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Risk Factors of Postoperative Myocardial Infarction after Colorectal Surgeries

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There are limited data regarding the specific risk factors of postoperative myocardial infarction (MI) in patients undergoing colorectal resectional surgery. We sought to identify risk factors of acute MI after colorectal resection operations. The National Inpatient Sample database was used to identify patients who had postoperative MI after colorectal resection operations between 2002 and 2010. Statistical analysis was performed to identify factors predictive of postoperative MI. We sampled a total of 2,513,124 patients undergoing colorectal resection, of whom 38,317 (1.5%) sustained a postoperative MI. Patients with postoperative MI had associated 28.5 per cent in-hospital mortality. Risk factors identified include (P\0.01): history of congestive heart failure (odds ratio [OR], 8.18), chronic renal failure (OR, 3.86), age 70 years or older (OR, 3.68), peripheral vascular disorders (OR, 2.93), fluid and electrolyte disorders (OR, 2.69), emergency admission (OR, 2.56), preoperative weight loss (OR, 2.49), cardiac valvular disease (OR, 2.46), chronic lung disease (OR, 1.75), deficiency anemia (OR, 1.22), colorectal cancer (OR, 1.77), and hypertension (OR, 1.14). Postoperative MI occurs in less than 2 per cent of colorectal resections. However, patients sustaining postoperative MI are over six times more likely to die. Congestive heart failure and chronic renal failure are the strongest predictors of postoperative MI.

Postoperative myocardial infarction (MI) is one of the most important surgical complications and is associated with higher cost of treatment, longer hospital stay, and increased morbidity and mortality of patients undergoing noncardiac procedures.[1–5] Furthermore, postoperative MI with adverse long-term cardiac outcomes affects long-term survival of patients.[6] It is important to recognize and attempt to correct risk factors before operation to decrease the morbidity and mortality of these patients. In addition, creating awareness of patients at risk for postoperative MI should aid physicians in early identification and early intervention if the complication should occur.

A number of previous studies have identified risk factors influencing postoperative cardiac complication rates with the goal of controlling postoperative cardiac events. In 1977 Goldman, with a multifactorial approach, introduced nine risk factors of cardiac complication. Since then, other predictors were added to the list of predictors of postoperative cardiac complications.[7–10] Using previously identified risk factors, the American College of Cardiology/American Heart Association introduced a guideline for assessing and managing the postoperative risk from coronary artery disease associated with major noncardiac surgery in 1997.[10] This guideline was updated in 2002.[11]

The incidence of postoperative MI has been reported between 0.5 and 38 per cent in inpatient operations.[2, 4, 12] The wide variance of incidence of postoperative MI is considered to be related to the difference in the prevalence of risk factors according to the patient's pathology or procedure.[11, 13] Considering the effect of surgical procedures on postoperative cardiac complications, the American College of Cardiology/American Heart Association classified procedures into three groups.[11] Intraperitoneal surgeries are classified as surgeries with medium risk of cardiac complications with 1 to 5 per cent risk of postoperative cardiac complications.[11] However, a large nationwide study analyzing the rate of cardiac complications in colorectal surgery is lacking. Therefore, we aim to report the incidence, risk factors, and outcomes of MI in patients undergoing colorectal surgery.

Materials and Methods

This study was performed using the Nationwide Inpatient Sample (NIS) database[14] from January 1, 2002, to December 31, 2010. As a result of missing data, we could not include any information before 2002 in

