Colorectal Trauma: Primary Repair or Anastomosis with Intracolonic Bypass *vs.* Ostomy

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This prospective, randomized, controlled study was undertaken to compare primary repair or anastomosis with intracolonic bypass *vs.* ostomy in severe colon and intraperitoneal rectal injury. Patients were randomized at surgery following confirmation of injury. Data collected included demographics, mechanism and location of injury, trauma score (TS), injury severity score (ISS), penetrating abdominal trauma index (PATI), complications, length of hospital stay, and hospital charges. Twenty-two patients were studied: 11 with intracolonic bypass and 11 controls. The experimental and control groups were statistically similar in demographics and mechanism of injury, severity of injury (TS = 13.8 *vs.* 12.8; ISS = 27.5 *vs.* 24.2; PATI = 40.5 *vs.* 35.0), and complication rate. Length of stay (12.2 days *vs.* 20.7 days) and charges $27,885 *vs.* $53,599) tended to be greater in controls, and the comparison did not include subsequent colostomy closure. This study supports intracolonic bypass as a safe alternative to ostomy in severe colon and intraperitoneal rectal trauma. [Key words: Colorectal injury; Primary repair; Intracolonic bypass]

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At the outbreak of World War II, Ogilvie[1] advocated the exteriorization or diversion of all colorectal injuries, and by 1943 the United States Surgeon General made colostomy mandatory for all colorectal injury.[2] At the war's end, combat-trained surgeons returned to civilian life, and colostomy remained the gold standard for the management of colorectal injury.[3] With the advent of better preoperative and postoperative care, early definitive treatment, and newer antibiotics, civilian surgeons began to advocate primary closure in selected cases,[3,4] a trend that has continued to the present.

Although there are few prospective, randomized, controlled studies in the literature,[5,6] there is a current consensus that most minor colon injuries can be repaired primarily.[5–10] Generally, the criteria for primary repair describe a stable patient with minimal contamination, little operative delay, and few associated injuries. Controversy continues to surround primary repair in moderate-to-severe colorectal injury. Recent advances in the primary anastomosis of the unprepared colon on an emergency basis using intracolonic bypass may be applicable to injury.[11–15] The following study was undertaken to address this question in a randomized, controlled fashion.

METHODS

Patient Population. All patients with suspected colon or intraperitoneal rectal injury undergoing operative intervention at the study center provided the basic patient pool. Consent for study inclusion was obtained preoperatively.

Exclusion Criteria. The following were excluded: patients dying within 24 hours of injury, patients presenting more than eight hours after injury, patients initially operated on elsewhere, and patients not deemed admissible by the operating surgeon.

Management. Patients underwent standard resuscitation and evaluation. The decision for randomization was made intraoperatively based on inclusion criteria (Table 1).

Study patients were randomly assigned to Group 1—primary repair or anastomosis with intracolonic bypass—or Group 2—colostomy. The Coloshield™ (Deknatel, Inc., Fall River, MA) was used in stand-

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Table 1.
Study Inclusion Criteria

One or more of the following:
1. >25 percent of circumference
2. Shock on arrival or during surgery
3. Blood loss >1,500 cc
4. Three or more associated organ injuries
5. Fecal contamination
6. Colon resection required

ard fashion.[13] Techniques of repair or anastomosis were at the discretion of the operating surgeons. Drains were not used for colonic injury, and skin wounds were closed by delayed primary closure.

All patients received a broad-spectrum antibiotic (cefoxitin) preoperatively and for 24 hours postoperatively. Subsequent antibiotic therapy was individualized based on clinical course and cultures.

Postoperative care was individualized to include ventilatory support, nutritional support, and a careful surveillance for complications including fever, intra-abdominal phelgmon, intra-abdominal abscess, fecal fistula, wound infection, pneumonia, urinary tract infection, phlebitis, and any other systemic complication.

Participating surgeons were limited to five trauma surgeons working at the study center. Each surgeon was required to complete an animal workshop on intracolonic bypass before clinical participation.

