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Colorectal Surgery in Patients with HIV and AIDS: Trends and Outcomes over a 10-Year Period in the USA

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Abstract
Background HIV has become a chronic disease, which may render this population more prone to developing the colorectal pathologies that typically affect older Americans. Methods A retrospective review of the Nationwide Inpatient Sample was performed to identify patients who underwent colon and rectal surgery from 2001 to 2010. Multivariate analysis was used to evaluate outcomes among the general population, patients with HIV, and patients with AIDS.

Results Hospital admissions for colon and rectal procedures of patients with HIV/AIDS grew at a faster rate than all-cause admissions of patients with HIV/AIDS, with mean yearly increases of 17.8 and 2.1 %, respectively ($p < 0.05$). Patients with HIV/AIDS undergoing colon and rectal operations for cancer, polyps, diverticular disease, and Clostridium difficile were younger than the general population (51 vs. 65 years; $p< 0.01$). AIDS was independently associated with increased odds of mortality (OR 2.11; 95 % CI 1.24, 3.61), wound complications (OR 1.53; 95 % CI 1.09, 2.17), and pneumonia (OR 2.02; 95 % CI 1.33, 3.08). Risk adjusted outcomes of colorectal surgery in patients with HIV did not differ significantly from the general population.

Conclusion Postoperative outcomes in patients with HIV are similar to the general population, while patients with AIDS have a higher risk of mortality and certain complications.

Keywords HIV. AIDS .Colorectal. Outcomes

Introduction

According to the Centers for Disease Control and Prevention (CDC), more than 1.2 million people in the USA are living with the human immunodeficiency virus (HIV).1 While the incidence of HIV has remained relatively stable over the past decade, the introduction of highly active anti-retroviral therapy (HAART) in 1995 has led to an increased prevalence of this disease.2 Patients with HIV are now living longer, and it is estimated that 25 % of the American HIV patient population is age 50 years or older.2 The increased life expectancy with modern therapy may render this population more prone to developing the benign and malignant colon and rectal pathologies that typically affect older Americans.

It is estimated that between 20 to 25 % of patients with HIV/AIDS will require an elective or emergency surgery during the course of their illness,3 a procedure which may be unrelated to their HIV/AIDS diagnosis. Therefore, surgeons may more frequently encounter patients with HIV/AIDS presenting with pathologies that require surgical intervention. To our knowledge, no population-based studies have demonstrated this trend.

Data on HIV and AIDS among surgical patients and the associated postoperative outcomes have been described in case series with conflicting results.4–13 Although there is an abundance of literature describing the outcomes of patients with HIV or AIDS undergoing anorectal surgery,14–16 little is

known about patient characteristics and outcomes of other colorectal pathologies such as colon and rectal cancer, diverticular disease, and inflammatory bowel disease.

Based on the CDC classification of HIV and AIDS,[17] we hypothesize that patients with HIV (but without an AIDS defining condition) undergoing colon and rectal operations will have outcomes similar to the general population. Patients with AIDS undergoing colon and rectal operations will have worse outcomes compared to the general population. To study these hypotheses, a large retrospective review was performed analyzing the trends and outcomes of colon and rectal operations in patients with HIV and AIDS in the USA over a decade.

Methods

Study Design

A retrospective review of the Healthcare Cost and Utilization Project-Nationwide Inpatient Sample (HCUP-NIS) database was performed. In the first part of the study, we evaluated hospital admission trends for patients with HIV and AIDS in the USA over a decade. We compared admissions for any indication to admissions for colon and rectal surgery. In the second part of the study, patients who underwent colon and rectal operations for selected indications were divided into three groups based on the presence or absence of HIV or AIDS. Patient characteristics, surgical indications, and postoperative outcomes were compared among patients with HIV, patients with AIDS, and the general population.

