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Colorectal resection in emergency general surgery: An EAST multicenter trial

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DISCLOSURE

The authors declare no conflicts of interest.

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Abstract

OBJECTIVE: Evidence comparing stoma creation (STM) versus anastomosis after urgent or emergent colorectal resection is limited. This study examined outcomes after colorectal resection in emergency general surgery patients.

METHODS: This was an Eastern Association for the Surgery of Trauma-sponsored prospective observational multicenter study of patients undergoing urgent/emergent colorectal resection. Twenty-one centers enrolled patients for 11 months. Preoperative, intraoperative, and postoperative variables were recorded. χ^2, Mann-Whitney *U* test, and multivariable logistic regression models were used to describe outcomes and risk factors for surgical complication/mortality.

RESULTS: A total of 439 patients were enrolled (ANST, 184; STM, 255). The median (interquartile range) age was 62 (53–71) years, and the median Charlson Comorbidity Index (CCI) was 4 (1–6). The most common indication for surgery was diverticulitis (28%). Stoma group was older (64 vs. 58 years, $p < 0.001$), had a higher CCI, and were more likely to be immunosuppressed. Preoperatively, STM patients were more likely to be intubated(57 vs. 15, $p < 0.001$), on vasopressors (61 vs. 13, $p < 0.001$), have pneumoperitoneum (131 vs. 41, $p < 0.001$) or fecal contamination (114 vs. 33, $p < 0.001$), and had a higher incidence of elevated lactate (149 vs. 67, $p < 0.001$). Overall mortality was 13%, which was higher in STM patients (18% vs. 8%, $p = 0.02$). Surgical complications were more common in STM patients (35% vs. 25%, $p = 0.02$). On multivariable analysis, management with an open abdomen, intraoperative blood transfusion, and larger hospital size were associated with development of a surgical complication, while CCI, preoperative vasopressor use, steroid use, open abdomen, and intraoperative blood transfusion were independently associated with mortality.

CONCLUSION: This study highlights a tendency to perform fecal diversion in patients who are acutely ill at presentation. There is a higher morbidity and mortality rate in STM patients. Independent predictors of mortality include CCI, preoperative vasopressor use, steroid use, open abdomen, and intraoperative blood transfusion. Following adjustment by clinical factors, method of colon management was not associated with surgical complications or mortality.

Keywords

Emergency general surgery; colon resection; ostomy; colon anastomosis

Emergency general surgery (EGS) patients undergoing urgent or emergent colorectal resection have high complications rates. Complications may be related to the decision of whether to perform a primary anastomosis (ANST) or fecal diversion with an ostomy (stoma creation [STM]). In the trauma population, many advocate that, in the absence of the most severe and devastating wounds, primary ANST should be performed,[1,2] with the caveat that, in severely injured patients, anastomotic failure (AF) can become a lethal event. In the EGS patient requiring colorectal resection, generalized peritonitis, bowel wall edema, and, often, numerous medical comorbidities may confound the decision to perform an ANST. Current data are lacking to guide this decision.

Anastomotic failure has a mortality rate approaching 40% in some series, making it one of the most dreaded complications following colorectal resection.[3–6] Aside from mortality, AF has adverse effects on length of stay and cost of hospitalization, can lead to a permanent stoma, may require unplanned reoperation or percutaneous drain placement, and is associated with increased rates of wound complications and diminished quality of life. Risk factors for increased AF include higher ASA or Charlson Comorbidity Index (CCI), male sex, emergency surgery, and prolonged operating time.[6–9] The incidence of AF varies widely depending on the type of ANST, its distance from the anal verge, and the indication for bowel resection.[3,9]

Fecal diversion by ileostomy or colostomy is used to protect an ANST or avoid creating an ANST entirely. Fecal diversion comes at the expense of certain complications including dehydration, peristomal dermatitis, prolapse, and parastomal hernia formation. These complications occur in up to 75% of patients depending on stoma type,[10–13] with nearly 20% of these patients requiring hospital admission,[14] making this an increasingly important issue as financial penalties for hospital readmissions are increasingly common. Further complications may be amassed at stoma reversal, with morbidity reported in the range of 10% to 50%, with the highest rates in patients with end colostomy.[10,12,13,15]

