Paraplegic and quadriplegic patients undergoing emergency abdominal surgery: Sicker presentations, worse outcomes

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BACKGROUND: Patients with paraplegia or quadriplegia presenting with abdominal surgical emergencies pose major clinical challenges. Difficulties in prompt diagnosis and treatment may influence patient outcomes.

METHODS: This is an American College of Surgeons National Surgical Quality Improvement Program study of patients undergoing an emergent abdominal operation. Patients were stratified into paraplegic (PARA), quadriplegic (QUAD), and control (CONT). PARA and QUAD groups were matched with controls by 1:2 ratio. Regression models were used to analyze the effect of paraplegia and quadriplegia on outcome.

RESULTS: A total of 76,766 patients underwent emergent abdominal operations: 274 PARA, 132 QUAD, and 76,356 CONT patients. Lower gastrointestinal operations were the most common procedures in PARA and QUAD groups; appendectomy was the most common in the CONT group. After cohort matching, patients with cord paralysis were significantly more likely to present with severe sepsis, have "infected" wounds at operation, and have increased rates of postoperative sepsis and need for reoperation.

CONCLUSION: Patients with paraplegia or quadriplegia with acute abdominal surgical emergencies are more likely to present late and have a significantly higher incidence of postoperative septic complications and longer hospital stay. Early surgical consultation and aggressive evaluation and postoperative management are warranted in these populations. (*J Trauma Acute Care Surg*. 2015;78: 808–815. Copyright © 2015 Wolters Kluwer Health, Inc. All rights reserved.)

LEVEL OF EVIDENCE: Epidemiologic study, level III; therapeutic study, level IV.

KEY WORDS: Spinal cord paralysis; abdominal surgical emergencies; paraplegic; quadriplegic.

The evaluation of a surgical abdomen in the paraplegic or quadriplegic patient is a clinical challenge. Despite the many advances during the past decades, which have improved patient quality of life in this population, early and accurate identification of an acute abdominal process remains difficult. Several factors can confound the physical examination and cause delay or absence of diagnosis. First, paraplegic and quadriplegic patients at baseline have an increased incidence of bowel abnormalities and infectious complications including urinary tract infection and decubitus ulcers. These baseline abnormalities can obscure the subtle symptoms that accompany a new physical finding. Changes in baseline examination can be mistakenly attributed to these more common "routine" complications. Second, the presenting symptoms are often not obvious to the untrained examiner, and the reliability of the traditional abdominal examination is variable based on the location and completeness of the spinal cord abnormality. Physical examination can be unreliable because patients can have significant alterations in the somatic sensory pathways, present with referred pain symptoms, have autonomic dysreflexia, or have abnormalities of abdominal tone.[1–3] Several small series with case studies have sought to identify early indicators of the acute abdomen in the paraplegic and quadriplegic population. There are subtle examination findings of distension or shoulder pain that have been described in patients with high lesions, changes in micturition or anorexia, variable reliability of leukocytosis, and a heavy reliance on radiographic imaging that may aid diagnosis.[1,2,4–6] Although late symptoms of abdominal catastrophe are more apparent as patients manifest sepsis and shock, the early signs and symptoms can often be easily missed, thus often resulting in delayed diagnosis.

Paraplegic and quadriplegic patients are thought to have an increased morbidity and mortality because of surgical emergencies, a phenomenon largely attributed to presumed delay in diagnosis. A retrospective study of 30 spinal cord injury patients with appendicitis calculated a mean duration of symptoms before admission of 4 days with an additional 2 days in the hospital before diagnosis.[4] Several case studies support this concern of delayed presentation and diagnosis due to difficulty in recognizing early symptoms that can ultimately impair outcomes.[2,5,7,8] These include a vague "squeezing" sensation that was the cue for bowel obstruction with compromised bowel or chronic diarrhea associated with a carcinoid tumor.[8,9] In an acute cervical spine injury patient with abdominal distention and no other clinical signs or symptoms of injury, a several-day colonic perforation was discovered with the incidental finding of free air on routine chest x-ray.[10] Although there are no large series studies to guide the optimal evaluation and management, these case studies highlight the difficulties that practitioners face in accurately identifying acute abdominal pathology in the spinal cord injury patient. This causes increased risk in the management of an already difficult to manage population.

The purpose of this study was to use a large national database to compare the presentation and outcomes of patients with and without spinal cord injury requiring emergent abdominal operations.

