Research Article

Postoperative Complications of Colectomy in Diabetes Patients

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Abstract

Background: In this study, we sought to determine whether Insulin Dependent Diabetes (IDDM) and Non-Insulin Dependent Diabetes (NIDDM) have different risks in comparison to non-diabetics during perioperative period of colectomy using a large national-level database.

Study Design: In our study, de-identified patients who underwent colectomy from 2012 to 2015 were selected from the American College of Surgeons National Surgical Quality Improvement Program (ACS-NSQIP) using the following CPT codes: 44140, 44141,44143, 44144, 44145, 44146, 44147, 44150, 44151, 44155, 44156, 44157, 44158, 44160, 44204, 44205, 44206, 44207, 44208, 44210, 44211, and 44212. Descriptive analysis is used to compare postoperative complication rates in each diabetes group.

Results: IDDM increased the risk of postoperative infection across all studied parameters compared to non-DM. Superficial incision SSI, deep incision SSI, and wound disruption were significantly higher in IDDM compared to non-diabetics (OR 1.39 (1.28, 1.5), 1.36 (1.16, 1.60), and 1.48 (1.27, 1.73)) respectively. IDDM was 1.85 times (1.69, 2.03) more likely to develop pneumonia and 1.66 (1.49, 1.85) times more likely to develop UTI than non-DM. Sepsis, reoperation, and readmission were also higher in IDDM patients compared to the control with an odds ratio of 1.27 (1.17, 1.38), 1.36 (1.26, 1.48), 1.52 (1.42, 1.62) respectively. NIDDM had a smaller increase in risks of superficial incision SSI, pneumonia, UTI, and readmission; however, these risks were not as high as in IDDM.

Conclusion: Clinicians should inform DM patients about their risks with colectomy and encourage them to control their DM, especially to become independent on insulin injection, to avoid these potential perioperative complications.

Keywords: Diabetes; Colectomy; Colorectal surgery; Insulin dependent diabetes; Non-insulin dependent diabetes; Perioperative complications; Perioperative infection; Surgical site infection

Abbreviations

Non-DM: without Diabetes; IDDM: Insulin Dependent Diabetes; NIDDM: Non-Insulin Dependent Diabetes; SSI: Surgical Site Infection; UTI: Urinary Tract Infection

Introduction

A careful preoperative evaluation for surgical procedures is the first step in optimizing surgical outcomes, including gathering patients' history and performing physical examination. A risks, benefits, and alternatives analysis is carried out and conveyed to patients so they can make the most informed decision of whether to proceed with the surgery. Therefore, understanding the preoperative risks is extremely important not only in the informed decision making process but also to monitor potential complications.

Diabetes, impacting 9.3% of the population in the United States, is one of the most common preoperative risk factors for poor surgical outcomes [1]. It impacts multiple organ systems in the body causing gastro paresis, chronic kidney disease, myocardial infarct, retinopathy, and limp amputation. Stress during surgery and general anesthesia causes release of stress-related hormones and inflammatory cytokines, which in turn induce hyperglycemic state by altering insulin regulation, and protein and lipid catabolism [2]. Thus, preexisting diabetes may pose a higher risk of preoperative complications compared to healthy individuals. Multiple studies report a high incidence of preoperative infections associated with poor glycemic control [3-5]. Therefore, preoperative laboratory studies and preoperative glucose control have been carefully evaluated to avoid marked blood sugar, and fluid and electrolyte imbalance.

Tsang S et al. [6] found that the Diabetes Mellitus (DM) was associated with an increased risk of Surgical Site Infection (SSI) (OR 2.04), urinary infection (OR 1.43), and lower respiratory tract infections (OR 1.95) in total hip replacement. Ata A et al. [7] found that the incidence of SSI in patients undergoing colorectal surgery was 3.8 times higher than in patients undergoing general surgery. For those patients undergoing colorectal surgery Insulin Dependent DM (IDDM) and Non-Insulin Dependent DM (NIDDM) were more likely than non-diabetics to develop SSI. For those patients undergoing general surgery, only IDDM were at increased risk.

Despite extensive research on diabetes related infections, there is limited data on the types of wound infections. Data on diabetes's

Table 1: Patient Demographics for Colectomy from 2012 to 2015.

Characteristic	IDDM	NIDDM	Non-DM
Median age (years)	67	68	61
Weight (pounds)	194	188	168
BMI	32.33	31.24	27.86
Female	49%	48%	53%

Non-DM: without Diabetes; IDDM: Insulin Dependent Diabetes; NIDDM: Non-Insulin Dependent Diabetes; Patients over 90 were grouped as 90+; therefore, the median age was used in place of mean; Weight and BMI are averages

effect in cardiac and orthopedic surgeries is abundant, however, similar data surrounding the effect of diabetes on colectomy is lacking. Therefore, we sought to determine whether IDDM and NIDDM have different risks post-colectomy in comparison to non-diabetics using a large national-level database.