A recently published prospective multicenter trial sponsored by the American Association for the Surgery of Trauma illustrated that, overall, urgent or emergent bowel resection and ANST in EGS patients had an AF rate of 12.5%, with nearly twice the rate for colocolonic anastomoses (23%), and a 22% failure rate in patients managed with an open abdomen.[5] This study primarily involved small bowel resections and anastomoses (72%) and excluded patients with fecal diversion, thereby failing to evaluate the ideal management of EGS patients requiring colon resection. Other groups have found similar or lower AF rates in predominately elective, oncologic colorectal surgery, with scarce prospective data in the EGS population.[3,10,16–20] The aim of the current study was to evaluate outcomes in the EGS patient requiring urgent or emergent colon resection, with a specific focus on the comparison of patients undergoing ANST versus STM, hypothesizing that ANST is associated with higher rates of perioperative morbidity and mortality. In addition, we hypothesized that STM is associated with improved overall mortality and decreased length of stay and lowered the incidence of surgical complications requiring unplanned operative intervention.

PATIENTS AND METHODS

Institutional review board approval and the requisite data-sharing agreements were secured at all enrolling sites. Patients undergoing urgent/emergent (<24 hours after decision to operate) colon resection were prospectively enrolled from April 1, 2018, to February 13, 2019. Exclusion criteria included elective operations performed within 24 hours of the decision to operate (e.g., scheduled resection of nonobstructed, nonperforated malignancy), prisoners, pregnancy, wards of the state, patients younger than 18 years, patients experiencing traumatic mechanisms of injury, death within 24 hours of the index operation, and death before abdominal closure in patients managed with an open abdomen. Investigators at participating institutions prospectively collected data points on a standardized form and entered into the Research Electronic Data Capture portal hosted at the study coordinating center.[21,22]

The decision to perform STM or ANST was solely the responsibility of the managing surgeon. No guidelines or protocols were suggested to avoid any influence on practitioner decision making. To account for preoperative comorbidities, the components of the CCI were queried and calculated. Body mass index (BMI), age, sex, physical examination, preoperative vital signs, and laboratory values within 24 hours of operation were recorded if available. The following indications for operation were queried: obstruction, hernia, ischemia, diverticulitis, infectious colitis, appendicitis, bleeding, and other. The presence of intraoperative vasopressors (defined as any continuous vasopressor use in the operating room), intraoperative hypothermia (a single temperature <36°C), and any postoperative corticosteroid administration, transfusion, or use of vasopressors were recorded as dichotomous variables. Patients were followed through their hospitalization. The primary outcomes were in-hospital mortality or need for unplanned procedural intervention (intervention by a surgeon, radiologist, or interventional radiologist). Secondary outcomes examined included the incidence of surgical complications (surgical site infections [superficial, deep incisional, organ space], AF, enterocutaneous or atmospheric fistula, bowel obstruction requiring operation, stoma complication requiring operation, fascial dehiscence), operative time, intensive care unit and hospital length of stay, need for nutritional support or antimotility agents upon discharge, and discharge disposition. Definitions of recorded variables are included in Supplementary Digital Content, Supplementary Table 1 (http://links.lww.com/TA/B799). Thirty patients who were enrolled had an ANST with proximal diversion (ANST-STM). To truly examine the differences between performing ANST or STM, these patients were excluded from our analyses unless specified.

Previously studied risk factors for complications in the EGS population (age, sex, BMI, hypothermia, vasopressor usage, corticosteroid usage, diversion vs. ANST, CCI, contamination at initial operation, and open abdomen management) were used for univariate and multivariate analyses. Continuous variables were analyzed using Student's *t* test or Wilcoxon-Mann-Whitney *U* test depending on the distribution of the data. Categorical variables were analyzed with χ^2 or Fisher's exact tests. Multivariable logistic regression models were used to describe outcomes and risk factors for surgical complication or mortality. For all analyses, statistical significance was defined as a two-tailed probability of ≤0.05. Descriptive statistics were summarized as a mean and SD or median and interquartile range for continuous variables, and as frequencies and percentages for categorical variables. Given the lack of data regarding the management of EGS patients after colon resection, our sample size and power estimates are largely based on our clinical experience, the previously cited American Association for the Surgery of Trauma trial,[5] and literature from trauma and elective surgical practice. We assumed a difference in mortality and need for unplanned intervention of 8%. With these estimates, we anticipated requiring 100 patients with ANST and 200 patients with diversion to achieve a power of 90% and an α value of 0.05 with an SD in each group of 20%. Because they comprised a minority of the overall population, ANST-STM patients were excluded from comparative analyses. Unless otherwise specified, all statistical analyses are comparisons between STM and ANST.