the study. The healthcare cost and use project NIS is an inpatient care database in the United States with an approximately 20 per cent stratified sample of the American community, nonmilitary, and nonfederal hospitals, resulting in a sampling frame that approximates 95 per cent of all hospital discharges in the United States.[14] Approval for use of the NIS patient-level data in this study was obtained from the NIS. We evaluated patients who had undergone colorectal resections for the diagnosis of benign or malignant colorectal tumor, diverticular diseases, and ulcerative colitis using the appropriate procedural and diagnosis codes as specified by the International Classification of Diseases, 9th Revision, Clinical Modifications (ICD-9-CM). Patients who had colorectal procedures were defined based on the following ICD-9 codes (Table 1): 17.31 to 17.39, 45.71 to 45.79, 45.81 to 45.83, 48.50 to 48.52, 48.59, 48.62, and 48.63. Patients who underwent colorectal surgery without colon or rectal resection were excluded from this study, including patients with ostomy creation procedures without bowel resection resulting from lower operation time and smaller incision length. Anorectal procedures were also excluded from the study, even if they required admission to the hospital in the postoperative setting (Fig. 1). Patients' diagnosis was defined based on the following ICD-9 codes: malignant neoplasm of the colon and rectum (153.0 to 153.9, 154.0, 154.1, 230.3, and 230.4), benign neoplasm of the colon and rectum (211.3, 211.4), diverticulosis or diverticulitis of the colon (562.10 to 562.13), and ulcerative colitis (556.0 to 556.9). In-hospital postoperative acute MI was defined as the presence of postoperative acute myocardial infarction (with or without ST-elevation) defined based on ICD-9 diagnosis codes of (410.00 to 410.92).

Preoperative factors that were analyzed include patient characteristics (age, sex, and race), admission type (emergent or elective), patient comorbidities (history of peripheral vascular disorders, congestive heart failure, chronic pulmonary disease, chronic renal failure, hypertension, diabetes mellitus with or without complications, fluid and electrolyte disorders, cardiac valvular disease, deficiency anemia, chronic lung disease, obesity, chronic blood loss anemia, and weight loss more than 10% in last six months), pathologic conditions (colorectal cancer, diverticulosis or diverticulitis, ulcerative colitis, and benign colorectal tumor), surgical type (total colectomy, right colectomy, transverse colectomy, left colectomy, sigmoidectomy, multiple segmental resections of the colon, cecectomy, abdominoperineal resection of the rectum, and anterior resection of the rectum), and surgical techniques (laparoscopic vs open). The overall rate of postoperative MI after colorectal resection, and the rate of postoperativeMI by procedure type, and admission type were examined. Statistical analysis was performed to identify predictors of postoperative MI after colorectal surgery. Female gender, age younger than 70 years, black race, abdominoperineal resection of the rectum, open surgery, benign colorectal tumor, and elective admission were used as reference data points for comparison in line with the literature.[5, 7, 9, 10, 15]

Statistical Analysis

Statistical analysis was performed with SPSS software, Version 19 (SPSS Inc., Chicago, IL). Logistic regression analysis was used for in-hospital mortality. The relation between variables and postoperative MI was discovered using the x^2 test, and t test ($P < 0.05$ was considered statistically significant) and the odds ratio (OR) with a 95 per cent confidence interval was calculated to determine the effect of various preoperative factors on postoperative MI. Patients with missing data points were excluded from final analysis. Univariate and multivariate statistical analysis were conducted on unweighted numbers. Discharge weight variable in the NIS database that can estimate national discharge according to the American Hospital Association data was used to create national estimates for all analyses.[14]

Table 1. *Variables Codes According to* International Classification of Diseases, 9th Revision (ICD-9) *Codes*

Patient-specific Factors		*International Classification of Diseases, 9th Revision (ICD-9)* Code
Diagnosis	Malignant neoplasm of the colon and rectum	153.0–153.9, 154.0, 154.1, 230.3, 230.4
	Benign neoplasm of the colon and rectum	211.3, 211.4
	Diverticulosis or diverticulitis of the colon	562.10–562.13
	Ulcerative colitis	556.0–556.9
	Acute myocardial infarction	410.00–410.92
Colorectal procedures	Colon procedures	17.31–17.39, 45.71–45.79, 45.81–45.83
	Rectum procedures	48.50–48.52, 48.59, 48.62, 48.63

