and left half of the transverse colon complicated by those of the left diaphragm and left lung caused by a single missile were operated upon transdiaphragmatically. Some of the advantages of a thoracic operative approach in left-sided thoraco-abdominal wounds were: Excellent visualization of the wound tract; easy removal of the frequently fragmented spleen; mobilization of the splenic flexure under direct vision; and the elimination of the separate celiotomy incision, with its subsequent pain, which permitted the institution of an intensive cough routine so necessary for the postoperative intrapleural injury. Before closure of the diaphragm, the injured segment of the splenic flexure or transverse colon was exteriorized either as a loop or double-barrel colostomy with spur through a stab incision in the left upper quadrant of the abdomen. Likewise, if drainage of the abdomen was desired, the drains were brought out through another, but smaller, stab incision of the left abdominal wall. On the contrary, injury of the hepatic flexure complicated by those of the liver, right diaphragm and right lung caused by a single missile necessitated thoracotomy and a separate celiotomy incision, as the liver offers complete obstruction to exploration of the right abdomen.

The initial surgery of extraperitoneal perforations of the rectum consisted of thorough débridement of the wound tract, suture of perforations, and sigmoid colostomy. In addition, resection of the coccyx and incision of the fascia propria were done to insure adequate drainage of the retroperitoneal, posterior, and pararectal spaces. All sigmoid colostomies were of the loop type. However, a recent personal communication with surgeons in Base Hospitals has revealed that loop colostomy for rectal injuries has failed, in many instances, to completely divert the fecal current. Consequently, patients with rectal injuries have arrived at the Base from the Forward Area Hospitals with fecally contaminated buttock wounds, and the rectum filled with feces. In the future, we expect to transect the sigmoid and prepare a spur at the

time of initial operation of all extraperitoneal rectal injuries. Colcock[4] has reported from a hospital in the Zone of Communication that osteomyelitis of the sacrum has been a frequent complication of coccygectomy in those with rectal wounds. Because of this, posterior drainage is now being accomplished without resection of the coccyx. It is the feeling of most of our surgeons that adequate drainage can be ensured through a curved incision inferior to the coccyx; incision of the fascia propria; and opening of the posterior and pararectal spaces by blunt dissection.

USE OF SULFONAMIDES AND PENICILLIN—POSTOPERATIVE CARE

The methods of administration and dosage of sulfonamides, according to a suggested regimen developed by Theater and Army Consultants for the guidance of Forward Area surgeons, were constant throughout the entire series of cases. An amount not exceeding 10 Gm. of sulfanilamide per patient was used at operation. Five grams were dusted into the peritoneal cavity before closure of the abdominal wall. The remaining 5 Gm. were dusted into, and distributed proportionately, among the operative sites of concomitant wounds. Consequently, those patients sustaining only an intra-abdominal injury received 5 Gm. of sulfanilamide at operation. Intravenous sodium sulfadiazine was started 24 hours after operation in the dosage of 2.5 Gm. every 12 hours until the patient could tolerate 1 Gm. orally every four hours. Therapy was continued from five to seven days and longer, if indicated. The only exceptions to this rule were two patients whose urinary output did not exceed 1,200 cc. daily, in spite of an adequate fluid intake.

Penicillin for routine use in intra-abdominal injuries was available for only the last ten of the 39 patients. Twenty-five thousand units of penicillin in 10 cc. of distilled water were injected into the peritoneal cavity in conjunction with 5 Gm. of sulfanilamide before closure of the abdominal wall. Postoperatively, 25,000 units of penicillin were administered intramuscularly every three hours for five days, and longer, if indicated. Five of the ten patients died—four of sepsis and one of anuria. Therefore, in this small series of cases, there was no evident reduction in mortality as compared to that when sulfonamides were used alone.

Postoperative care consisted of skilled nursing, correction of protein and vitamin depletion, and the utilization of specific measures to combat shock and infection. A lowered protein intake combined with the additional loss from hemorrhage, and a lowered vitamin intake were responsible for protein and vitamin depletion. Plasma and blood were administered to elevate the blood proteins and the lowered circulatory blood volume. To insure an effective vitamin "C" level, ascorbic acid was given intravenously until polyvitamins could be tolerated orally. Hydration and nutrition were maintained by the daily administration of 3,000 cc. or more of 5 per cent glucose in normal saline. Ileus and abdominal distention were controlled by nasogastric suction. In the absence of marked peritoneal infection, delayed colostomy function was initiated by the installation of 30 cc. of mineral oil

into the proximal loop of the colostomy on the fourth or fifth postoperative day.