Randomization was provided by a central independent party using a random number table and a card system. Ultimate outcome, length of stay, hospital cost, basic demographics, mechanism of injury, TS,[16] ISS,[17] and PATI[18] were obtained on study patients.

Statistical analysis was performed using a two-tailed Student's *t*-test for continuous variables, a chi-squared test for proportions, and Fisher's exact test for proportions with a cell size <5, as appropriate. Significance was established at $P < 0.05$.

DEFINITIONS

Fever. Temperature >37.5°C.

Intra-abdominal phlegmon. Nondrainable intra-abdominal infection associated with fever, leukocytosis, or positive cultures and diagnosed by CAT scan, ultrasound, or re-exploration.

Intra-abdominal abscess. Drainable intra-abdominal collection associated with fever, leukocytosis, or positive cultures and diagnosed by CAT scan, ultrasound, or re-exploration.

Fecal fistula. Fecal drainage from the colon into the abdominal cavity, wound, or other organ system.

Wound infection. Wound not closed after five days, wound reopened or treated with antibiotics following closure, or wound draining pus.

Pneumonia. X-ray evidence of infiltrate associated with fever, leukocytosis, or pathogenic Gram's stain of bronchial aspirate.

Urinary tract infection. Culture-proven urinary tract infection with colonies >100,000.

Phlebitis. Deep venous thrombosis proven by venogram.

Leukocytosis. White blood cell count >15,000/mm^3.

Positive culture. Bacterial growth from blood, abdominal cavity, abscess cavity, wound, or other body fluid.

Shock. Systolic blood pressure < 90 mmHg.

RESULTS

The study population was composed of 22 patients. There were 14 men and 8 women averaging 26.7 years of age (range, 15–44 years). The mechanisms of injury were primarily penetrating, with 13 gunshot wounds, 2 shotgun wounds, one stab wound, and six motor vehicle accidents. The average scores were: TS 14, ISS 25.5, and PATI 32.

There were 11 patients in Group 1 (intracolonic bypass) and 11 patients in Group 2 (control). Four patients were not randomized (two in each group) because informed consent could not be obtained. They were otherwise treated per the protocol and included in data analysis. Two control patients underwent primary repair (HB and FP). They were included for completeness but were not included in data analysis for complications. Table 2 provides a patient summary.

The two populations were remarkably similar. Group 1 patients were younger than Group 2 patients (22.9 years *vs.* 30.5 years; $P < 0.04$). However, there were no statistically significant differences in gender distribution, criteria for study inclusion (Table 3), or severity of injury (Table 4).

Outcomes were also similar (Table 5), although there was a trend toward longer hospitalization and higher hospital costs for the control patients. Hospital cost did not include subsequent readmission for colostomy closure in control patients, which averaged 7.7 hospital days and $7,116.00 per patient (Table 6). Additionally, three patients were

Table 2.
Patient Summary

Group	Patient	Age (yr)	Sex	Mechanism	Location	TS	ISS	PATI
1	CD*	31	F	MVA	LC	16	29	37
1	BM*	20	M	MVA	LC	10	41	38
1	DB	20	M	GSW	LC	16	34	34
1	DL	17	M	GSW	LC	16	34	49
1	MS	25	M	GSW	RS	16	24	33
1	RT	30	F	GSW	RS	15	16	44
1	AB	23	F	MVA	TC	12	29	27
1	RB	33	M	SGW	LC	5	41	62
1	LM	18	M	GSW	TC	16	20	26
1	KG	20	M	SGW	LC	14	18	60
1	SK	15	F	GSW	LC	16	9	35
2	HB†	41	M	GSW	RC & TC	16	16	30
2	RW	37	M	SW	LC	16	18	28
2	OO	39	F	MVA	LC	15	13	35
2	AJ	18	M	GSW	RS	16	25	27
2	DS	34	F	GSW	TC	16	14	33
2	FP†	35	M	GSW	LC	7	16	44
2	PP	21	M	GSW	RC	3	50	50
2	RW	20	M	GSW	LC	16	13	28
2	LB	19	F	MVA	LC	8	24	39
2	BF*	44	M	GSW	LC	9	18	25
2	AS*	27	F	MVA	LC	9	57	38

LC = left colon; TC = transverse colon; RC = right colon; RS = rectosigmoid colon; MVA = motor vehicle accident; GSW = gunshot wound; SGW = shotgun wound; SW = stab wound.