RESULTS

Patients

Twenty-one medical centers enrolled 469 patients (Fig. 1). The most common indication for operative intervention was diverticulitis (29%), followed by obstruction (27%) and ischemia (23%; Table 1). Table 2 describes the demographics, comorbidities, and preoperative laboratory values of the included patients. The median (interquartile range) age was 62 (52–71) years, and 211 (47%) were women. The median CCI was 4 (1–6). Before operation, 192 patients (41%) had pneumoperitoneum, 76 (16%) had respiratory failure requiring intubation, and 78 (17%) required vasopressors to maintain their blood pressure. Patients with STM had a higher CCI, were more likely to have respiratory failure requiring intubation, receive vasopressors preoperatively, and had more severe laboratory derangements including anemia, leukocytosis, acute renal failure, and elevated serum lactate. There was no difference in sex or BMI between the two groups.

Surgical Data

The distribution of management following colon resection was as follows: ANST, 184 (40%); STM, 255 (54%); and ANST-STM, 30 (6%). Table 3 shows intraoperative variables. Laparoscopy was attempted in 73 operations (17%) with 43 (59%) requiring conversion to an open procedure. Fewer STM patients had laparoscopic procedures than ANST patients ($p < 0.001$). There was more intraoperative hypothermia and vasopressor use in the STM group. The STM participants were more likely to receive an intraoperative transfusion of a blood product and had a higher estimated blood loss. There was no difference in length of operation. Simultaneous small bowel resection was performed in 22% of participants, excluding resection of the terminal ileum in a cecal resection. This was not different between the two groups ($p = 0.73$). Ileocectomy was performed in 146 participants (33%), 51 (12%) had a total abdominal colectomy, and in 49 participants (11%), the resection specimen was limited to the rectum. The remaining had segments of ascending, transverse, or descending colon resection resected. In the ANST group, 128 (70%) underwent ileocolic; 34 (18%), colorectal; 17 (9%), colocolonic; 4 (2%), ileorectal; and 1, (1%) both ileocolic and colocolonic ANST. A stapler was used in 141 anastomoses (77%). The others were either hand sewn (10%) or a combined technique (13%). In the STM group, 144 (55%) had an end colostomy; 100 (40%), an end ileostomy; 7 (3%), a loop ileostomy; and 4 (2%), a loop colostomy.

Outcomes

Surgical complications, defined as surgical site infection, AF, enterocutaneous or atmospheric fistula, bowel obstruction, stoma complication, or fascial dehiscence, occurred in 133 participants (30%) (Table 4). Of these, 63 participants (13%) required unplanned surgical intervention or percutaneous drain placement. Forty-one patients required surgical intervention, and 34 had both surgery and a percutaneous drain placed. A total of 172 participants (37%) required parenteral nutrition in their first 7 postoperative days. Only 282 participants (60%) tolerated an enteral diet during this period. Sixty-two participants (13%) died during their hospital stay. About half of participants (51%) were discharged to home. The others were discharged to an acute care facility (10%), skilled nursing facility (19%), or hospice (4%).

There were significant differences in the surgical complications experienced in each group. Anastomotic failure was experienced in 21 patients (11%) in the ANST group. As expected, this was significantly higher than the STM group and, interestingly, was also higher than the incidence in patients with ANST-STM (11% vs. 24%, $p = 0.02$). Of the 21 patients experiencing AF, 5 (24%) died. Of the ANST patients, those who experienced AF had comparable CCI ($p = 0.2$), incidence of preoperative vasopressor use ($p = 0.17$), intubation ($p = 0.28$), pneumoperitoneum ($p = 0.86$), and intraoperative vasopressor use ($p = 0.75$) as patients without AF. They had significantly higher rates of fecal contamination ($p < 0.001$) and management with an open abdomen ($p = 0.003$).