Study Aims

1. To analyze the trend of colon and rectal surgical procedures performed in the HIV and AIDS populations over a decade

2. To compare patient characteristics and outcomes among the general population, patients with HIV and patients with AIDS undergoing colon and rectal operations for selected indications

Patient Population

The NIS is the largest all-payer inpatient care database in the USA. It represents a 20 % stratified sample approximating 95 % of all hospital discharges across the country. Data elements within the NIS are drawn from hospital discharge abstracts, which provide information on patient characteristics, length of stay, procedures performed, postoperative morbidity, and in-hospital mortality. Approval for the use of the NIS was obtained from the institutional review board of the University of California Irvine Medical Center and the HCUP-NIS.

Inclusion Criteria

Patients who underwent colon and rectal procedures for selected disease types from 2001 to 2010 were identified using the International Classification of Diseases, Clinical Modification 9th Edition (ICD-CM-9) diagnosis and procedure codes.

The following colon and rectal disease types were included: benign colonic polyps (211.3, 230.3, V12.72), colon cancer (153.0–153.9), benign rectal polyps (211.4, 230.4, 230.5, and 569.0), anorectal cancer (154.0–154.2, 154.8), diverticular disease (562.10–562.13), inflammatory bowel disease (555.1, 555.2, 555.9, and 556.0–556.9), and Clostridium difficile colitis (008.45).

The following procedures were included: right colectomy (45.72, 45.73, 17.32, and 17.33), transverse colectomy (45.74 and 17.34), left colectomy (45.75 and 17.35), sigmoidectomy (45.76 and 17.36), partial colectomy (45.79 and 17.39), total colectomy (45.8, 45.81, and 45.82), low anterior resection (LAR) (48.4×, 48.62, and 48.63), and abdominoperineal resections (APR) (48.5×).

The patient population was divided into three groups. The first group labeled "general population" included patients without a diagnosis of HIV or AIDS. The second group labeled "HIV" included patients with the ICD-9-CM diagnosis code for "asymptomatic HIV" (V08). The third group labeled "AIDS" included patients who had the ICD-9-CM diagnosis code for AIDS (042).

Exclusion Criteria

In order to examine the effect of immunosuppression caused by HIV/AIDS, patients with a history of a transplanted organ or chronic immunosuppressive therapy were excluded from the analysis. Patients with missing ethnicity, payer type, and hospital factors data were also excluded from the analysis. The exclusion criteria were applied to the study populations as well as the "general population."

Study Variables

The variables in the study and in the adjusted multivariate regression analysis included the following:

1. Patient demographics: age, gender, and comorbidities provided by NIS and based on the Elixhauser comorbidity index[18] as well as a comorbidity score based on the Elixhauser-Van Walraven's model[19]
2. Admission type: elective vs. urgent/emergency
3. Hospital factors: teaching vs. non-teaching, urban vs. rural, small vs. medium vs. large hospitals
4. Disease types listed in the inclusion criteria
5. Procedure types listed in the inclusion criteria
6. Use of a defunctioning or end stoma performed during the index procedure (46.03, 46.1×, 46.2×)
7. Use of laparoscopy and conversion rates. Laparoscopic procedures were identified by their specific codes in the 2009–2010 data. For the 2001–2008 data, laparoscopic modifiers were used

Within the NIS database, demographic designations such as urban/rural status, hospital size, and teaching status are based on standard definitions provided by the NIS, American Hospital Association, the United States Census and the Office of Management and Budget, and specific definitions vary by year and region within the US. Hospital charges are supplied by individual hospitals and the specifics of what is reported varies by state. In general, hospital charges include all charges billed to the insurance company or patient, excluding professional fees and non-covered charges.

Endpoints

The following endpoints, chosen a priori, were studied on multivariate analysis: mortality, morbidity, anastomotic leak, wound complications, pneumonia, urinary tract infection (UTI), and length of stay. The general population was used as a reference group to which the HIV and AIDS groups were compared.