Results

A total of 2,513,124 patients underwent colorectal resection during 2002 to 2010. The mean age of patients was 63 years old and 37.9 per cent of the patients were 70 years old or older (Table 2); the majority of the patients were white (79.3%) and female (53.3%). Most common comorbidities included hypertension (43.9%), fluid and electrolyte disorders (23.2%), deficiency anemia (15.7%), and chronic lung disease (15.4%). Demographic data of patients are reported in Table 2. Of the patients who underwent colorectal resection, 38,317 (1.5%) had a postoperative MI. Compared with the rate of postoperative MI in elective or admitted patients (0.9%), emergent admission was associated with a nearly two times higher rate (2.3%) of postoperative MI ($P < 0.01$). The overall mean hospitalization length was 11 ± 12 days. The mean length of stay in the hospital for patients with postoperative MI was higher than patients without postoperative MI (19 ± 17 vs 11 ± 12 days, $P < 0.01$).

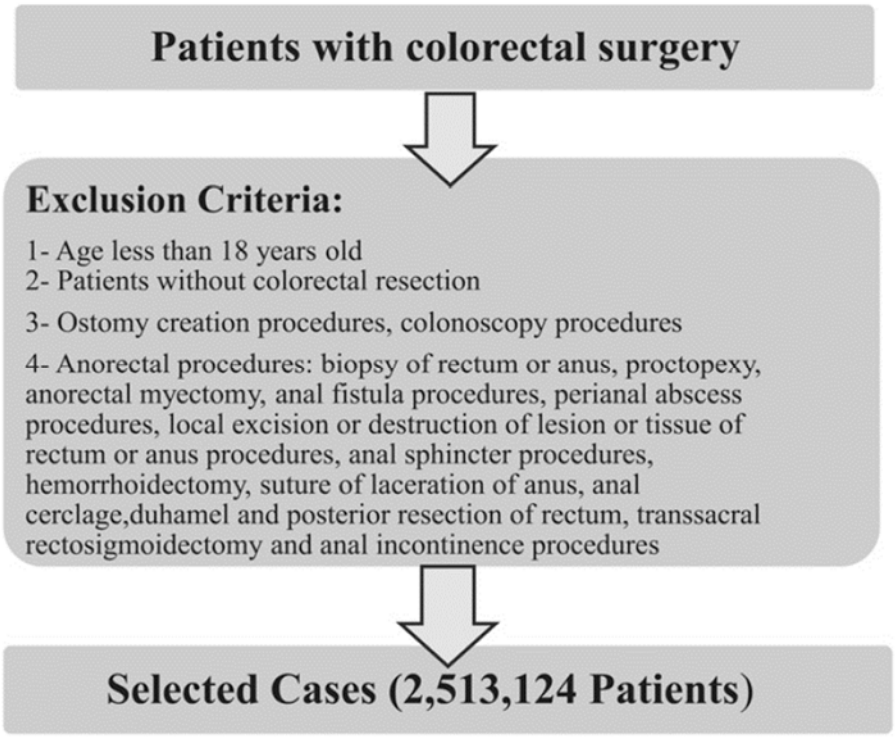

FIG. 1. Inclusion and exclusion criteria in case selection for the study.

The mortality rate in patients with postoperative MI is 28.5 *versus* 4.32 per cent for patients who did not experience postoperative MI ($P < 0.01$). When compared with patients without postoperative MI, patients who experienced postoperative MI had a higher mean total hospital charge ($146,211 *vs* $67,161; $P < 0.01$).