The STM group had significantly higher rates of organ-space surgical site infection (SSI) (20% vs. 7%, $p < 0.001$). Complications associated with STM necessitated unplanned surgical intervention in 6% of STM participants. Thirty-five percent of STM participants compared with 25% of ANST participants ($p = 0.02$) experienced a surgical complication (superficial SSI, deep SSI, organ-space SSI, anastomotic dehiscence, enterocutaneous or atmospheric fistula, bowel obstruction necessitating surgical operation, stoma complication necessitating operation, or fascial dehiscence). Of those participants, 67% of ANST required an unplanned intervention for one of these complications (62% surgical, 29% percutaneous drain), and 76% of STM required an intervention (54% surgical, 49% percutaneous drain). Only the difference in need for percutaneous drain placement was significant ($p = 0.02$).

Other complications were experienced at a significantly higher rate in the STM versus ANST group. These included acute renal failure (22% vs. 6%, $p < 0.001$), tracheostomy (11% vs. 3%, $p = 0.002$), sepsis (31% vs. 15%, $p < 0.001$), need for vasopressors, corticosteroids, and bleeding requiring blood transfusions within 72 hours of the index operation (44% vs. 20%, 23% vs. 7%, 33% vs. 15%, respectively; all $p < 0.001$). The average hospital stay was 15(10–15) days in the STM group and 10 (6–16) in the ANST group ($p < 0.001$). Intensive care unit days were greater in the STM compared with the ANST group (0 [0–5] vs. 5 [1–12] days, $p < 0.001$). On multivariable analysis, management with an open abdomen, intraoperative blood transfusion, and larger hospital size were associated with development of a surgical complication, while CCI, preoperative vasopressor use, steroid use, open abdomen, and intraoperative blood transfusion were independently associated with mortality (Table 5). Stoma creation versus ANST was not associated with these outcomes.

DISCUSSION

In this large multicenter study examining management options for bowel after colorectal resection, surgeons preferentially chose STM in patients with higher burden of physiologic disease as evidenced by higher CCI and greater need for both preoperative vasopressors and mechanical ventilation. Patients with STM had more complications and a higher mortality rate, perhaps not unexpected given the higher burden of disease. After controlling for plausible confounders, there was no difference in either mortality or surgical complications between STM and ANST. It is worth noting that, in patients undergoing bowel ANST, AF resulted in an almost 25% mortality rate. This rate is comparable with the rate reported in other studies.[23–26] Only presence of fecal contamination and management with an open abdomen were associated with AF in patients with ANST. In addition, STM patients received parenteral nutrition more frequently and were less likely to achieve goal enteral nutrition when compared with ANST patients. They were also less likely to be discharged to home than ANST patients. Larger hospital size (more than 500 beds) was associated with the development of a surgical site complication, but there was a protective effect with regards to mortality that did not reach statistical significance. This suggests that there may be an ability to "rescue" these patients from demise from their postoperative complication; however, it is not clear from the data collected. The transfer status of patients was not collected and may also contribute to this finding.

The most frequently experienced complications in this study were organ-space infections, stoma complications requiring surgery, fascial dehiscence, and AF. Our study reports an AF rate of 11% in patients undergoing ANST and 27% in patients undergoing ANST-STM. While this is certainly higher than the rate reported other studies, it is comparable with the complication rate in other studies of EGS patients. Bruns et al.[5] reported an AF rate of 22.7% (10 of 44 patients) in a prospective study of EGS patients undergoing large bowel to large bowel anastomoses. Other studies cite emergency surgery as a risk factor for postoperative complications in colorectal surgery, suggesting that the overall complication rate reported here may be within the expected range.[6,8] Many of these studies are confounded by the patient populations focusing on colorectal resection for malignancy.