PATIENTS AND METHODS

Patient Selection and Data Collection

This is a retrospective analysis using the American College of Surgeons National Surgical Quality Improvement Program[11] (ACS NSQIP) database from 2005 to 2009. The NSQIP database collects clinical data, including preoperative patient characteristics, operative parameters, and postoperative mortality and morbidity outcomes for patients undergoing surgical procedures. The NSQIP database contains Health Insurance Portability and Accountability Act (HIPAA) deidentified data of participating hospitals. Patients of all ages undergoing emergent abdominal procedures were extracted from the NSQIP database. Pregnant patients were excluded.

The analysis included all patients who underwent an emergency abdominal operation during the study period. Included patients were divided into three groups as follows: paraplegic (PARA), quadriplegic (QUAD), and nonparaplegic/nonquadriplegic controls (CONT). Operative procedures were classified into the following five groups: appendectomy or drainage of periappendiceal abscesses (appendix); cholecystectomy and gallbladder-related procedures (gallbladder); hepatobiliopancreatic procedures and operations of the spleen (HBP and spleen); upper gastrointestinal tract procedures (upper GIT) including esophagus, stomach, and duodenum; and lower gastrointestinal tract procedures (lower GIT), including jejunum, ileum, colon and rectum. Upper GIT procedures were predominately

TABLE 1. Operative Groups (Unmatched Cohort)

	PARA	QUAD	CONT
Appendix	38 (13.9)	10 (7.6)	40,325 (52.8)
Gallbladder	23 (8.4)	7 (5.3)	7,751 (10.2)
HBP and spleen	4 (1.5)	1 (0.8)	1,094 (1.4)
Upper GIT	22 (8.0)	18 (13.6)	3,394 (4.4)
Lower GIT	187 (68.2)	96 (72.7)	23,792 (31.2)

Values are n (%). Distribution of operative procedures significantly different between the case (PARA/QUAD) and CONT group (p = 0.000, Fisher's exact test).

Appendix group includes appendectomy and operative drainage of appendiceal abscess; gallbladder group includes cholecystectomy and other gallbladder procedures; HBP and spleen group includes hepatobiliopancreatic procedures and operations on the spleen; upper GIT group includes upper gastrointestinal tract procedures; and lower GIT group includes lower (jejunum to rectum) gastrointestinal tract procedures.

ulcer operations, while lower GIT operations were largely small or large bowel resections. Body mass index (BMI) was categorized as underweight (<18.5 kg/m^2), normal weight (18.5–24.9 kg/m^2), overweight (25.0–29.9 kg/m^2), and obese (>30.0 kg/m^2).

Patient characteristics including sex, age, American Society of Anesthesiologists (ASA) physical status classification scores, BMI category, and operative procedure groups as well as the distribution of operative procedure groups of PARA and QUAD patients were compared with those of the CONT patients.

To account for the significantly different patient characteristics between the PARA/QUAD and CONT groups, 1:2 cohort matching of PARA and QUAD with CONT patients was performed. Matching variables were as follows: sex, age, ASA score, BMI category, and operative procedure group. Matching tolerance was 0 for sex, ASA score, BMI category and operative procedure, and 10 years for age. Matching was performed without replacement.

In the matched cohort, PARA and QUAD patients were subsequently compared with the CONT patients in univariable