The risk-adjusted analysis for factors associated with postoperative MI is reported in Table 3. Patient demographic factors associated with higher mortality rate and increased postoperative MI were age 70 years or older (OR, 3.68; confidence interval [CI], 3.6 to 3.76; $P < 0.01$) and male sex (OR, 1.14; CI, 1.11 to 1.16; $P < 0.01$). Comorbidities showing higher rates of postoperative MI included congestive heart failure (OR, 8.18; CI, 8.01 to 8.36; $P < 0.01$), chronic renal failure (OR, 3.86; CI, 3.75 to 3.97; $P < 0.01$), and peripheral vascular disorder (OR, 2.93; CI, 2.83 to 3.03; $P < 0.01$). For procedure type, total colectomy (OR, 2.88; CI, 2.49 to 3.34; $P < 0.01$), multiple segmental resection of the colon (OR, 2.22; CI, 1.88 to 2.61; $P < 0.001$), and transverse colectomy (OR, 1.83; CI, 1.61 to 2.09; $P < 0.01$) were factors that resulted in higher rates of postoperative MI. Also, emergent admission (OR, 2.56; CI, 2.51 to 2.62; $P < 0.01$) and colorectal cancer (OR, 1.77; CI, 1.69 to1.86; $P < 0.01$) were independently associated with increased rate of postoperative MI. There was a statistical correlation between the age of the patients and postoperative MI as shown in Figure 2. The incidence of MI in patients younger than 50 years old is 0.2 per cent and this rate increases to 1 per cent in patients between 50 and 70 years old and reaches 2.8 per cent in patients older than 70 years ($P < 0.01$).

TABLE 2. Demographic Data of Patients undergoing Colon and Rectum Surgery in the United States, 2002–2010

Patient Characteristics		All Colorectal Patients	Patients without Postoperative Myocardial Infarction	Patients with Postoperative Myocardial Infarction
Age	Mean (years)	63	63	74
	Median (years)	65	65	76
	≥70	37.9%	37.4%	68.8%
Sex	Male	46.7%	46.6%	49.9%
Race	White	79.3%	79.2%	82.7%
	Black	9.4%	9.4%	8%
	Hispanic	6.8%	6.8%	4.9%
	Asian or Pacific Islander	1.9%	1.9%	1.7%
	Native American	0.4%	0.4%	0.4%
	Other	2.3%	2.3%	2.4%
Admission	Emergency admission	44.6%	44.3%	67.1%
Comorbidities	Hypertension	43.9%	43.8%	47.1%
	Fluid and electrolyte disorders	23.2%	22.9%	44.5%
	Deficiency anemia	15.7%	15.6%	18.5%
	Chronic lung disease	15.4%	15.3%	24.1%
	Diabetes without complication	13.8%	13.8%	16.8%
	Congestive heart failure	7.9%	7.4%	39.7%
	Preoperational weight loss	7.3%	7.2%	16.1%
	Obesity	6.3%	6.3%	3.6%
	Chronic renal failure	4.4%	4.2%	14.6%
	Cardiac valvular disease	4.4%	4.3%	10.1%
	Chronic blood loss anemia	4.1%	4%	6.4%
	Peripheral vascular disorders	3.9%	3.8%	10.4%
	Diabetes with complication	1.4%	1.4%	3.2%
Procedures	Right colectomy	32.9%	32.9%	36.1%
	Sigmoidectomy	29.9%	29.9%	26%
	Left colectomy	11.3%	11.2%	14.7%
	Anterior resection of the rectum	10.3%	10.4%	7.7%
	Transverse colectomy	4.6%	4.6%	6.2%
	Cecectomy	4.9%	5%	3.8%
	Total colectomy	1.3%	1.2%	2.6%
	Abdominoperineal resection of the rectum	0.9%	0.9%	0.6%
	Multiple segmental resection of the colon	0.6%	0.6%	1%
	Laparoscopic procedures	0.5%	0.5%	0.4%
Pathology	Colorectal cancer	36.9%	37%	34.7%
	Diverticulosis or diverticulitis	21.4%	21.5%	16.4%
	Metastatic cancer	15.9%	16%	14.2%
	Benign colorectal tumor	12.1%	12.1%	7%
	Ulcerative colitis	1.3%	1.3%	1.2%

Discussion

Postoperative MI in patients after colorectal resection is associated with a poor prognosis with a significant mortality rate and increase in hospital charges and hospitalization period, which deserves specific consideration.