Postoperative complications can create significant problems and result in mortality after colorectal surgery. While rare, these complications can be devastating for the patient and surgeon. Even after reoperation for one of these complications, multisystem organ dysfunction can lead to prolonged hospitalization, morbidity, or mortality. Identifying patients at risk is essential for optimizing their clinical status and maintaining a high threshold of suspicion for postoperative complications. Although proximal diversion may limit the severity of consequences of AF as stool is diverted from the ANST, global use is cautioned secondary to the morbidity associated with ostomy creation, maintenance, and reversal. For these reasons, the performance of STM or ANST in cases of peritonitis remains a controversial theme in EGS. The answers to these questions are challenging and are not always supported by scientific data because comparative studies of the diseased population are not feasible. The present study highlights CCI, preoperative vasopressor use, need for management with an open abdomen, and intraoperative transfusions as factors that are associated with mortality in this population. We believe that the decision to perform STM or

ANST should include consideration of severity of peritonitis, patient's general condition, and etiology of disease. The most difficult to evaluate is likely the severity of peritonitis, which is subjective and likely related to the surgeon's experience. Our study shows that some patients undergoing emergent colorectal resection tolerate an ANST; however, it remains difficult to predict which patients will do so.

This is the largest study of EGS patients undergoing urgent/emergent colon resection. The strengths of this study include the large sample size and prospective data collection. In addition, the study included a diverse span of surgical indications, which is representative of the EGS population. Study limitations include inherent variability in operative technique and patient management associated with multiple surgeons distributed across multiple centers. We allowed surgeons to make clinical decisions without external guidance, thereby practicing in ways that are representative of their normal clinical practice. Undoubtedly, there is inherent bias in choosing to perform an ANST or a diversion in a patient undergoing urgent/emergent surgery; however, given the outcomes of this study, it seems that illness severity has a greater impact on outcome than method of colon management. Missing laboratory values limited the ability to control for differences in coagulopathy, renal function, or ischemia as International Normalized Ration, platelet count, creatinine, and lactate may have allowed. These values were not collected in all patients limiting our ability to assess their usefulness in predicting outcomes. Treatment centers may not routinely obtain these laboratory values preoperatively in this population, and specific laboratory tests were not required to enroll patients in the study. Other studies have examined differences between stapled and hand-sewn anastomoses.[5,27] This study was not powered to identify a difference in this management decision.

In conclusion, following adjustment by clinical factors, method of colon management was not associated with surgical complication or mortality. Independent predictors of mortality include CCI, preoperative vasopressor use, steroid use, open abdomen, and intraoperative blood transfusion. Management with an open abdomen and intraoperative blood transfusion were associated with development of a surgical complication. Clinical status at time of surgery should alert surgeons for the possibility of postoperative morbidity and mortality. Swift identification and treatment of colon pathology are imperative, and prompt recognition of postoperative complications may offer the greatest opportunity to alter outcomes. Surgeon judgment in these situations works in deciding between stoma STM or ANST.

Supplementary Material

Refer to Web version on PubMed Central for supplementary material.

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Figure 1.

Twenty-one medical centers enrolled patients. Enrolling centers included the following: Cooper University Hospital, George Washington University Hospital, Loma Linda University Medical Center, Los Angeles County + University of Southern California Medical Center, Marshfield Clinic, Massachusetts General Hospital, Mayo Clinic Rochester, Medical City Plano, Methodist Dallas Medical Center, Northwestern Memorial Hospital, R Adams Cowley Shock Trauma Center/University of Maryland Medical Center, Reading Hospital, Rutgers Robert Wood Johnson, Southside Hospital—Northwell Health, Tufts Medical Center, UCHealth—Memorial Hospital, UCHealth—University of Colorado Hospital, University of California—Irvine, University of Miami/Ryder Trauma Center, University of Texas Southwestern Medical Center/Parkland Hospital, and West Virginia University Hospital (listed alphabetically).

TABLE 1.

Indication for Operative Intervention

	ANST-STM (n = 30)	ANST (n = 184)	STM (n = 255)	*p*
Diverticulitis	12 (40)	36 (19.6)	89 (34.6)	<0.001
Obstruction	8 (26.7)	72 (39.1)	49 (19.1)	
Ischemia	7 (23.3)	22 (12.0)	77 (30.0)	
Other	3 (10)	12 (6.5)	14 (5.5)	
Appendicitis	0	25 (13.6)	3 (1.2)	
Infectious colitis	0	2 (1.1)	18 (7.0)	
Hernia	0	11 (6.0)	2 (0.8)	
Bleeding	0	4 (2.2)	5 (1.9)	

p Value describes *ANST* versus diversion. Data are presented as n (%).