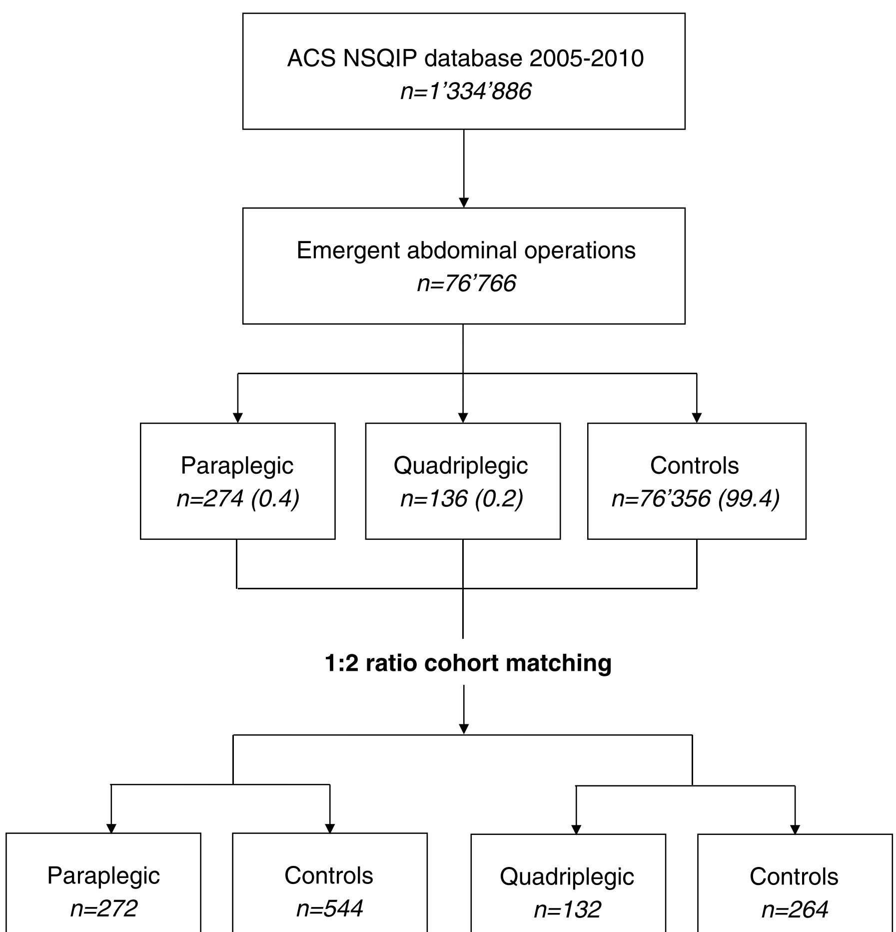

Figure 1. Case selection and cohort matching. Values in parentheses are percentages.

TABLE 2. Baseline Characteristics at Hospital Admission

	PARA	CONT	p*	QUAD	CONT	p*
Admission from home	185 (68.0)	470 (86.4)	**0.000**	81 (61.4)	220 (83.3)	**0.000**
Pneumonia	26 (9.6)	37 (6.8)	0.167	19 (14.4)	21 (8.0)	0.052
Acute renal failure	13 (4.8)	35 (6.4)	0.430	8 (6.1)	15 (5.7)	1.000
Corticosteroid use	33 (12.1)	51 (9.4)	0.224	11 (8.3)	31 (11.7)	0.387
SIRS	59 (21.7)	171 (31.4)	**0.004**	35 (26.5)	76 (28.8)	0.722
Sepsis	54 (19.9)	42 (7.7)	**0.000**	30 (22.7)	22 (8.3)	**0.000**
Septic shock	61 (22.4)	67 (12.3)	**0.000**	32 (24.2)	30 (11.4)	**0.001**

*Fisher's exact test.
Univariable analysis. Values are n (%).
SIRS, systemic inflammatory response syndrome.
Boldface indicates statistical significance.

and multivariable regression analyses, including baseline characteristics at hospital admission, operative parameters, and postoperative outcome parameters.

Statistical Analysis

Normal distribution of continuous variables was assessed using histograms, skewness, and the Shapiro-Wilk test.

Univariable analysis was performed for all included variables. Categorical variables were compared using Fisher's exact test. Continuous variables were analyzed using Mann-Whitney U-test. Results were reported as numbers and percentages or medians and interquartile ranges (IQRs), as appropriate. $p < 0.05$ was considered statistically significant.

The effect of PARA and QUAD on baseline characteristics, operative parameters, and outcomes was adjusted in a multivariable regression analysis. Statistically significant variables of the univariable analysis were included as dependent variables in logistic or linear regression analysis. Clinically important predictor variables (sex, age, BMI, ASA score, nicotine abuse, ethanol abuse, operating surgeon [attending or resident], and wound contamination or infection) as well as operative procedure groups were correlated with dependent variables using Spearman's correlation and entered in regression models if the p value was less than 0.1. Not normally distributed dependent variables were log10 transformed for linear regression analysis. A value of 0.5 was added to the prehospital, total hospital, and postoperative length of stay before the log10 transformation, to account for zero values. The regression coefficient (RC) and confidence interval (CI) were then back-transformed to the original scale for ease of interpretation. Results were reported as odds ratio (OR) and 95% CI or RC and 95% CI as appropriate.

Regression model performance was assessed using χ^2 goodness of fit, Snell R^2 and Nagelkerke R^2 for logistic regression, and analysis of variance (ANOVA), R^2, and adjusted R^2 for linear regression.

Statistical analysis was performed using SPSS statistics (IBM Corporation, Armonk, NY).