Statistical Analysis

All statistical analyses were conducted using the Statistical Analysis System (SAS), version 9.3 and the R Statistical Environment. Chi-square with Yate's correction (categorical variables) and t test with

unequal variance (continuous variables) were used for univariate analysis. Multivariate logistic regression for categorical endpoints and multivariate linear regression for continuous endpoints were used to compare endpoints between groups. Estimates of adjusted mean differences and adjusted odds ratios (OR) were obtained with 95 % confidence intervals (CI). Statistical significance was declared if $p<0.05$.

Results

A total of 2,178,983 patients who underwent colon and rectal surgeries for the indications within the inclusion criteria from 2001 to 2010 were identified. Of these cases, 5473 (0.25 %) patients had a diagnosis of HIV or AIDS. From 2001 to 2010, hospitalizations, for any indication, of patients with HIV or AIDS increased by 17.8 % with a mean yearly increase of 2.1 %. During the same period, the number of colon and rectal surgical procedures on patients with HIV or AIDS increased by 111.3 % with a mean yearly increase of 17.8 %. The difference between the mean yearly increases was statistically significant with a $p<0.01$ (Fig. 1).

Patient characteristics, ethnicity, payer type, and comorbidities are listed in Table 1. The majority of patients in the HIV and AIDS groups were males, a statistically significant difference compared to the general population ($p<0.01$). African- Americans and Hispanics were found at higher proportions in the HIV and AIDS groups ($p <0.01$). With regards to comorbidities, patients with AIDS had a worse functional status as shown by their relatively high comorbidity scores of 6.90 compared to patients with HIV and to the general population, which had comorbidity scores of 4.74 and 4.71, respectively. When examining specific comorbidities, we noted only minor differences between patients with HIV and the general population. In contrast, patients with AIDS were more likely to have anemia, weight loss, chronic kidney disease, and liver disease compared to the general population ($p<0.01$).

Patients with HIV or AIDS undergoing colon and rectal operations were younger than the general population (51 vs. 65 years; $p <0.01$). On subgroup analysis for specific diseases, this age difference persisted for all indications except inflammatory bowel disease. Patients with HIV or AIDS undergoing colon and rectal operations for cancer, polyps, diverticular disease, and C. difficile colitis were younger compared to the general population (Table 2).

Patients with HIV or AIDS were more likely to undergo colon and rectal operations in teaching rather than nonteaching hospitals (72 vs. 28 %), in urban rather than rural settings (96.44 vs. 3.56 %), and in large hospitals rather than medium and small hospitals (67.07 vs. 24.57 vs. 8.36 %). In contrast, the general population was more likely to undergo colon and rectal operations in non-teaching hospitals (55.24 %). Similar to patients with HIV or AIDS, the general population was more likely to undergo colon and rectal operations in urban hospitals (86.05 %) and large hospitals (63.34 %).

Table 3 lists the admission types, disease types, surgery types, use of stoma, use of laparoscopy, and the associated conversion rates in the three groups. Patients with AIDS were more likely to be admitted emergently compared to the general population and patients with HIV ($p<0.01$). Diverticular disease was the most common indication for surgery in the HIV and AIDS groups, whereas colon cancer was the most common indication in the general population. Rectal cancer was a more common indication for surgery in the HIV and AIDS groups compared to the general population ($p<0.01$). C. difficile colitis and inflammatory bowel disease were more common indications for surgery in the AIDS group compared to the general population and patients with HIV ($p < 0.01$). The use of laparoscopy and the use of stoma during the index operation were significantly different in the AIDS group compared to the general population and the HIV group ($p<0.05$).