COMPLICATIONS

Shock and infection were the dominant complications. Most patients admitted in suspected, or a moderate degree of shock, responded favorably to blood and plasma replacement therapy during resuscitation, operation and the postoperative period.

Peritoneal contamination and early infection responded gratifyingly to forward surgery and its adjuncts, sulfonamides and penicillin, for only 12 of the 33 intra-abdominal injuries exhibited objective signs of peritonitis. We have attributed our low incidence of pulmonary complications to routine postoperative bronchoscopy and catheter suction of the trachea of all intra-abdominally injured patients sustaining concomitant intrapleural injury or possessing excessive tracheobronchial secretion. Five of the 33 intra-abdominal injuries developed severe infection of the celiotomy incision, although colostomies were placed in separate incisions. None of the wound infections led to dehiscence. Other complications recorded during the postoperative period are listed in Table VII.

TABLE VII

COMPLICATIONS

Complications	No. of Cases	Died
Peritonitis	12	2
Pneumonia	5	2
Atelectasis	2	0
Shock (severe)	8	5
Severe infection of celiotomy incision	5	0
Anuria	2	2
Shock and peritonitis	2	2

MORTALITY

Thirteen of the 39 patients died—a mortality rate of 33.3 per cent (Table VIII). Injury to the colon or rectum alone occurred in eight of the 39 cases. Five of the eight patients sustained injuries of either the right,

TABLE VIII

MORTALITY

	No. of Deaths	Per Cent
Right colon	6	42.8
Transverse colon	2	50.0
Left colon	5	33.3
Rectum (extraperitoneal)	0	—

Total deaths.....13 Mortality rate.....33.3%

transverse, or left colon, and three of the extraperitoneal rectum. All of these patients survived, and were evacuated to the Zone of the Interior on an average of 65 days after initial surgery. The remaining 31 cases were complicated by concomitant wounds varying in severity from mild soft-tissue wounds to such severe injuries as small bowel transections, necessitating two small bowel resections; kidney fragmentation; liver perforation, compound

comminuted fractures of the skull, pelvis and long bones; intrapleural injury; and traumatic extremity amputation.

Two patients died during surgery. Both were admitted to the hospital with a long time-interval; septic from a generalized peritonitis; and in severe peripheral circulatory collapse. Both responded very poorly to resuscitation therapy. In our experience, all battle casualties presenting a picture of sepsis and profound peripheral circulatory collapse tolerate anesthesia and surgery very poorly, and are obviously designated "bad risks."

Two deaths on the eighth postoperative day were attributed to uremia. Both presented evidence of urinary suppression at the end of the first postoperative day, which gradually increased until death. They were admitted to the hospital in severe peripheral circulatory collapse and given either low titer "o" or cross-matched blood during resuscitation and surgery.

Bilateral lobar pneumonia was responsible for two deaths. Their injuries were of the thoraco-abdominal type, with the pneumonic process involving first the injured lobes and, later, the lobes of the contralateral lung.

Five of the 13 deaths occurred during the first postoperative day. All failed to respond to quantities of blood up to 4,500 cc. administered during the resuscitation, operative, and postoperative periods. The 12th and 13th deaths were due to generalized peritonitis. One of these died on the ninth postoperative day, and the other on the 12th postoperative day.

Detailed information concerning the reparative phase of surgery of the 26 surviving patients was obtained by communication with the office of the Base surgeon and surgeons of Station and General Hospitals located in the Zones of Communications. All of the patients were evacuated to the Zone of the Interior on an average of 65 days following initial surgery.

We have not obtained any information concerning the patients after their arrival in the Zone of the Interior.

SUMMARY

Initial surgery of 39 injuries of the colon and rectum was performed by a general surgical team of an auxiliary surgical group functioning with the Fifth Army in Italy. Most of the injuries were caused by fragments. Twenty-nine patients were operated upon within 12 hours of injury; five within six hours. A short time-interval can contribute toward an increased mortality, because more of the severely wounded come to surgery. The average time-interval was 15 hours. The contribution of shock toward an increased mortality was exemplified by five deaths, in spite of vigorous replacement therapy, out of eight patients admitted in severe shock. The second part of the duodenum was injured in two of four injuries of the hepatic flexure. Peritoneal contamination and early infection responded gratifyingly to Forward surgery and its adjuncts, sulfonamides and penicillin, for only 12 patients exhibited objective signs of peritonitis. Eight patients sustaining injuries of the colon or rectum alone were treated successfully. Thirteen colon injuries complicated by severe concomitant wounds died—a

mortality rate of 33.3 per cent. Severe shock, secondary to injuries of the colon complicated by concomitant wounds, was the dominant cause of death. Next to shock, sepsis was the leading cause of death.

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