TABLE 2.

Demographics, Comorbidities, and Preoperative Patient Variables

	ANST-STM (n = 30)	ANST (n = 184)	STM (n = 255)	*p*[*]
Demographics, comorbidities, and other preoperative characteristics				
Female sex	12 (40.0)	80 (43.5)	130 (51.0)	0.12
Age, y[**]	60 (50–69)	58 (46–69)	64 (56–73)	<0.001[†]
BMI, kg/m^2 [**]	26.7 (23.9–30.6)	27.1 (23.7–32.2)	27.4 (23.6–31.9)	0.77[†]
Current or former tobacco use	14 (46.7)	75 (40.8)	123 (48.2)	0.12
Cardiovascular disease				
Ischemic heart disease	6 (20.0)	18 (9.8)	40 (15.6)	0.07
Congestive heart failure	4 (13.3)	18 (9.8)	34 (13.3)	0.26
Peripheral vascular disease	1 (3.3)	11 (6.0)	27 (10.5)	0.09
Chronic pulmonary disease	4 (13.3)	22 (12.0)	49 (19.2)	0.04
Chronic kidney disease	5 (16.7)	20 (10.9)	48 (18.8)	0.02
Liver disease	1 (3.3)	4 (2.2)	22 (8.6)	0.005
Prior abdominal surgery				
Laparotomy	6 (20.0)	44 (23.9)	67 (26.2)	0.57
Laparoscopy	4 (13.3)	25 (13.6)	29 (11.4)	0.49
Diabetes	6 (20.0)	38 (20.6)	62 (24.3)	0.37
Cancer	1 (3.3)	31 (16.8)	52 (20.4)	0.35
CCI				<0.001
0	3 (10.0)	39 (21.2)	21 (8.2)	
1	4 (13.3)	28 (15.2)	25 (9.8)	
2	6 (20.0)	32 (17.4)	32 (12.5)	
3	2 (6.7)	13 (7.1)	23 (9.0)	
4	6 (20.0)	17 (9.2)	51 (20.0)	
≥5	9 (30.0)	55 (29.9)	103 (40.4)	
Current outpatient medications				
Chemotherapy for malignancy	1 (3.3)	3 (1.6)	15 (5.9)	0.03
Steroids	4 (13.3)	10 (5.4)	41 (16.0)	<0.001
NSAID	6 (20.0)	17 (9.2)	38 (14.9)	0.08

	ANST-STM (n = 30)	ANST (n = 184)	STM (n = 255)	p*
Other immunosuppressant	2 (6.7)	4 (2.2)	21 (8.2)	0.007
Preoperative examination				
Continuous vasopressor infusion	4 (13.3)	13 (7.1)	61 (23.7)	<0.001
Respiratory failure requiring intubation	4 (13.3)	15 (8.2)	57 (22.2)	<0.001
Pneumoperitoneum	18 (60.0)	41 (22.3)	131 (51.4)	<0.001
Preoperative laboratory values				
INR ≥1.5 (n = 129, 197)	5 (22.7)	28 (21.7)	67 (34.0)	0.02
Cr ≥1.2 (n = 177, 230), mg/dL	9 (31.0)	45 (25.4)	104 (45.2)	<0.001
GFR <60 (n = 173, 240)	6 (22.2)	51 (29.5)	134 (55.8)	<0.001
Albumin <3.0 (n = 151, 216), U/L`	8 (29.6)	26 (17.2)	94 (43.5)	<0.001
Bilirubin >1.0 (n = 150, 213), mg/dL	6 (25.0)	39 (26.0)	73 (34.3)	0.09
Lactate >1.5 (n = 131, 214)	15 (68.2)	67 (51.2)	149 (69.6)	<0.001
Hgb (n = 184, 254), g/dL **	13 (11–14)	12.8 (10.9–14.7)	11.9 (9.5–14.0)	0.002†
WBC count (n = 184, 254), per µL **	14 (9–18)	11.9 (9.0–17.0)	13.1 (8.4–18.6)	0.37†
Platelet count (n = 184, 254), $\times 10^3$/µL **	263 (192–362)	256 (199–316)	233 (165–310)	0.03†

p Value describes ANST versus diversion. Data are presented as n (%), unless otherwise indicated. (n = x, y) indicates the number of variables available for analysis in each group if other than 184, 255. Other immunosuppressant includes tacrolimus, methotrexate, highly active antiretroviral therapy, azathioprine, mycophenolic acid, keflunomide, hydroxychloroquine, and azathioprine.