RESULTS

Populations

During the study period, a total of 1,334,886 patients were captured by the NSQIP database and 76,766 underwent emergency abdominal operations. Of these, 274 patients (0.4%) were PARA and 132 patients (0.2%) were QUAD patients. Emergent abdominal operations were divided according to the previously defined groups (Table 1): appendix, gallbladder, hepatobiliary/spleen, upper GIT, and lower GIT (including operations involving the jejunum to rectum). The distribution of emergency operations differed significantly between groups (see Figure, Supplemental Digital Content 1, http://links.lww.com/TA/A544).

TABLE 3. Operative Parameters

	PARA	CONT	p*	QUAD	CONT	p
Preoperative LOS**	1.0 (7.0)†	1.0 (3.0)†	**0.000‡**	1.0 (4.0)§	1.0 (4.0)§	0.192‡
Operative time, min**	101 (75)	75 (70)	**0.000‡**	104 (92)	79 (69)	**0.000‡**
Wound classification**	3.0 (2.0)	2.0 (2.0)	**0.000‡**	3.0 (2.0)	2.0 (2.0)	**0.000‡**
Wound contaminated	52 (19.1)	74 (13.6)	**0.050**	24 (18.2)	41 (15.5)	0.565
Wound infected	111 (40.8)	87 (16.0)	**0.000**	53 (40.2)	46 (17.4)	**0.000**

*Fisher's exact test unless indicated otherwise.
**Numbers are median (IQR).
†PARA, mean (SD), 5.6 (10.9); CONT, mean (SD), 3.15 (9.0).
‡Mann-Whitney U-test.
§QUAD, mean (SD), 5.4 (13.9); CONT, mean (SD), 3.9 (9.8).
Univariable analysis. Values are n (%) unless indicated otherwise.
Boldface indicates statistical significance.
Wound classification, 1 to 4 number scale (1, clean; 2, clean-contaminated; 3, contaminated; 4, infected).
LOS, length of stay.

TABLE 4. Postoperative Outcome

	PARA	CONT	*p**	QUAD	CONT	*p**
Superficial SSI	18 (6.6)	37 (6.8)	1.000	9 (6.8)	15 (5.7)	0.660
Deep SSI	7 (2.6)	11 (2.0)	0.619	0 (0.0)	4 (1.5)	0.306
Organ space SSI	16 (5.9)	15 (2.8)	**0.033**	11 (8.3)	10 (3.8)	0.093
Wound dehiscence	8 (2.9)	13 (2.4)	0.644	5 (3.8)	5 (1.9)	0.312
Pneumonia	28 (10.3)	59 (10.8)	0.904	19 (14.4)	34 (12.9)	0.754
Pulmonary embolism	5 (1.8)	11 (2.0)	1.000	1 (0.8)	4 (1.5)	0.669
Progressive renal failure	4 (1.5)	6 (1.1)	0.738	1 (0.8)	0 (0.0)	0.333
Urinary tract infection	31 (11.4)	21 (3.9)	**0.000**	10 (7.6)	7 (2.7)	**0.033**
Cardiac arrest	9 (3.3)	19 (3.5)	1.000	2 (1.5)	6 (2.3)	0.724
Sepsis	40 (14.7)	45 (8.3)	**0.007**	19 (14.4)	28 (10.6)	0.323
Septic shock	29 (10.7)	55 (10.1)	0.808	11 (8.3)	27 (10.2)	0.592
Return to operating room	50 (18.4)	70 (12.9)	**0.046**	26 (19.7)	51 (19.3)	1.000
30-d mortality	51 (18.8)	79 (14.5)	0.128	19 (14.4)	33 (12.5)	0.637
Total LOS**	15.5 (21)	10.0 (13)	**0.000†**	19.0 (20)	17.3 (14)	**0.000†**
Postoperative LOS**	10.0 (17)	8.0 (10)	**0.000†**	15.0 (17)	8.0 (10)	**0.000†**

*Fisher's exact test unless indicated otherwise.
**Numbers are median (IQR).
†Mann-Whitney U-test.
Univariable analysis. Values are n (%) unless indicated otherwise. Boldface indicates statistical significance.
LOS, length of stay; SSI, surgical site infection.

Appendectomy was the most common operation in the CONT group, occurring in 52.8% of the patients, with lower GIT operations occurring in only 31.2%. In contrast, the most common operation in the PARA and QUAD patients was lower GIT (68.2% and 72.7%, respectively), with appendiceal operations relatively rare (13.9% and 7.6%, respectively). In addition to the differences noted in operative distribution, the PARA and QUAD patients were noted to have several other baseline differences including a significantly higher preoperative ASA score (see Table, Supplemental Digital Content 2, http://links.lww.com/TA/A545). For these reasons, the PARA and QUAD groups were cohort matched by 1:2 with respective control patients from the nonparaplegic/nonquadriplegic controls (Fig. 1). Efficacy of matching was confirmed with Fisher's exact or Mann-Whitney U-test as appropriate (see Table, Supplemental Digital Content 3, http://links.lww.com/TA/A546).