* Patients were not randomized; see text for explanation.

† Patients underwent primary repair; see text for explanation.

Table 3.
Criteria for Study Inclusion

Indication	Percent with Indication		Significance
	Group 1	Group 2	
Colon injury >25% of circumference	11/11	10/11	$\chi^2 = 0.0244, P > 0.05$
Preoperative shock	2/11	3/11	FET = 0.6109, $P > 0.05$
Intraperitoneal blood loss >1,500 cc	3/11	3/11	FET = 0, $P > 0.05$
Three or more intra-abdominal organs injured	7/11	6/11	$\chi^2 = 0.0484, P > 0.05$
Fecal contamination	6/11	9/11	$\chi^2 = 0.3591, P > 0.05$
Colon resection	9/11	11/11	$\chi^2 = 0.105, P > 0.05$

FET = Fisher's exact test.

readmitted for complications: *Clostridium difficile* enterocolitis in an intracolonic bypass patient (Group 1) and thrombophlebitis in two control patients (Group 2), for an additional average hospital stay of 12.3 days and $24,881.00.

Complication rates (Table 7) also did not differ significantly between groups. There was one death in Group 1 unrelated to the management of colonic injury: RB was a 33-year-old male with a self-inflicted shotgun wound to the abdomen. He was hypotensive in the field for at least one hour prior to surgery and presented to the emergency department *in extremis*. His TS was 5, ISS was 41, and PATI was 62. Injuries included liver, spleen, kidney, pancreas, inferior mesenteric vein, portal vein, small bowel, left colon, and multiple intercostal vessels. Surgery included laparotomy with hepatorrhaphy, splenectomy, nephrectomy, pancreatectomy, small bowel resection, left colectomy with anastomosis, repair of the portal vein, and thoracotomy with ligation of multiple bleeding vessels. He developed fulminant multiple organ failure on

the first hospital day and died on hospital day nine of multiple organ failure with his colonic anastomosis intact.

Patient follow-up was difficult, with almost half of the patients lost to follow-up before they were released from medical care (Table 8). In general, Group 1 patients were released from care or lost to follow-up an average of 33 days postinjury. Group 2 patients were released from care or lost to follow-up an average of 105 days postinjury, longer than Group 1 because of subsequent ostomy closure ($P < 0.05$).

All Coloshields™ passed (Group 1) within the first postoperative month without complication.

Table 4.
Severity of Injury

Variable	Group 1	Group 2	Significance
Mechanism	8/11 GSW	7/11 GSW	$\chi^2 = 0.0397, P > 0.05$
Injury	8/11 LC	8/11 LC	$\chi^2 = 0, P > 0.05$
TS	13.8	12.8	$t = 0.642, P > 0.05$
ISS	27.5	24.2	$t = 0.756, P > 0.05$
PATI	40.5	35.0	$t = 1.239, P > 0.05$

GSW = gunshot wound; LC = left colon.

DISCUSSION

A variety of contemporary authors have developed criteria for primary repair in colonic injury. Stone and Fabian[5] in a prospective, controlled

Table 5.
Outcome

Variable	Group 1	Group 2	Significance
Diet*	5.5 days	7.3 days	$t = 1.401, P > 0.05$
Bowel movement†	6.7 days	6.3 days	$t = 0.305, P > 0.05$
Length of stay‡	12.2 days	20.7 days	$t = 1.463, P > 0.05$
Hospital charge§	$27,885	$53,599	$t = 1.055, P > 0.05$

* Number of days postinjury before initiation of oral diet.
† Number of days postinjury before first bowel movement.
‡ Length of initial hospital stay.
§ Hospital charges for initial hospital stay.