We found a 1.5 per cent incidence rate of postoperative MI in colorectal operations, which is in the range of 1 to 5 per cent previously reported by other studies to define medium-risk procedures.[9, 11, 16] The mortality rate of patients with postoperative MI in this study (28.8%) is higher than the overall mortality rate previously reported for noncardiac surgeries (17%) and even high-risk procedures such as vascular operations (20%).[17, 18] The fact that the mortality rate after MI is higher in patients undergoing colorectal resection compared with that reported for other operations is previously unrecognized and may be related to the subsequent or confounding effects of MI such as anastomotic leak.[19] Kang et al.,[19] in an evaluation of 72,055 patients who underwent rectal surgery, observed that cardiac complications were associated with an increased chance of anastomotic leak and mortality.

Patients with postoperative MI have higher hospitalization length. The overall mean hospitalization length for colorectal resection patients was 11 days and this is in line with the previously reported 10-day

hospitalization length for patients with bowel resection by Pritts.[20] Also, our results show postoperative MI increases hospitalization length of patients by nearly two times.

Using the power of the large NIS database, this study identified significant predictors of postoperative MI for colorectal resection operations that could change the preoperative criteria for cardiac risk assessment. The most significant predictors were: patient-specific factors (age 70 years or older), comorbidities (congestive heart failure, chronic renal failure, peripheral vascular disorders, chronic pulmonary disease, diabetes mellitus, fluid and electrolyte disorders, anemia, cardiac valvular disease, and weight loss), procedures (transverse colectomy, multiple segmental resection of the colon, and total colectomy), pathology (colorectal cancer), and admission type (emergent admission). Also this study confirmed the previously reported risk factors of postoperative MI of age 70 years or older, diabetes, congestive heart failure, cardiac valvular disease, diabetes, peripheral vascular disorders, hypertension, and chronic renal failure as significant risk factors of postoperative MI.[3, 7–9, 11] Although Kheterpal[7] introduced obesity as a risk factor of postoperative cardiac complications, we were unable to confirm obesity as a risk factor in patients undergoing colorectal resection.

Considering data on patient-specific factors, we found that age 70 years or older is a very significant predictive risk factor of MI in colorectal surgery, male gender and white race were lesser risk factors of MI. This is in line with the literature.[5, 7, 9, 21] Lee et al.[9] in evaluation of 4315 patients who underwent major noncardiac surgeries reported male gender and age 70 years or older increase the risk of postoperative MI. A systematic review of patients' comorbidities before surgery is appropriate. Some of the risk factors introduced in this study (preoperative weight loss, peripheral vascular disorders, and fluid and electrolyte disorders) are more potent predictors of MI than some previously identified risk factors such as hypertension and diabetes.[11] Control of hypertension, chronic lung disease, congestive heart failure, chronic renal failure, anemia, and diabetes in elective operations may reduce risk of postoperative MI and should be given due consideration before treatment. Correctable factors such as correction of electrolyte imbalances and anemia may also decrease the chances of postoperative MI in the high-risk patient. Preoperative optimization of patients with the mentioned correctable risk factors should be a priority to improve postoperative outcomes.

Our data confirm that diabetes increases the risk of postoperative MI, particularly in the presence of diabetes complications where the risk of postoperative MI increases more than twofold. This is in line with the literature.11 This study also confirms the previous report of anemia as a risk factor of postoperative MI by Hogue.[22] Effect of type of the surgery as a predictor of postoperative MI has been reported in several previous studies. High incidence rates of postoperative MI have been reported for major vascular operations. Our data show that there is an obvious correlation between different colon procedures and postoperative MI. Patients who had total colectomy had the highest risk of postoperative MI with an odds ratio of 2.88 in comparison to other procedures. The risk decreases in smaller procedures (left colectomy) and in cecectomy procedures, there is no correlation regarding postoperative MI. Therefore, more major colon procedures need specific consideration regarding postoperative MI. Surprisingly, rectal procedures have lower risk of postoperative MI compared with colon procedures. This can perhaps be related to incision site and size differences between colon procedures and rectum procedures. The higher rates of respiratory complications in procedures with upper abdominal incisions compared with lower abdominal incisions have been previously documented in the literature.[23] Further studies are indicated to see if there is an association between the site/size of the abdominal incision and postoperative MI.