Baseline Characteristics

Both the PARA and QUAD patients were predictably less likely to present from home for hospital admission. Prehospital pneumonia, acute renal failure, and steroid use were similar between groups. In both the PARA and QUAD groups, patients were sicker on admission, with an increased percentage of patients presenting with sepsis and septic shock (PARA vs. CONT, 19.9% vs. 7.7% sepsis, $p < 0.001$; 22.4% vs. 12.3% septic shock, $p < 0.001$; QUAD vs. CONT, 22.7% vs. 8.3% sepsis, $p < 0.001$; 24.2% vs. 11.4% septic shock, $p = 0.001$; Table 2).

Operative Parameters

Median preoperative hospital length of stay was more than 2 days longer in the PARA group relative to the CONT group ($p < 0.001$), with a trend toward increased preoperative length of stay in the QUAD group ($p = 0.192$; Table 3). Operative time was longer in both PARA and QUAD patients, despite matching for operation subtype (PARA vs. CONT, 101 min vs. 75 min, $p < 0.001$; QUAD vs. CONT, 104 min vs. 79 min, $p < 0.001$).

Consistent with the increased levels of sepsis and septic shock on presentation in the PARA and QUAD patients, both groups had significantly more infected or dirty, Class 4 wounds at operation, defined as "old traumatic wounds with retained devitalized tissue and those that involve existing clinical infection or perforated viscera" (PARA vs. CONT, 40.8% vs. 16.0%, $p < 0.001$; QUAD vs. CONT, 40.2% vs. 17.4%, $p < 0.001$). The PARA and QUAD patients had an overall higher wound classification than the respective CONT groups, with a median wound classification in the PARA patients of 3.0 (IQR, 2.0) versus 2.0 in the CONT patients (IQR, 2.0) ($p < 0.001$) and 3.0 (IQR, 2.0) in the QUAD patients versus 2.0 (IQR, 2.0) in the CONT patients ($p < 0.001$, Table 3).

Postoperative Outcomes

No difference was noted between groups in surgical site infections (PARA, $p = 1.000$; QUAD, $p = 0.660$); however, deep organ space infections were more common in the PARA patients (5.9% vs. 2.8% in the CONT patients, $p = 0.033$), consistent with the findings of increased wound contamination at the time of operation (Table 4). Similarly, PARA patients were noted to have increased rates of postoperative sepsis (14.7% vs. 8.3%, $p = 0.007$) and return to the operating room (18.4% vs. 12.9%, $p = 0.046$). Other postoperative complications were similar between the groups, with the notable exception of urinary tract infections in the PARA and QUAD patients, an expected outcome with the likely increased dependence on urinary catheters in this population (PARA vs. CONT, 11.4% vs. 3.9%, $p < 0.001$; QUAD vs. CONT, 7.6% vs. 2.7%, $p = 0.033$).

Total hospital length of stay was significantly higher in both the PARA and QUAD patients relative to the matched CONT patients (PARA vs. CONT, 15.5 days vs. 10.0 days, $p <$

TABLE 5. Adjusted Effect of Paraplegia

	OR	95% CI	*p*	Goodness of fit χ^2	Goodness of fit *df*	Goodness of fit *p*	Cox and Snell R^2	Nagelkerke R^2
Admission from home*[1]	0.328	0.211–0.442	0.000	85.242	7	0.000	0.099	0.158
Sepsis on admission*[2]	2.977	1.927–4.598	0.000	28.271	2	0.000	0.034	0.066
Septic shock on admission*[3]	2.485	1.605–3.847	0.000	164.288	4	0.000	0.182	0.314
Wound contaminated*[4]	1.511	1.021–2.236	0.039	14.820	3	0.002	0.018	0.031
Wound infected*[5]	3.855	2.732–5.439	0.000	87.558	4	0.000	0.102	0.152
Organ space SSI*[6]	2.234	1.079–4.622	0.030	15.872	4	0.003	0.019	0.070
Urinary tract infection*[7]	3.245	1.820–5.786	0.000	25.934	3	0.000	0.031	0.083
Sepsis postoperative*[8]	1.945	1.234–3.067	0.004	12.048	2	0.002	0.015	0.030
Return to operating room*[9]	1.608	1.058–2.445	0.026	45.065	6	0.000	0.054	0.095
	RC	**95% CI**	**p**	**ANOVA F**	**ANOVA df**	**ANOVA p**	R^2	**Adjusted** R^2
Preoperative LOS**[10]	0.473	0.241–0.750	0.000	18.020	7	0.000	0.135	0.128
Operative time**[11]	0.244	0.148–0.349	0.000	19.152	8	0.000	0.160	0.151
Total hospital LOS**[12]	0.454	0.271–0.664	0.000	30.149	8	0.000	0.230	0.222
Postoperative LOS**[13]	0.330	0.157–0.529	0.000	19.623	8	0.000	0.163	0.155