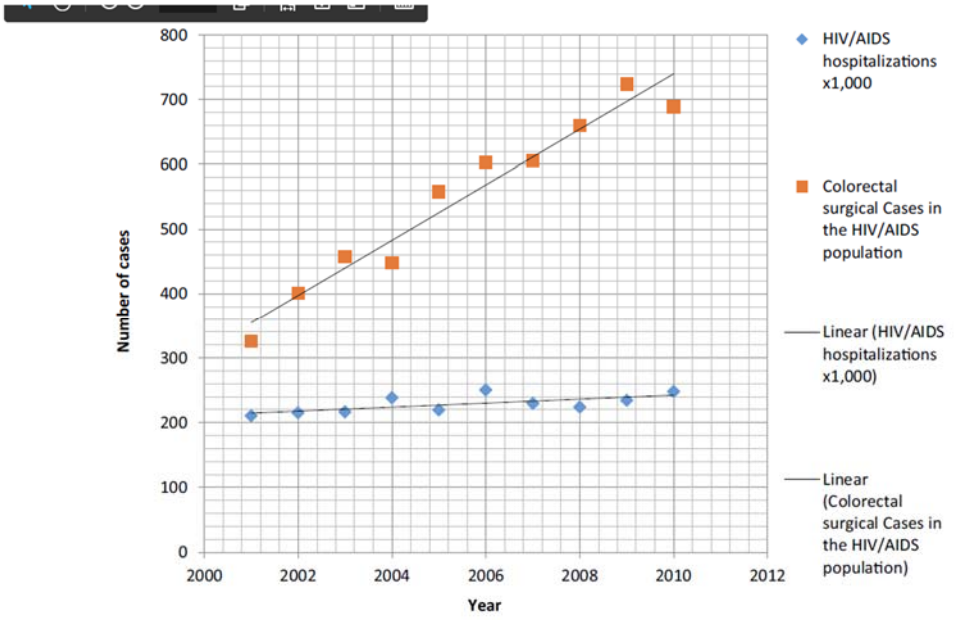

Fig. 1 Number of HIV and AIDS hospitalizations in the USA (×1000) per year and number of colorectal surgical procedures performed in the HIV and AIDS populations

Table 4 shows a univariate analysis of postoperative outcomes in the three groups. Patients with AIDS had the highest total hospital charges, statistically different than the general population and patients with HIV ($p < 0.01$). Patients with AIDS also had a longer length of stay (15 days) compared to patients with HIV (10 days) and the general population (10 days) ($p < 0.01$). Patients with AIDS had a significantly higher in-hospital mortality (5.70 %) compared to the general population and patients with HIV ($p = 0.02$). The difference in mortality between the HIV group and the general population was not statistically significant. Patients with AIDS had a higher incidence of respiratory failure, pneumonia, wound complications, and acute renal failure compared to the general population and patients with HIV ($p < 0.01$). Postoperative outcomes were not statistically different between the general population and the HIV group.

Table 5 shows a risk-adjusted analysis of selected outcomes, using the general population as a reference group. After controlling for age, gender, admission type, disease type, surgery type, use of laparoscopy, and use of stoma, we found that AIDS was independently associated with a 2.11- fold increased odds of mortality ($p < 0.05$), a 1.53-fold increased odds of wound complications, and a 2.02-fold increased odds of pneumonia ($p < 0.01$). Patients with AIDS also had a longer length of stay by 3 days compared to the general population ($p< 0.01$). There was a tendency towards higher morbidity rates in patients with AIDS compared to the general population; however, this difference did not reach statistical significance ($p = 0.08$). In contrast to patients with AIDS, the risk-adjusted outcomes of colorectal surgery in patients with HIV did not differ significantly from the general population. Finally, there were no associations between HIV or AIDS and the incidence of anastomotic leak or UTI.

Discussion

The advent of HAART has led to a marked decrease in mortality and a concomitant increase in the prevalence of HIV.2 For many patients, HIV has become a chronic disease, rather than an acute and life-threatening illness.20 Our study shows that the number of patients with HIV and AIDS undergoing colon and rectal procedures has grown significantly over the recent years. An understanding of how HIV and AIDS may impact the evaluation, management, and outcomes of these patients has become increasingly necessary within the field of colon and rectal surgery. The present work highlights the three important points. First, age at presentation of colon and rectal polyps and cancer differs significantly between patients with HIV/AIDS and the general population. This difference may indicate a need to

initiate screening at an earlier age. Second, the indications for undergoing colon and rectal surgery differ among patients with HIV or AIDS and the general population. Third, patients with HIV who are well controlled with medication tend to have surgical outcomes similar to the general population. In contrast, patients with AIDS have higher complication rates and are more likely to require emergency procedures.