* χ^2 test was used unless otherwise indicated.

** Values are median (IQR).

† Mann-Whitney U test.

GFR, glomerular filtration rate; NSAID, nonsteroidal anti-inflammatory drug; bpm, beats per minute; GCS, Glasgow Coma Scale; INR, International Normalized Ration; Cr, creatinine; Hgb, hemoglobin; WBC, white blood cell.

TABLE 3.

Intraoperative Variables

	ANST-STM (n = 30)	ANST (n = 184)	STM (n = 255)	*p*[*]
Length of operation, min[**]	170 (128–248)	151 (102–194)	149 (104–202)	0.85[†]
≥1 U PRBC transfused (n = 184, 254)	1 (3.3)	22 (12.0)	73 (28.7)	<0.001
≥1 U FFP transfused (n = 184, 254)	1 (3.3)	16 (8.7)	40 (15.7)	0.03
≥1 U platelet transfused (n = 184, 254)	1 (3.3)	2 (1.1)	19 (7.5)	0.002
Intraoperative vasopressor	21 (70.0)	73 (39.5)	173 (67.8)	<0.001
Intraoperative hypothermia	7 (23.3)	39 (21.1)	76 (29.8)	0.04
Fecal contamination	11 (36.7)	33 (17.9)	114 (44.7)	<0.001
Managed with an open abdomen	10 (33.3)	35 (19.0)	84 (32.9)	0.001
Operative approach				<0.001
Celiotomy	26 (86.7)	132 (71.7)	238 (93.3)	
Laparoscopic	1 (3.3)	24 (13.0)	5 (2.0)	
Laparoscopic converted o celiotomy	3 (10.0)	28 (15.2)	12 (4.7)	

p Value describes ANST versus diversion. Data are presented as n (%), unless otherwise indicated. (n = *x*, *y*) indicates the number of variables available for analysis in each group if other than 184, 255.

[*] Fisher's exact test was used unless otherwise indicated.

[**] Values are median (IQR).

[†] Mann-Whitney *U* test.

PRBC, packed red blood cell; FFP, fresh frozen plasma.

TABLE 4.

In-hospital Incidence of Specific Postoperative Complications in Patients Undergoing ANST-STM, ANST, and STM Highlighting the Differences Between ANST and STM

	ANST-STM (n = 30)	ANST (n = 184)	STM (n = 255)	p^*
Surgical complications				
Surgical site infection				
Superficial	3 (10.0)	18 (9.8)	16 (6.3)	0.17
Deep	1 (3.3)	5 (2.7)	12 (4.7)	0.29
Organ	7 (23.3)	13 (7.1)	53 (20.6)	<0.001
Anastomotic dehiscence	8 (26.7)	21 (11.4)	0 (0)	<0.001
Enterocutanous or atmospheric fistula	0	5 (2.7)	3 (1.2)	0.29
Bowel obstruction requiring surgery	0	0 (0.0)	1 (0.4)	1.00
Stoma complication requiring surgery	0	0 (0.0)	16 (6.3)	<0.001
Fascial dehiscence	3 (10.0)	6 (3.3)	16 (6.3)	0.16
≥1 of the above complications	9 (30.0)	45 (24.5)	88 (34.5)	0.02
Need for unplanned intervention for above complication	12 (40.0)	30 (16.3)	67 (26.3)	0.01
Surgical	7 (23.3)	17 (9.2)	24 (9.4)	0.71
Percutaneous drain	10 (33.3)	2 (1.1)	20 (7.8)	0.001
Initiation/modification of antibiotics	10 (33.3)	11 (6.0)	23 (9.0)	0.24
Other complications				
Acute renal failure	5 (16.7)	11 (6.0)	57 (22.4)	<0.001
Tracheostomy	2 (6.7)	6 (3.3)	29 (11.4)	0.002
Sepsis	9 (30.0)	27 (14.7)	79 (31.0)	<0.001
Vasopressor use	10 (33.3)	36 (19.6)	113 (44.3)	<0.001
Postoperative corticosteroid use	7 (23.3)	12 (6.5)	58 (22.7)	<0.001
Bleeding requiring transfusion	5 (16.7)	28 (15.2)	85 (33.3)	<0.001
Nutritional outcomes				
Failure to achieve goal enteral nutrition by POD7	14 (46.7)	52 (28.3)	119 (46.7)	<0.001
Need for parenteral nutrition	15 (50.0)	50 (27.2)	107 (42.0)	0.001
Need for antimotility or bulking agents	12 (40.0)	14 (7.6)	52 (20.4)	<0.001
Discharge nutrition				0.02