Multivariable regression analysis.
*Logistic regression.
**Linear regression.
[1]Adjusted for appendectomy, upper GIT surgery, lower GIT surgery, ASA score, age, and BMI.
[2]Adjusted for ASA score.
[3]Adjusted for appendectomy, lower GIT surgery, and ASA score.
[4]Adjusted for appendectomy and lower GIT surgery.
[5]Adjusted for upper GIT surgery and ASA score.
[6]Adjusted for attending operating surgeon, HBP surgery, and ASA score.
[7]Adjusted for appendectomy and ASA score.
[8]Adjusted for attending alone.
[10]Adjusted for sex, appendectomy, upper GIT surgery, lower GIT surgery, age, and ASA score.
[11]Adjusted for sex, attending operating surgeon, appendectomy, upper GIT surgery, lower GIT surgery, BMI, and ASA score.
[12]Adjusted for sex, attending operating surgeon, appendectomy, cholecystectomy, lower GIT surgery, age, and ASA score.
[13]Adjusted for sex, attending operating surgeon, appendectomy, cholecystectomy, upper GIT surgery, lower GIT surgery, age, and ASA score.
LOS, length of stay; SSI, surgical site infection.

0.001; QUAD vs. CONT, 19.0 days vs. 17.3 days, $p < 0.001$). Although this can be partially explained by the increased preoperative length of stay reported in each group on univariate analysis, postoperative length of stay, independently, is also increased in both of these groups (PARA vs. CONT, 10.0 days vs. 8.0 days, $p < 0.001$; QUAD vs. CONT, 15.0 days vs. 8.0 days, $p < 0.001$). Thirty-day mortality was similar across cohort-matched groups.

Regression Analysis

After adjusting for sex, age, BMI, ASA score, nicotine abuse, ethanol abuse, operating surgeon (attending vs. resident), and operative procedure, the influence of paraplegia and quadriplegia on outcome variables was estimated (Tables 5 and 6). PARA and QUAD patients were approximately three times more likely to present in sepsis or septic shock (PARA: OR, 2.977 [95% CI, 1.927–4.598]; OR 2.485 [95% CI, 1.605–3.847]; QUAD: OR, 2.862 [95% CI, 1.560–5.250]; OR, 3.197 [95% CI, 1.698–6.020], for sepsis and septic shock, respectively). Similarly, PARA and QUAD patients were significantly more likely to have infected, Class 4 wounds on operation (PARA: OR, 3.855 [95% CI, 2.732–5.439]; QUAD: OR, 3.665 [95% CI, 2.206–6.087]). This remained significant in the PARA patients, with an increased risk of sepsis in the postoperative period (OR, 1.945 [95% CI, 1.234–3.067]). Analysis of linear variables also confirmed an increased hospital length of stay in the PARA patients driven by both increased preoperative and postoperative stay.

DISCUSSION

The diagnosis of an acute abdomen in a spinal cord injury patient is a challenge and may affect patient hospital course and overall morbidity. The available literature on this topic is limited to small case series. The current study, which is based on a large, well-maintained national database, provides some important information about the nature of acute abdominal surgical emergencies, the clinical presentation, and postoperative outcomes in this group of patients. In PARA and QUAD patients, "lower GIT" surgical emergencies were, by far, the most common indication for operation in contrast to appendiceal operations, which were the most commonly performed procedure in the nonparaplegic/nonquadriplegic population, even after matching for age and sex. This difference in operation distribution may be caused by different underlying physiology, driven by widely reported abnormalities in bowel and urinary habits, or possibly from a more progressed presentation of a similar pathology. For example, appendicitis left untreated may progress and ultimately require a more extensive exploration or resection