Because of the chronicity of HIV, non-AIDS defining malignancies have become increasingly common in the HIV/ AIDS population.[21,22] In contrast, AIDS-defining malignancies (e.g., Kaposi Sarcoma) have decreased in incidence.[23]

Table 1 Patient characteristics in the HIV and AIDS groups compared to the general population (GP) undergoing colorectal surgical procedures

Number	GP 2,173,510	HIV 2647	AIDS 2826	*p* value
Age (years)	65 (55–76)	51 (44–58)	51 (43–57)	<0.01*
Gender				
Male	47.98	80.19	74.25	<0.01*
Ethnicity				
White	61.08	40.26	40.72	<0.01*
African-American	6.88	32.27	32.34	<0.01*
Hispanic	3.94	8.95	8.68	<0.01*
Other	2.80	3.20	2.70	0.88
Missing	25.29	15.34	15.57	
Payer type				
Private	39.48	44.73	28.74	<0.01
Medicare	51.49	27.16	37.72	<0.01
Medicaid	3.95	17.25	22.46	<0.01*
Other	4.94	10.22	10.19	<0.01*
Missing	0.15	0.64	0.90	
Comorbidities				
Anemia	15.74	15.31	20.25	<0.01**
Hypertension	46.18	34.35	36.81	<0.01*
Diabetes	15.93	13.26	12.88	0.64
Obesity	6.51	3.40	2.15	<0.01*
Weight loss	6.19	5.10	14.72	<0.01**
CHF	7.24	1.70	5.21	<0.01[a]
Valvular heart disease	4.45	1.36	2.15	<0.05*
Chronic lung disease	15.23	14.63	13.80	0.99
Chronic liver disease	1.47	9.52	12.27	<0.01*
Chronic kidney disease	3.71	6.12	10.12	<0.05
PVD	3.12	1.02	1.53	0.08
Comorbidity score[a]	4.71 (0.00–10.00)	4.74 (0.00–9.00)	6.90 (0.00–12.00)	<0.01**

Total numbers are provided in the second row. The remaining data represent percentages

CHF congestive heart failure, *PVD* peripheral vascular disease

*No statistically significant difference between HIV and AIDS

**No statistically significant difference between HIV and general population

[a] Based on the Elixhauser-Van Walraven model of comorbidity model

Table 2 Mean age of patients undergoing colon and rectal surgical procedures for the disease types considered in the analysis

Number	GP 2,173,510	HIV 2647	AIDS 2826	*p* value
C. difficile	67 (59–79)	45 (41–49)	47 (42–50)	<0.01
Colon benign polyps	65 (57–75)	54 (52–58)	55 (50–61)	<0.01
Colon cancer	70 (61–80)	53 (47–60)	54 (48–61)	<0.01
Diverticular disease	61 (50–73)	50 (42–57)	52 (43–58)	<0.01
IBD	46 (31–60)	46 (40–49)	46 (31–60)	1
Rectal polyps	64 (54–73)	N/A	32 (32–32)	<0.01
Rectal cancer	65 (55–75)	50 (44–54)	50 (43–56)	<0.01

Management of HIV must therefore include adequate access to preventative and screening studies (e.g., colonoscopy) to detect these non-AIDS defining malignancies. Patients with HIV are significantly less likely to undergo colon and rectal cancer screenings compared to the general population.24 The reasons for this disparity are not clear, although it is likely due to a combination of factors including patient, provider, and health system issues. Regardless, adequate screening for common (i.e., colorectal polyps) and specific (anal cancer) pathologies should be viewed as an important component of the national health efforts in offering access to care to this population.