Methodology

Database and study population

American College of Surgeons National Surgical Quality Improvement Program (ACS-NSQIP) collects preoperative, intraoperative, and 30-day postoperative information on a surgical patient from more than 250 participating hospitals. In our study, de-identified patients who underwent colectomy from 2012 to 2015 were selected from this database using the following CPT codes: 44140, 44141, 44143, 44144, 44145, 44146, 44147, 44150, 44151, 44155, 44156, 44157, 44158, 44160, 44204, 44205, 44206, 44207, 44208, 44210, 44211, and 44212.

All patients under the age of 18 were excluded. We collected the following variables from 2012 to 2015: diabetes status, age, gender, weight, SSI, UTI, pneumonia, sepsis, readmission, reoperation and length of stay. BMI was collected from 2013 to 2015 since height data for 2012 was not available.

We also collected variables such as indications, oral antibiotics, and postoperative leaks in a participant user file for colectomy separately. This file does not contain CPT codes and diabetes status, so we merged this file with the main file using Case ID as the fixed variable. There are cases listed in the main file that were not found in the colectomy specific file, and some of the CPT codes we used in the main data were not included (44155, 44156, 44157, 44158, 44211,

44212). Therefore, to limit data error, we used the merged data for only indications.

Variable definitions

Diabetes status is categorized into IDDM, NIDDM and non-diabetes. IDDM are those who require insulin alone or in conjunction with other non-insulin anti-diabetic agents to control their condition. NIDDM are those who take oral on-insulin anti-diabetic agents such as metformin. Patients who have never been diagnosed with diabetes or whose diabetes is controlled with diet and exercise alone are considered non-diabetes.

All postoperative variables must have occurred within 30 days of the procedure. SSI is limited to only postoperative findings and is categorized as superficial, deep, and organs/spaces. Superficial incision SSI involves the skin and subcutaneous tissue, deep incision SSI involves deep soft tissues including fascia and muscles, and organ/spaces SSI involves any anatomy manipulated during the operations other than incision site. Wound disruption indicates reopening of a previously closed wound. Reoperation indicates a second operation to correct any complications at any surgical facility or hospital within 30 days of postoperative period.

Statistical analysis

We categorized our CPT filtered data into non-diabetes, NIDDM, and IDDM. In each category, we counted the number of cases and determined their percentage for specified postoperative complications and compared them across diabetic status using chi-square tests. Age was normally distributed but age above 90 was grouped as 90+, therefore, we opted to use median for the age. Age, weight, BMI, and length of stay are compared using ANOVA tests. Indications in the merged file were analyzed in a similar way.

Results

A total of 169,325 patients were identified in the NSQIP database that underwent colectomy from 2012 to 2015. A total of 9,130 (5.39%) patients were IDDM, 14,999 (8.86%) patients were NIDDM, and 145,196 (85.75%) patients were non-diabetic. The median age of IDDM was 67, NIDDM was 68, and non-diabetics was 61 (Table 1). There was a 1:1 ratio of male to female patients who underwent colectomy despite diabetes status. Patients with IDDM weighed 26

Table 2: Postoperative outcomes in patients underwent colectomy between 2012 and 2015.

Outcomes	Non-DM	IDDM/Odds ratio*	p value (IDDM)	NIDDM/Odds ratio*	p value (NIDDM)
Superficial Incisional SSI	5.49%	7.48% 1.39 (1.28, 1.5)	P < 0.0001	6.76% 1.18 (1.10, 1.3)	P < 0.0001
Deep Incisional SSI	1.38%	1.91% 1.36 (1.16, 1.60)	P <0.0001	1.53% 1.09 (0.94, 1.25)	P = 0.2467
Organs/Space SSI	5.17%	5.63% 1.09 (0.99, 1.19)	P = 0.0738	4.78% 0.94 (0.87, 1.01)	P = 0.0952
Wound Disruption	1.39%	2.09% 1.48 (1.28, 1.73)	P < 0.0001	1.30% 0.88 (0.75, 1.02)	P = 0.0932
Pneumonia	3.14%	5.75% 1.85 (1.69, 2.03)	P < 0.0001	3.78% 1.25 (1.14, 1.36)	P < 0.0001
UTI	2.59%	4.27% 1.66 (1.49, 1.85)	P < 0.0001	3.13% 1.12 (1.01, 1.24)	P = 0.0309
Sepsis	5.42%	6.94% 1.27 (1.17, 1.38)	P < 0.0001	4.96% 0.90 (0.84, 0.98)	P = 0.0108
Reoperation	5.58%	6.83% 1.36 (1.26, 1.48)	P < 0.0001	6.03% 1.08 (1.00, 1.16)	P = 0.0388
Readmission	10.04%	14.58% 1.52 (1.42, 1.62)	P < 0.0001	11.51% 1.17 (1.10, 1.23)	P < 0.0001
Ileus	16.76%	21.89% 1.40 (1.30, 1.49)	P < 0.0001	17.85% 1.08 (1.01, 1.14)	P = 0.0152