TABLE 6. Adjusted Effect of Quadriplegia

	OR	95% CI	*p*	Goodness of fit χ^2	Goodness of fit *df*	Goodness of fit *p*	Cox and Snell R^2	Nagelkerke R^2
Admission from home*[1]	0.328	0.200–0.536	0.000	37.619	5	0.000	0.091	0.136
Sepsis on admission*[2]	2.862	1.560–5.250	0.001	21.890	3	0.000	0.054	0.099
Septic shock on admission*[3]	3.197	1.698–6.020	0.000	84.411	5	0.000	0.192	0.331
Wound contaminated*[4]	1.210	0.676–2.163	0.521	27.251	4	0.000	0.067	0.113
Wound infected*[5]	3.665	2.206–6.087	0.000	62.548	4	0.000	0.146	0.216
Organ space SSI*[6]	2.442	0.978–6.099	0.056	19.809	3	0.000	0.049	0.144
Urinary tract infection*[7]	3.282	1.204–8.941	0.020	10.616	2	0.005	0.026	0.089
Sepsis postoperative*[8]	1.426	0.759–2.676	0.270	6.661	2	0.036	0.017	0.032
Return to operating room*[9]	1.026	0.596–1.766	0.926	23.035	4	0.000	0.057	0.090
	RC	**95% CI**	**p**	**ANOVA F**	**ANOVA df**	**ANOVA p**	R^2	**Adjusted** R^2
Preoperative LOS**[10]	0.212	-.0.054–0.553	0.129	10.537	5	0.000	0.119	0.108
Operative time**[11]	0.247	0.105–0.408	0.000	8.243	5	0.000	0.096	0.084
Total hospital LOS**[12]	0.372	0.153–0.633	0.000	15.263	8	0.000	0.240	0.224
Postoperative LOS**[13]	0.321	0.091–0.600	0.004	8.486	8	0.000	0.149	0.132

Multivariable regression analysis.
*Logistic regression.
**Linear regression.
[1]Adjusted for nicotine abuse, appendectomy, upper GIT surgery, and ASA score.
[2]Adjusted for nicotine abuse and ethanol abuse.
[3]Adjusted for appendectomy, lower GIT surgery, BMI, and ASA score.
[4]Adjusted for cholecystectomy, lower GIT surgery, and age.
[5]Adjusted for appendectomy, lower GIT surgery, and ASA score.
[6]Adjusted for upper GIT surgery or lower GIT surgery.
[7]Adjusted for age.
[8]Adjusted for upper GIT surgery.
[9]Adjusted for appendectomy, upper GIT surgery, and ASA score.
[10]Adjusted for appendectomy, lower GIT surgery, age, and ASA score.
[11]Adjusted for sex, appendectomy, upper GIT surgery, and age.
[12]Adjusted for nicotine abuse, appendectomy, cholecystectomy, upper GIT surgery, lower GIT surgery, age, and ASA score.
[13]Adjusted for nicotine abuse, appendectomy, cholecystectomy, upper GIT surgery, lower GIT surgery, age, and ASA score.
LOS, length of stay; SSI, surgical site infection.

rather than the traditional appendectomy. Colorectal pathologies that are often treated nonoperatively, such as constipation, diverticulitis, or distention may go unrecognized and progress to ulceration, perforation, and/or sepsis requiring operative intervention.

Even after cohort matching, including operation class, the PARA and QUAD patients presented with more advanced disease, as evidenced by increased levels of sepsis and septic shock on admission. At the time of operation, the field was more likely to be classified as "infected" in PARA and QUAD patient procedures. This likely contributed to the higher incidence of postoperative sepsis, need for repeat operation, and longer hospital stay in the PARA patients.

The suggestion of delayed presentation is supported by the existing literature that describes the paraplegic and quadriplegic population as often having a difficult physical examination because of their underlying injury or physiology. Baseline sensory deficits, abnormalities in tone, as well as underlying chronic medical and infectious problems all lead to decreased reliability of the traditional examination findings.[1,2,4,5] This can result in delayed recognition of symptoms as well as present a diagnostic challenge for the emergency surgeon even after the patient seeks medical attention. The medical staff examining these patients is often not conditioned to the baseline differences or well versed in the specific findings expected of the level and completeness of the spinal cord injury. Even after hospital admission, there is often significant delay in diagnosis of the spinal cord injury patient with a surgical abdomen.[2,4,10] In a 1999 review of 26 spinal cord injury patients with appendicitis in the Veteran system, the authors noted that the diagnosis of appendicitis was made on admission in only 35% of the patients, with nearly all patients presenting with abnormal but nonspecific physical examination findings.[4] Mean duration of symptoms before admission was 4.1 days, and mean time to diagnosis once admitted was 2 days. All 26 patients underwent appendectomy with 92% perforated, three requiring concomitant cecal resection, and one patient mortality caused by postoperative sepsis. This represents a disease distribution distinct from the traditional nonparaplegic/nonquadriplegic patient who presents with appendicitis.