Our data confirm that presence of colorectal cancer increases the risk of postoperative MI. We confirmed previous reports have demonstrated a correlation between diagnosis of malignancy and postoperative MI.[24] Our data show that emergency admission significantly increases the risk of postoperative MI. The American College of Physicians also identifies emergency surgery as a predictor of postoperative MI.[10] Because of the limitations of our data, we could not discern emergency versus nonemergency operation in patients with emergency admission; however, there is an obvious correlation between emergency admission and postoperative MI.

Our data show that open procedures are associated with an increased rate of postoperative MI compared with laparoscopic procedures (Table 3). Also, laparoscopic procedures have been observed to result in lower mortality, lower charges, shorter hospital stay, and decreased respiratory failure compared with open procedures in patients undergoing colorectal surgery.[25]

TABLE 3. Predictors of Postoperative Myocardial Infarction in Colon and Rectal Surgery

Patient-specific Factors		*P* Value	Odds Ratio	95% Confidence Interval
Age	<70 years	Reference	Reference	Reference
	≥70 years	<0.0001	3.68	3.60–3.76
Sex	Female	Reference	Reference	Reference
	Male	<0.0001	1.14	1.11–1.16
Race	Black	Reference	Reference	Reference
	White	<0.0001	1.22	1.17–1.28
Comorbidity	No comorbidities	Reference	Reference	Reference
	Congestive heart failure	<0.0001	8.18	8.01–8.36
	Chronic renal failure	<0.0001	3.86	3.75–3.97
	Peripheral vascular disorders	<0.0001	2.93	2.83–3.03
	Fluid and electrolyte disorders	<0.0001	2.69	2.64–2.75
	Preoperational weight loss	<0.0001	2.49	2.42–2.56
	Cardiac valvular disease	<0.0001	2.46	2.38–2.54
	Diabetes with complication	<0.0001	2.33	2.20–2.47
	Chronic lung disease	<0.0001	1.75	1.71–1.79
	Chronic blood loss anemia	<0.0001	1.58	1.52–1.65
	Diabetes without complication	<0.0001	1.26	1.22–1.29
	Deficiency anemia	0.0001	1.22	1.19–1.25
	Hypertension	<0.0001	1.14	1.11–1.16
	Obesity	<0.0001	0.54	0.51–0.57
Procedures	Abdominoperineal resection of the rectum	Reference	Reference	Reference
	Total colectomy	<0.0001	2.88	2.49–3.34
	Multiple segmental resection of the colon	<0.0001	2.22	1.88–2.61
	Transverse colectomy	<0.0001	1.83	1.61–2.09
	Left colectomy	<0.0001	1.76	1.55–2
	Right colectomy	<0.0001	1.53	1.34–1.75
	Sigmoidectomy	0.012	1.17	1.03–1.33
	Cecectomy	>0.05	1.05	0.91–1.20
	Anterior resection of the rectum	>0.05	1.002	0.87–1.14
Pathology	Benign colorectal tumor	Reference	Reference	Reference
	Colorectal cancer	<0.0001	1.77	1.69–1.86
	Ulcerative colitis	<0.0001	1.61	1.46–1.78
	Diverticulosis or diverticulitis	< .0001	1.32	1.26–1.39
Admission type	Elective	Reference	Reference	Reference
	Emergent	0.0001	2.56	2.51–2.62
Procedure type	Laparoscopic	Reference	Reference	Reference
	Open	<0.0001	1.42	1.20–1.68