Non-DM: without Diabetes; IDDM: Insulin Dependent Diabetes; NIDDM: Non-Insulin Dependent Diabetes; SSI: Surgical Site Infection; UTI: Urinary Tract Infection
*Odds Ratio of postoperative outcomes in IDDM or NIDDM in comparison to non-DM patients.

Table 3: Indications for colectomy procedure from 2012 to 2015.

Indications	IDDM	NIDDM	Non-DM
Colon cancer	37.45	43.95	31.89
Colon cancer with obstruction	5.2	5.04	4.8
Non-malignant polyp	9.51	11.07	8.4
Chronic diverticular disease	7.46	11.61	14.95
Acute diverticulitis	5.44	6.4	8.45
Crohn's disease	1.91	1.17	6.37
Ulcerative colitis	1.81	0.95	2.27
Bleeding	1.97	1.27	0.85
Enterocolitis (e.g. C. Difficile)	1.71	0.56	0.67
Volvulus	2.45	1.78	2.73
Other	24.91	16.03	18.43
Unknown	0.16	0.17	0.18
Total	100	100	100

Non-DM: without Diabetes; IDDM: Insulin Dependent Diabetes; NIDDM: Non-Insulin Dependent Diabetes; Indications are expressed as percentages within each diabetes category.

pounds more on average than those without diabetes, while those with NIDDM weighed 20 pounds more on average compared to those without diabetes.BMI was higher in diabetic patients than non-diabetic patients (32.33 in IDDM, 31.24 in NIDDM, and 27.86 in non-diabetes).

IDDM increased the risk of postoperative infection across all studied parameters compared to non-DM (Table 2). Superficial incision SSI, deep incision SSI, and wound disruption were significantly higher in IDDM compared to non-diabetics (OR 1.39 (1.28, 1.5), 1.36(1.16, 1.60), and 1.48 (1.27, 1.73)) respectively. IDDM was 1.83 times more likely to develop pneumonia and 1.65 times more likely to develop UTI than non-DM. Sepsis, reoperation, and readmission were also higher in IDDM patients compared to the control with the odds ratio of 1.27 (1.17, 1.38), 1.36 (1.26, 1.48), 1.52 (1.42, 1.62) respectively. NIDDM had a smaller increase in risks of superficial incision SSI, pneumonia, and UTI, and readmission, however, these risks were not as high as in IDDM.

IDDM patients stayed in the hospital 7.5 days on average while patients with NIDDM stayed in the hospital 6.0 days on average; this is slightly higher than the hospital length of stay of non-DM patients with 5.75 days on average. Sepsis was the only statistically significant parameter that appears to be lower in NIDDM than in non-DM.

Colon cancer was the most common indication for colectomy followed by diverticulitis. Interestingly, acute diverticulitis, chronic diverticulitis, and Crohn's disease were more prevalent indicators for colectomy in non-DM than DM patients. Specifically, colectomy for acute diverticulitis was done in 5.44% of IDDM patients and 8.45% of non-DM patients. 7.46% of IDDM patients underwent colectomy for chronic diverticular disease compared to 14.95% in non-DM patients. Similarly, Crohn's disease as an indication for colectomy was found in 6.37% of non-DM and 1.91% of IDDM. In contrast, colon cancer resection was more prevalent in patients with IDDM than in patients without DM. NIDDM fell between IDDM and non-DM group in term of indications (Table 3).