Table 3 Admission type, disease type, surgery type, and use of stoma in the general population (GP), HIV pat

Number	GP 2,173,510	HIV 2647	AIDS 2826	*p* value
Admission type				
Urgent/emergency	37.27	38.34	62.28	<0.001*
Disease type				
Diverticular disease	33.49	35.46	31.14	0.55
Colon cancer	37.28	28.43	22.16	<0.01**
Rectal cancer	13.47	23.00	20.36	<0.01**
Colon benign polyps	10.65	9.90	6.29	<0.05*
Rectum benign polyps	0.12	0	0.30	1
C. difficile colitis	1.07	0.64	10.48	<0.01*
IBD	3.92	2.56	9.28	<0.01*
Use of laparoscopy	13.35	15.98	9.88	<0.05*
Conversion rates	19.40	14.00	27.27	0.64
Use of stoma	16.12	15.65	26.35	<0.001*

Total numbers are provided in the second row. The remaining data represent percentages

*No statistically significant difference between HIV and general population

**No statistically significant difference between HIV and AIDS

Based on this study and previous studies,25,26 it may be prudent to reevaluate the age at which patients with HIV or AIDS should begin colon and rectal cancer screening. Our data shows that the mean age at the time of surgery for colon cancer was 53 years in patients with HIV and 54 years in patients with AIDS, compared to 70 years in the general population. Additionally, the mean age at the time of surgery for rectal cancer in the HIV and AIDS population was 50 years for both groups, compared to 65 years in the general population. We can extrapolate from this information that patients

with HIV and AIDS are being diagnosed with colon and rectal cancer at younger ages compared to the general population. These findings are consistent with the reports from Demopoulos et al. and Yeguez et al.[25,26]

Rectal cancer was a more common indication for surgery in the patients with HIV/AIDS than for the general population. There are two possibilities to explain this result. One explanation is that patients with HIV/AIDS may have an increased risk of developing rectal cancers. However, to our knowledge, this relationship has not been clearly established.[27] An increased risk of colonic neoplasia in patients with HIV has been demonstrated previously, although this relationship is not clear either.[28] In an effort to capture low rectal cancers in our analysis, we included ICD-9 codes 154.2 and 154.8. These codes represent malignant neoplasm of the anal canal and anorectum, respectively. In the NIS, it is not possible to differentiate malignancy by histologic type. It is widely understood that there is an increased incidence of anal cancer among patients with HIV and AIDS. Therefore, our data may represent the known increased incidence of anal cancer[29] and not a true increase in the incidence of rectal cancer in this population. What is clear however is that patients with HIV and AIDS present with advanced stage neoplasm and at an earlier age.[26,30] Therefore, efforts should be made to screen them appropriately, possibly starting at age 40 years.

Table 4 Postoperative outcomes in the general population (GP), HIV patients, and AIDS patients

	GP	HIV	AIDS	*p* value
Number	2,173,510	2647	2826	
Total charge ($)	52,716 (22,473–58,011)	60,700 (28,136–72,850)	99,733 (36,821–121,952)	<0.01
Length of stay (days)	10 (5–11)	10 (5–12)	15 (7–21)	<0.01*
Mortality	3.20	1.92	5.70	0.02*
Complications				
CVA	0.14	0	0	N/A
Cardiac complications	2.28	1.92	0.60	0.16
Respiratory failure	5.70	4.79	9.88	<0.01*
Pneumonia	3.88	2.88	8.98	<0.01*
Ileus	18.11	19.81	16.17	0.54
Anastomotic leak	13.39	16.92	13.38	0.49
Acute renal failure	7.29	8.31	12.28	<0.01*
Urinary tract infection	5.31	4.15	6.89	0.37
Urinary retention	2.05	2.56	1.50	0.99
Wound complications	5.37	6.71	11.68	<0.01*
Bleeding	2.00	2.24	1.80	0.99
DVT	0.52	0.64	1.20	0.39

Total numbers are provided in the second row. The remaining data represent percentages

*No statistically significant difference between HIV and general population

Clostridium difficile colitis was the indication for surgery in 10% of the patients with AIDS. For patients with HIV and the general population, C. difficile colitis represented only a small proportion of the surgical indications: 0.64 and 1.07 %, respectively. The incidence of C. difficile diarrhea is increased in patients with AIDS compared to patients with HIV.[31,32] However, the response to medical treatment for C. difficile infection appears to be similar between the general population and patients with HIV or AIDS.[33] Therefore, the higher proportion of surgery for C. difficile in our data likely represents the higher incidence of C. difficile infection in patients with AIDS rather than a poorer response to medical management in this population.