Table 6.
Ostomy Closure: Patient Summary

Patient	Length of Stay	Hospital Charges	Complications
RW	8 days	$7,951	None
OO	9 days	$9,577	Wound infection
DS	6 days	$5,863	None
PP	9 days	$9,348	Wound infection
RW	8 days	$11,925	None
BF	6 days	$3,024	None
Total	46 days	$42,697	Two wound infections
Average	7.7 days	$7,116	33% wound infections

Table 7.
Complications

Complications	Group 1	Group 2	Significance
Wound infection	2/11	2/9	FET = 0.625, $P > 0.05$
Abdominal abscess	1/11	2/9	FET = 0.421, $P > 0.05$
Pneumonia	1/11	2/9	FET = 0.421, $P > 0.05$
Sepsis	0/11	2/9	FET = 0.189, $P > 0.05$
ARDS	1/11	1/9	FET = 0.710, $P > 0.05$
Renal failure	1/11	0/9	FET = 0.550, $P > 0.05$
Phlebitis	1/11	1/9	FET = 0.710, $P > 0.05$
Other	1/11	0/9	FET = 0.550, $P > 0.05$
Total	8/11	10/9	$\chi^2 = 0.516, P > 0.05$

FET = Fisher's exact test; ARDS = adult respiratory distress syndrome.

Table 8.
Follow-up

Patient	Group	Days Postinjury	Comment
CD	1	36	Released
BM	1	40	Released
DB	1	16	Lost to follow-up
DL	1	15	Lost to jail
MS	1	36	Released
RT	1	85	Released
AB	1	43	Lost to follow-up
RB	1	8	Deceased
LM	1	15	Lost to follow-up
KG	1	20	Lost to follow-up
SK	1	48	Released
HB	2	50	Lost to follow-up
RW	2	175	Released
OO	2	150	Released
AJ	2	22	Lost to follow-up
DS	2	96	Released
FP	2	145	Lost to follow-up
PP	2	65	Lost to follow-up
RW	2	92	Lost to follow-up
LB	2	52	Still has ostomy
BF	2	120	Released
AS	2	190	Still has ostomy

study were able to randomize 139 patients with colonic injury into two groups: primary repair *vs.* ostomy. Their indications for randomization demanded that preoperative shock was never profound, blood loss was less than 20 percent of estimated normal volume, there were no more than two intra-abdominal organ systems injured, fecal contamination was minimal, the operation was begun within eight hours, and the wounds of the colon and abdominal wall did not require resection. These authors found that their primary repair patients had a significantly lower wound infection rate and intra-abdominal infection rate and a shorter postoperative stay.

Flint *et al.*[7] reported on 137 patients who had sustained intraperitoneal colon injury during a three-year period. They were able to successfully and safely repair 16 percent of these injuries primarily. Using an intraoperative colon injury classification that included Grade I (injuries isolated to the colon with minimal contamination, no shock, and minimal preoperative delay), Grade II (through-and-through perforations, moderate lacerations, and moderate contamination), and Grade III (severe tissue loss, devascularization, and heavy fecal contamination), they repaired only Grade I injuries.

Shannon and Moore[8] reported on 228 colon injuries treated over a six-year period. They were able to successfully primarily repair 49 percent of these patients with 17 percent septic morbidity and 1 percent septic mortality, which compared favorably with those patients undergoing colostomy. In analyzing their data, they felt that the penetrating abdominal trauma index, colon injury severity, preoperative shock, and peritoneal contamination were the most important factors in determining successful outcome for primary repair and concluded that primary repair was appropriate for patients who were hemodynamically stable with a penetrating abdominal trauma index of less than 25.

Burch and others[2] reported on a five-year experience of 727 patients with colorectal injury. Fifty-two percent of these were treated by primary repair. These authors felt that the extent of colon injury was the most important factor in determining suitability for primary repair, with location, number and type of associated injuries, fecal contamination, and shock less important, and that none of these latter factors mandated colostomy.

George and colleagues[9] reported on a prospective trial in 102 consecutive patients in which primary repair or segmental resection with anastomosis was accomplished in 93 percent. Using logistic regression analysis to identify risk factors for sepsis, they found that transfusion of four or more units of blood, more than two associated injuries, significant contamination, and increase in colon injury severity scores were associated with higher septic complication rates. The method of colon wound management, location and mode of injury, presence of hypotension, and age did not significantly contribute to sepsis. Their conclusion was that essentially all colon injuries could be repaired primarily or with resection and anastomosis, with the exception of those patients with coagulopathy, who would require packing.