	ANST-STM (n = 30)	ANST (n = 184)	STM (n = 255)	p[*]
Enteral	26 (86.7)	161 (87.5)	196 (76.9)	
Parenteral	1 (3.3)	10 (5.4)	32 (12.5)	
Enteral-parenteral	3 (10.0)	13 (7.1)	27 (10.6)	
Discharge destination				
Hospital length of stay[†]	15 (11–25)	10 (6–16)	15 (10–25)	<0.001[‡]
Home	15 (50.0)	129 (70.1)	95 (37.3)	<0.001
Acute care facility	4 (13.3)	8 (4.3)	36 (14.1)	
Skilled nursing facility	6 (20.0)	26 (14.1)	55 (21.6)	
Other health care facility	1 (3.3)	5 (2.7)	9 (3.5)	
Hospice	1 (3.3)	2 (1.1)	15 (5.9)	
Deceased	3 (10.0)	14 (7.6)	45 (17.6)	

p Value describes ANST versus diversion. Data are presented as n (%), unless otherwise indicated. (n = *x*, *y*) indicates the number of variables available for analysis in each group if other than 184, 257. Other immunosuppressant includes tacrolimus, methotrexate, highly active antiretroviral therapy, azathioprine, mycophenolic acid, keflunomide, hydroxychloroquine, and azathioprine.

[*] χ^2 test was used unless otherwise indicated.

[†] Values are median (IQR).

[‡] Mann-Whitney *U* test.

POD7, post-operative day 7.

TABLE 5.

Multivariable Logistic Regression Model for at Least One Surgical Complication and Mortality in Patients Undergoing Urgent or Emergent Colorectal Resection

	At Least One Surgical Complication*			Mortality		
	Odds Ratio	**95% CI**	***p***	**Odds Ratio**	**95% CI**	***p***
Stoma (vs. ANST)	1.28	0.79–2.08	0.32	1.42	0.67–3.03	0.36
CCI	0.97	0.88–1.08	0.62	1.46	1.06–2.02	0.02
Preoperative vasopressor	1.22	0.62–2.41	0.57	3.07	1.35–6.97	0.007
Preoperative respiratory failure	0.64	0.31–1.31	0.22	1.32	0.54–3.20	0.54
Pneumoperitoneum	1.25	0.77–2.03	0.36	0.66	0.32–1.34	0.25
Open abdomen	2.07	1.24–3.46	0.006	2.62	1.30–5.29	0.007
Steroid use	0.77	0.39–1.51	0.44	3.02	1.26–7.20	0.01
Intraoperative PRBC transfusion	2.03	1.20–3.42	0.008	2.29	1.17–4.47	0.02
Diverticulitis	1.40	0.82–2.41	0.22	0.42	0.15–1.18	0.10
Hospital size	1.82	1.11–2.96	0.02	0.60	0.28–1.25	0.17

Hosmer-Lemeshow test: complication, $\chi_8^2 = 7.29$, $p = 0.51$; mortality, $\chi_8^2 = 6.53$, $p = 0.59$.

* Surgical complications include surgical site infection, anastomotic dehiscence, enterocutaneous or atomospheric fistula, bowel obstruction requiring surgery, stoma complication requiring surgery, and fascial dehiscence.

CI, confidence interval; PRBC, packed red blood cell.