Table 5 Risk adjusted analysis of outcomes

		OR/MD (95 % CI)	*p* value
Length of stay (days)*	HIV	+0.88 (−0.02, +1.78)	0.06
	AIDS	+3.15 (+1.98, +4.35)	<0.001
Pneumonia	HIV	0.95 (0.46, 1.97)	1
	AIDS	2.02 (1.33, 3.08)	<0.01
Wound complications	HIV	1.12 (0.71, 1.78)	1
	AIDS	1.53 (1.09, 2.17)	<0.05
Anastomotic leak	HIV	1.22 (0.87, 1.72)	1
	AIDS	0.75 (0.52, 1.07)	0.80
UTI	HIV	1.32 (0.74, 2.36)	1
	AIDS	1.29 (0.81, 2.04)	1
Overall morbidity	HIV	0.83 (0.62, 1.11)	1
	AIDS	1.29 (0.97, 1.73)	0.08
Mortality	HIV	1.35 (0.54, 3.39)	1
	AIDS	2.11 (1.24, 3.61)	<0.05

Multivariate linear regression (length of stay) and logistic regression (categorical variables) are used with the general population as the reference group

*Odds ratios and mean differences as well as *p* values were adjusted to account for multiple comparisons

Previous studies have evaluated the effects of CD4 count and HIV viral load on various abdominal surgeries, but the authors of this study are unaware of any previous studies specifically evaluating the effect of CD4 count and viral load on the outcomes of colon and rectal operations. Lower viral loads (less than 30,000 copies per milliliter) have been associated with fewer postoperative complications.[34] Lower CD4 counts have been associated with increased risk of emergency operation,[35] higher morbidity,[9,35] and higher mortality.[9,35,36] These studies, however, defined low CD4 count as less than 200, which also classifies these HIV-positive patients as having AIDS (a stratification similar to what was used in our study). Our study demonstrates that patients with HIV have postoperative outcomes that are no different than that of the general population. Patients with AIDS have higher rates of complications and mortality compared to patients with HIV and the general population. This difference may be related tooverall worse immune status in patients with AIDS. Based on our data, patients with AIDS also had higher rates of emergency operations. Postoperative outcomes after emergency operations are associated with worse morbidity and mortality.[37,38] Based on this data, we believe that HIV status should not play a factor in deciding whether to perform surgery.
However, knowing a patient's HIV status and severity of disease may help predict outcomes. This knowledge will allow for a more informed discussion and consent with this patient population prior to surgery.

There are a few limitations to this study due to its retrospective design and the inherent biases within the database. As with all database studies, coding errors may exist and can affect the accuracy of the data. The NIS database only tracks morbidity and mortality during the initial hospital stay, which may lead to an underestimation of complication rates. Furthermore, the NIS database does not track CD4 cell counts, HIV viral loads, or length of HIV diagnosis. While it would be interesting to examine the

effect of CD4 cell count and viral loads on outcomes, we relied on ICD-9 codes for HIV and AIDS to capture cases. Nevertheless, our study provides a comprehensive analysis of the postoperative outcomes of patients with HIV and AIDS undergoing colon and rectal operations.

Conclusion

Patients with HIV or AIDS undergoing colon and rectal operations represent a rapidly growing population with different demographics compared to the general population. They are prone to most colorectal pathologies at a younger age. Therefore, screening guidelines should be established, adjusting starting age, and frequency as data show that patients with HIV or AIDS are presenting with advanced disease at a younger age. Postoperative outcomes in patients with HIV are similar to the general population, while patients with AIDS have a higher risk of mortality, pneumonia, wound complications, and a longer hospital stay when compared with the general population.

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