Recently, Chappuis *et al.*[6] reported on a prospective, randomized, and controlled series of primary anastomosis or repair *vs.* ostomy in 56 patients. These authors demonstrated no increase in septic morbidity in primary repair in an unselected population. Interestingly, in the discussion of this paper, Fabian reported a 10 percent failure rate with primary anastomosis and suggested that further study was warranted in patients with injury so destructive that resection was necessary.[6]

In the present study, the authors selected only those patients with the most severe colorectal in-

juries for study inclusion. These patients were by definition not candidates for primary repair by most current published criteria. Inclusion criteria (Table 1) were developed to specifically exceed the exclusion criteria for primary repair developed by Stone and Fabian[5] in their prospective study. All of the patients in the present study were Flint Grades II and III. The average PATI for this population was 32, with all patients exceeding Shannon and Moore's[8] recommendation for primary repair of a PATI of 25 or less.

The majority of patients in the present study population underwent resection and anastomosis, compared with George *et al.*'s[9] series, in which only 13 percent underwent anastomosis. Clearly the present study looks only at the most severely injured patient population to evaluate the efficacy of primary anastomosis or repair with intracolonic bypass.

A variety of literature has been published on intracolonic bypass that allows for the exclusion of an unfavorable anastomosis from fecal stream.[11–15] The technique has been shown to be effective in a variety of nontrauma situations including colonic obstruction, emergency surgery in the unprepared colon, and colonic surgery in the face of peritonitis such as in diverticulitis. It would make sense that this technology would be adaptable to injury where circumstances might otherwise be unfavorable for primary repair or anastomosis.

The complication rates and mortality in the present series compare favorably with the results reported by other authors (Table 9). More importantly, the complication rates do not differ between patients undergoing primary repair with intracolonic bypass and those in the control group. A death did occur in the primary repair group and was unrelated to colon injury. This is consistent with the thinking of others who have suggested that death in the absence of technical error is almost always due to associated injuries. Perhaps as important in today's climate, the hospital stay for primary repair with intracolonic bypass tended to be shorter and the cost tended to be less. Comparison of hospital stay and cost did not include subsequent readmission for colostomy closure or the interval of convalescence required. Like the experience of Parks and Hastings,[19] where patients sustained a 36 percent complication rate for colostomy closure, the present study's patients sustained a colostomy closure complication rate of 33 percent. Moreover, the length of time from initial injury to final discharge or loss to follow-up in those patients undergoing colostomy closure averaged 100 days, a time during which they were not potentially productive. The cost of this would certainly add to the overall expense of ostomy.

Although these study numbers are small, the data, which were prospective, randomized, and controlled, suggest that intracolonic bypass was a safe, effective alternative to colostomy in severe colorectal injury. The need for subsequent ostomy closure and the disability period following initial hospital discharge awaiting colostomy closure was obviated. The potential savings when spread to a larger population could be significant. Further study is warranted and should be aimed at confirming these results in other centers. Additionally, the

Table 9.
Comparative Complication Rates

Authors	Technique	Wound Infection (%)	Abdominal Abscess (%)	Dead (%)
Burch *et al.*[2]	Colostomy	5.3	16.7	9.2
	Primary repair	4.5	5.3	1.6
Chappuis *et al.*[6]	Colostomy	3.6	14.3	0
	Primary repair	3.6	10.7	0
George *et al.*[9]	Colostomy	29	10	6.4
	Primary repair	8.6	5.5	1.4
Shannon and Moore[8]	Colostomy	12	25	2
	Primary repair	7	14	1
Stone and Fabian[5]	Colostomy	57	29	1.4
	Primary repair	48	15	1.5
Present series	Colostomy	22.2	22.2	0
	Primary repair	18.2	9.1	9.1

question of primary anastomosis *vs.* primary anastomosis with intracolonic bypass still needs to be answered.

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