Discussion

Diabetes is one of the most common chronic medical co-morbidities in the United States, with a prevalence of 9.3% [2]. The diagnosis of this condition causes significant distress on patients in terms of a strict and complicated medication regimen and numerous potential complications, such as cardiovascular incidents, limp amputation, immunosuppression, chronic kidney disease, operative complications, and gastroparesis.DM causes an inflammatory response leading to decreased peripheral blood flow and angiogenesis, which in turn can hinder the healing process of surgical wounds (8). In our study, patients with IDDM had increased risks in developing superficial and deep incision SSI, wound disruption, sepsis, pneumonia, UTI, readmission, reoperation, and longer hospital stay compared to NIDDM and non-DM patients. NIDDM posed a slighter higher risk of superficial incision SSI, pneumonia, UTI, readmission, reoperation, and longer hospital stay. These risks delay patients' recovery, expose them to antibiotics and antibiotics resistance, and additional cost for the hospital stay. Readmission, reoperation, and increased length of stay are postoperative complications that are not only inconvenient to the patients but also incur substantial cost to the healthcare system as a whole. Socially, this means that DM incurs higher medical spending on colectomy than non-DM. In fact, the medical expenditure in diabetic patients is 2.3 times higher compared to non-diabetes patients [9]. It is estimated that diabetes cost the United States 245 billion dollars in 2012 [9]. Therefore, it is extremely important that healthcare providers understand these perioperative outcomes well to educate their patients on the benefits of controlling their DM. Patients do not have to be DM free to get these benefits. Our study found that achieving NIDDM from previously diagnosed IDDM can substantially lower overall perioperative outcomes. Only 5% of the diabetes is type 1 or juvenile diabetes [10]. By the time of the type 2 diabetes diagnoses, half of the insulin producing cells are destructed, which makes the patients prone to insulin dependent therapy [11,12]. According to the American College of Endocrinology and the American Association of Clinical Endocrinologists, patients with A1C greater than 9.0% or uncontrolled despite oral therapy should be on insulin regimen [13]. Therefore, patients with morbidly uncontrolled DM should target their A1C first to be less than 9.0%. Its beneficial effect on perioperative outcomes of colectomy will be seen even without the complete resolution of DM.

Gastroparesis is one of the gastrointestinal complications of diabetes, occurring at 1% in type 2 diabetes and 5% in type 1 diabetes, and is tightly linked to concurrent obesity and poor glycemic control rather than the duration of the disease [14]. Our study found that IDDM was 1.4 times more likely to develop postoperative ileus compared to non-DM. This risk was not significant in NIDDM. Clinicians should be aware of this finding, and plan to provide the IDDM patients with adequate bowel regimen.

DM was associated with lower colectomy indications for acute diverticulitis, chronic diverticulitis, and Crohn's disease in our study. We have not been able to identify any studies that state that DM is protective or a risk factor for diverticulitis or Crohn's disease. Further research should be done to elucidate this correlation. Interestingly, patients with DM have delayed need for colectomy by 6-7 years in our study. This could imply that DM is in fact protective against

diverticulitis and Crohn's disease. In contrast, colon cancer indication for colectomy was more common in IDDM patients. This finding is supported by a recent study that type 2 DM is associated with 27% increased risk of colorectal cancer compared to control [15].

King JT and colleagues [16] found that postoperative glucose control rather than preoperative A1C and glycemic index affect postoperative outcomes in non-cardiac surgery. In vascular surgery, postoperative hyperglycemia was associated with a higher rate of infection in lower extremity vascular surgery, however, readmission rate was not affected by diabetic status [17]. Sehgal et al. [18] suggests that a tighter glucose control postoperatively (even less than currently recommended guideline of 200mg/dl) would reduce the risk of complications in colorectal surgery and this should be accomplished by intravenous instead of subcutaneous insulin. Our study did not specifically analyze postoperative glycemic control and outcomes; however, patients' preoperative insulin dependent status was correlated with poor postoperative outcomes. This could mean that molecular change in vasculature of chronic DM leads to poor wound healing and impaired immune response postoperatively [8]. Our finding could also imply that patients with DM generally have poor postoperative glycemic control compared to non-DM patients; therefore, they are prone to develop postoperative complications due to postoperative hyperglycemia rather than preoperative DM status. In either case, DM patients have worse outcomes than non-DM.

Our study did have limitations, one of which includes the database of choice. The ACS-NSQIP provides much data about each patient, but does not provide a holistic view of their care. Furthermore, the data only includes participating hospitals. It is likely that smaller, nonacademic hospitals are not included here. Additionally, limitation is inherent in database studies where coding error is of concern. Another limitation of our study includes the unavailability of certain variables from the database, including the missing BMI data for 2012. The merged data did not include all the CPT codes and cases as in the main data sheet. We have not been able to identify the pattern of exclusions for this colectomy specific file. Lastly, we did not have information about patients' A1C, and glycemic control preoperative and postoperatively. This information would further elucidate whether chronic uncontrolled diabetes or poor glycemic control immediately perioperative lead to poor postoperative outcomes, and what level of A1C or glucose would cause highest rate of complication. Nonetheless, we believe that the data is very valuable in stratifying risk factors of diabetes in colectomy.

Conclusion

Patients with DM, especially IDDM are more likely to develop postoperative infection, including superficial and deep incision surgical site infection, pneumonia, UTI, and sepsis post-colectomy. They also tend to have reoperation, readmission, postoperative ileus, and longer hospital stay compared to non-DM. Therefore, clinicians should not only inform DM patients about their risks with colectomy but also encourage them to control their DM, especially to become independent on insulin injection, to avoid these potential perioperative complications.

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