In the current study, hospital length of stay was significantly increased in the PARA group. Given the increased level of illness on admission and rates of postoperative sepsis, this is a largely expected result. The finding that preoperative length of stay was also increased, however, lends further support to the concern for delayed diagnosis in this population. Mean hospital length of stay before operative intervention in this population was more than 2 days longer than in the control group.

The PARA and QUAD population had a significantly more advanced wound classification than their matched counterparts with approximately 40% of these patients with "infected" wounds at the time of operation. Although these data do not allow a breakdown of the specific etiology of the infected wound, as defined by NSQIP, these wounds include those with existing clinical infection and those with perforated viscera. Given the likely delayed presentations and difficulties with physical examination in this population, it is likely that the early signs of hollow viscus inflammation, distention, or injury are missed and that this population is at increased risk of presenting with frank perforation and contamination. Because this is a retrospective database study, we are limited in our ability to precisely determine the timing and workup of diagnosis.

To date, the literature on emergent operations in spinal cord injury patients is largely based on case studies and small single-center reports. In addition to the Veteran study by Strauther et al. discussed earlier, two additional series out of Veteran databases have been published, one capturing 21 patients over 10 years in Arizona[2] and another out of California with 24 patients.[1] Both echoed the difficulties discussed with presenting symptoms, physical examination, and delayed diagnosis. A more contemporary review of 22 spinal cord injury patients with acute abdominal diagnoses in Australia had similar conclusions with an added focus on the diagnostic modalities used, advocating a liberal use of early imaging studies to improve patient outcomes. Several case studies have mirrored these conclusions; however, a large-volume, contemporary retrospective or prospective analysis of emergent abdominal operations in this paraplegic and quadriplegic population is lacking. The overall number of emergency general surgery operations performed is small compared with elective cases, and historically, these emergent cases are spread over a variety of specialties and centers. With the growing number of dedicated emergency general surgeons and the focus on emergent general surgery as a specific specialty, there will likely be more uniform data and management algorithms moving forward. These changes will help to centralize and standardize data collection and ultimately potentially allow for a more robust multicenter prospective analysis.

Stemming from the inherent bias of a retrospective study using a large volume database, this study has some important limitations. Most importantly, abdominal surgical emergencies are rare problems in an already small patient population, and the etiology of the emergency and degree of illness on presentation can be quite varied. It is, therefore, difficult to identify large, comparable populations. We chose to match our paraplegic and quadriplegic patients with similarly ill controls to generate the most meaningful comparison; however, this matching also introduces an element of bias that could potentially affect results. In addition, our data show an increased preoperative hospital length of stay in the PARA patients. Although there are several potential explanations for this, including system issues or new onset of disease, we assert that this increased preoperative hospital length of stay is likely caused by delayed diagnosis. This is supported by the increase in severity of presentation of PARA patients. Despite matching, PARA patients were more likely to have sepsis on admission and infected wounds at operation, both markers of more advanced disease. Although similar trends were noted in the QUAD patients, the statistical differences were often not as profound, likely secondary to the smaller sample size. These conclusions would benefit from a more detailed, prospective analysis.

This report is, to our knowledge, the first contemporary large-volume multicenter outcome analysis of the spinal cord injury patient requiring emergency general surgery intervention. These data identify this patient population as a high-risk population with likely delayed presentation and/or diagnosis resulting in increased rates of sepsis and shock on admission, increased likelihood of an infected field at operation, and potentially increased complication and sepsis rates postoperatively.

CONCLUSION

These data suggest that spinal cord injury patients with emergency abdominal surgical conditions present at a more advanced stage, are sicker, and have worse outcomes. These data support identification of an at-risk patient population that requires increased awareness, clinical vigilance, liberal use of ultrasound and computed tomographic scan investigations, and possibly management augmentation to ultimately improve outcome.

AUTHORSHIP

D.D., E.B., and T.H. designed the study. T.H. and E.B. conducted the literature search. T.H. and E.K. contributed to the data collection. T.H., E.K., E.B., D.D., K.I., and L.L. analyzed the data. T.H., E.B., D.D., K.I., and L.L. contributed to the data interpretation. E.B., T.H., D.D., K.I., and L.L. wrote the manuscript. K.I. and L.L. performed critical revision.

DISCLOSURE

The authors declare no conflicts of interest.

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