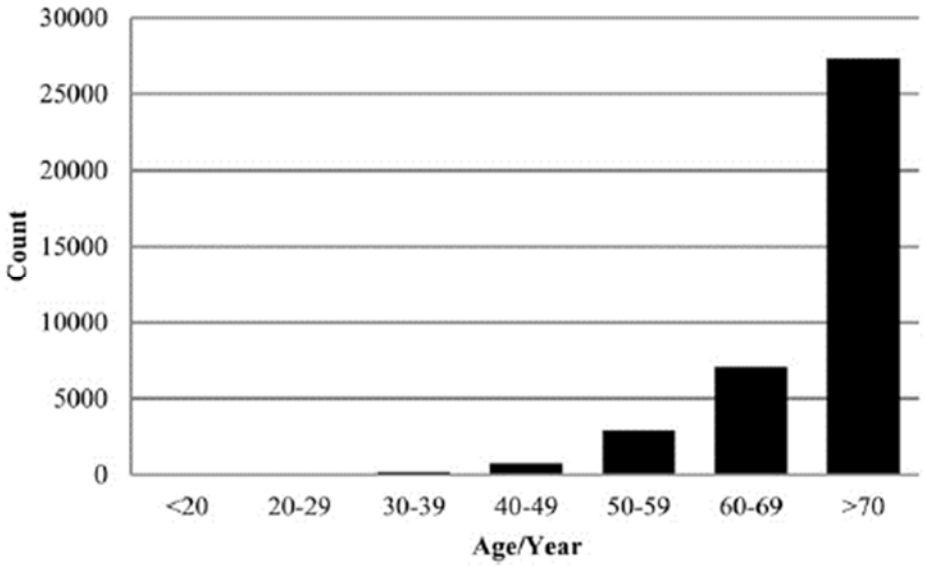

FIG. 2. Distribution of age in patients with postoperative myocardial infarction (MI).

Study Limitations

This study is a large retrospective review and is therefore subject to typical inherent biases for retrospective studies. The NIS is an inpatient care database that collects information from over 1000 hospitals and surgeons in the United States and there is a wide variety in hospital settings and surgeons' expertise that can affect the study. Data in this study were extracted from the NIS database and we do not have data beyond the index hospital admission. We lack outpatient follow-up data on myocardial events, which may have occurred in the 30-day postoperative period after discharge from the hospital. We do not have intraoperative factors (i.e., blood loss and operative time) that can predict postoperative MI.[11] Although an admission may be designated as emergent/emergent, we cannot discern if this equates to an urgent/emergent operation. Despite these limitations, this study is the first to report on postoperative MI in colorectal resection procedures specifically in this population subset.

Conclusion

Colorectal resection complicated by postoperative MI is uncommon (incidence rate of 1.5%) but carries an associated mortality rate of 28.5 per cent. We identified 12 significant predictors of MI for colorectal operations. Also, we identified correctable risk factors that could change the preoperative workup for the cardiac risk assessment and that could affect outcomes of the operations and should be considered before any colorectal procedure (anemia, preoperative weight loss, and fluid and electrolyte abnormalities). Age is an independent predictor of postoperative MI after colorectal resection. Major colon procedures such as total colectomy carry a higher relative risk of postoperative MI compared with other segmental colon procedures. There is a statistical correlation between diagnosis of malignancy and postoperative MI. Open procedures are associated with increased risk of postoperative MI compared with laparoscopic procedures in colorectal surgery.

Disclosure

REFERENCES

1. Maia PC, Abelha FJ. Predictors of major postoperative cardiac complications in a surgical ICU. Rev Port Cardiol 2008;27: 321–8.
2. Priebe HJ. Triggers of perioperative myocardial ischaemia and infarction. Br J Anaesth 2004;93:9–20.
3. Mangano DT. Perioperative cardiac morbidity. Anesthesiology 1990;72:153–84.
4. Lee TH, Thomas EJ, Ludwig LE, et al. Troponin T as a marker for myocardial ischemia in patients undergoing major noncardiac surgery. Am J Cardiol 1996;77:1031–6.
5. Gilbert K, Larocque BJ, Patrick LT. Prospective evaluation of cardiac risk indices for patients undergoing noncardiac surgery. Ann Intern Med 2000;133:356–9.
6. Mangano DT, Browner WS, Hollenberg M, et al. Long-term cardiac prognosis following noncardiac surgery. The Study of Perioperative Ischemia Research Group. JAMA 1992;268:233–9.
7. Kheterpal S, O'ReillyM, Englesbe MJ, et al. Preoperative and intraoperative predictors of cardiac adverse events after general, vascular, and urological surgery. Anesthesiology 2009;110:58–66.
8. Detsky AS, Abrams HB, McLaughlin JR, et al. Predicting cardiac complications in patients undergoing non-cardiac surgery. J Gen Intern Med 1986;1:211–9.
9. Lee TH,Marcantonio ER,Mangione CM, et al. Derivation and prospective validation of a simple index for prediction of cardiac risk of major noncardiac surgery. Circulation 1999;100:1043–9.
10. Guidelines for assessing and managing the perioperative risk from coronary artery disease associated with major noncardiac surgery. American College of Physicians. Ann Intern Med 1997; 127:309–12.
11. Eagle KA, Berger PB, Calkins H, et al. ACC/AHA guideline update for perioperative cardiovascular evaluation for noncardiac surgery—executive summary: a report of the American College of Cardiology/American Heart Association Task Force on Practice Guidelines (Committee to Update the 1996

Guidelines on Perioperative Cardiovascular Evaluation for Noncardiac Surgery). J Am Coll Cardiol 2002;39:542–53.
12. Larsen KD, Rubinfeld IS. Changing risk of perioperative myocardial infarction. Perm J 2012;16:4–9.
13. Glynne D, Stanley SKR. Postoperative Myocardial Infarction. New York, NY: Springer US; 2010:199–208.
14. Nationwide Inpatient Sample HCUP. (NIS). Healthcare Cost and Utilization Project (HCUP). 2011. Rockville, MD: Agency for Healthcare Research and Quality. Accessed January 15, 2012. Available at: www.hcup-us.ahrq.gov/nisoverview.jsp.
15. Goldman L, Caldera DL, Nussbaum SR, et al. Multifactorial index of cardiac risk in noncardiac surgical procedures. N Engl J Med 1977;297:845–50.
16. Davenport DL, Ferraris VA, Hosokawa P, et al. Multivariable predictors of postoperative cardiac adverse events after general and vascular surgery: results from the patient safety in surgery study. J Am Coll Surg 2007;204:1199–210.
17. Sprung J, Abdelmalak B, Gottlieb A, et al. Analysis of risk factors for myocardial infarction and cardiac mortality after major vascular surgery. Anesthesiology 2000;93:129–40.
18. Badner NH, Knill RL, Brown JE, et al. Myocardial infarction after noncardiac surgery. Anesthesiology 1998;88:572–8.
19. Kang CY, Halabi WJ, Chaudhry OO, et al. Risk factors for anastomotic leakage after anterior resection for rectal cancer. JAMA Surg 2013;148:65–71.
20. Pritts TA, Nussbaum MS, Flesch LV, et al. Implementation of a clinical pathway decreases length of stay and cost for bowel resection. Ann Surg 1999;230:728–33.
21. Eagle KA, Brundage BH, Chaitman BR, et al. Guidelines for perioperative cardiovascular evaluation for noncardiac surgery. Report of the American College of Cardiology/American Heart Association Task Force on Practice Guidelines. Committee on Perioperative Cardiovascular Evaluation for Noncardiac Surgery. Circulation 1996;93:1278–317.
22. Hogue CW, Goodnough LT, Monk TG. Perioperative myocardial ischemic episodes are related to hematocrit level in patients undergoing radical prostatectomy. Transfusion 1998;38: 924–31.
23. Brooks-Brunn JA. Predictors of postoperative pulmonary complications following abdominal surgery. Chest 1997;111: 564–71.
24. Sherman KL, Obi SH, Aranha GV, et al. Heparin-coated stents do not protect cancer patients from cardiac complications after noncardiac surgery. Am Surg 2009;75:61–5.
25. Kang CY, Halabi WJ, Chaudhry OO, et al. A nationwide analysis of laparoscopy in high-risk colorectal surgery patients. J Gastrointest Surg 2013;17:382–91.