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Association of Postdischarge Complications With Reoperation and Mortality in General Surgery

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Objectives: To describe procedure-specific types, rates, and risk factors for postdischarge (PD) complications occurring within 30 days after 21 groups of inpatient general surgery procedures.

Design: Retrospective cohort study.

Setting: American College of Surgeons National Surgical Quality Improvement Program 2005 through 2010 Participant Use Data Files.

Patients: A total of 551 510 adult patients who underwent one of 21 groups of general surgery procedures in the inpatient setting.

Main Outcome Measures: Postdischarge complications, reoperation, and mortality.

Results: Of 551 510 patients (mean age, 54.6 years), 16.7% experienced a complication; 41.5% occurred PD. Of the PD complications, 75.0% occurred within 14 days PD. Proctectomy (14.5%), enteric fistula repair (12.6%), and pancreatic procedures (11.4%) had the highest PD complication rates. Breast, bariatric, and ventral hernia repair procedures had the highest proportions of com-

plications that occurred PD (78.7%, 69.4%, and 62.0%, respectively). For all procedures, surgical site complications, infections, and thromboembolic events were the most common. Occurrence of an inpatient complication increased the likelihood of a PD complication (12.5% vs 6.2% without an inpatient complication; $P < .001$). Compared with patients without a PD complication, those with a PD complication had higher rates of reoperation (4.6% vs 17.9%, respectively; $P < .001$) and death (2.0% vs 6.9%, respectively; $P < .001$) within 30 days after surgery; those whose PD complication was preceded by an inpatient complication had the highest rates of reoperation (33.7%) and death (24.7%) (all $P < .001$). After adjustment, PD complications were associated with procedure type, American Society of Anesthesiologists class higher than 3, and steroid use.

Conclusions: The PD complication rates vary by procedure, are commonly surgical site related, and are associated with mortality. Fastidious, procedure-specific patient triage at discharge as well as expedited patient follow-up could improve PD outcomes.

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THE IMMEDIATE POSTDISCHARGE (PD) period is a vulnerable time for patients. Nearly 1 in 7 surgical patients captured in the Medicare fee-for-service program experienced potentially preventable adverse events that precipitated a hospital readmission within a month after the index hospitalization.¹ Given the attendant clinical and economic costs to the patient and health care system, the Patient Protection and Affordable Care Act has designated the reduction of avoidable rehospitalization as a target for health care cost savings; beginning in 2013, hospitals with high risk-standardized readmission rates will be subject to a Medicare reimbursement penalty.²

To develop appropriate quality improvement interventions and potentially avoid reimbursement penalties, detailed

data describing the burden of PD complications and their association with more serious adverse events among surgical patients are essential. An analysis of the effect of PD events on hospital quality performance using the American College of Surgeons National Surgical Quality Improve-

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ment Program (ACS-NSQIP) 2006 and 2007 Participant Use Data Files showed that almost a third of postoperative complications occurred PD and that inclusion of PD events considerably affected hospital quality rankings.³ In addition to

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a combined analysis of all procedures (outpatient and inpatient, specialty and general surgery), the ACS-NSQIP investigators separately examined a limited number of procedures (breast procedures, colectomy, pancreatotomy, and abdominal aortic aneurysm repair). Their results suggested that PD events vary by procedure type and setting (inpatient vs outpatient), but these variations were not further explored; the relationship between PD events and other outcomes such as mortality also was not explored. In an analysis of mortality after inpatient procedures in the ACS-NSQIP 2005 through 2007 Participant Use Data Files, Yu et al⁴ found that a quarter of deaths within 30 days of surgery occurred PD; they did not analyze PD complications that preceded mortality.

There is growing recognition that efforts to improve quality in general surgery will require a procedure-specific understanding of processes and outcomes.⁵ To our knowledge, a comprehensive, procedure-specific analysis of rates and types of PD complications that occur among patients who undergo inpatient general surgery in the United States has not been done. In this study, we examine the frequency and types of PD complications stratified by procedure among patients who underwent 21 groups of inpatient general surgery procedures. We also evaluate the overall association between PD complications and rates of reoperation and mortality as well as risk factors independently associated with occurrence of PD complications. We hypothesize that a procedure-dependent differential risk of PD complications exists among patients undergoing inpatient procedures and that, overall, PD complications are associated with adverse events such as reoperation and mortality as well as modifiable risk factors.

METHODS

DATA SOURCE

We used data collected from up to 250 US hospitals participating in the ACS-NSQIP that were included in the Participant Use Data File from 2005 through 2010. Through record review and patient follow-up, trained surgical clinical reviewers prospectively collect data regarding preoperative and operative characteristics as well as 30-day postoperative outcomes of surgical patients captured in the database, irrespective of whether the patient is an inpatient, has been discharged home or to another facility, or has been readmitted to another hospital. A description of the structure of the ACS-NSQIP program and detailed definitions of all variables used in this study are available from the ACS-NSQIP Participant Use Data File user guide.⁶ In this study, a PD complication was defined as one for which the interval between operation and complication was greater than the interval between operation and hospital discharge.

INCLUSION CRITERIA

This study was restricted to adult patients (aged ≥ 18 years) who underwent one of 21 groups of general surgery procedures in the inpatient setting. Inpatient and outpatient procedures portend different risks and patient cohorts^{7,8}; therefore, outpatient procedures were excluded from this study. As per ACS-NSQIP protocol, inpatient vs outpatient status is assigned to each case based on the local institutional criteria for

that distinction.⁶ In this study, an inpatient procedure was defined as one designated as inpatient in the ACS-NSQIP Participant Use Data File or for which the hospital length of stay (LOS) was 1 day or longer. Patients who experienced postoperative complications for whom data regarding timing of the complication were missing (n=1239) were excluded from the study.

Primary procedures were abstracted using the *Current Procedural Terminology* code variable included in the ACS-NSQIP. To minimize the number of procedure groups without compromising clinical specificity, procedures were grouped together if their rates of PD complication were within a percentage point and grouping made clinical sense. The procedure groups used in this study were the following: (1) appendectomy; (2) cholecystectomy; (3) colectomy (colectomy with or without colostomy); (4) proctectomy (proctectomy with or without colectomy and with or without anastomosis); (5) anorectal (all other procedures involving the rectum and/or anus); (6) small bowel (small-bowel resections and/or other bowel procedures); (7) pancreas (all pancreatic resections and procedures); (8) hepatobiliary (liver resections and biliary procedures other than cholecystectomy); (9) exploratory laparotomy (exploratory laparotomy and/or lysis of adhesions); (10) bariatric procedures; (11) gastrectomy (gastrectomy with or without gastrojejunostomy and with or without vagotomy); (12) fundoplasty or paraesophageal hernia repair; (13) esophagectomy (all esophagectomies and other esophageal procedures); (14) enteric fistula repairs; (15) ventral hernia repair; (16) other abdominal hernia repairs (inguinal, umbilical, spigelian, etc); (17) spleen procedures; (18) other abdominal procedures (including retroperitoneal excisions, lymphadenectomy, and omentectomy); (19) breast (all breast procedures with or without axillary lymphadenectomy); (20) skin (debridement, incision, and drainage or soft-tissue excision); and (21) endocrine procedures (thyroid, parathyroid, with or without thymus, and adrenal procedures).

BASELINE CHARACTERISTICS OF PATIENTS

Demographic characteristics included age, sex, race, residence, and functional status prior to surgery. Comorbidities included hypertension requiring medication; diabetes mellitus; history of chronic obstructive pulmonary disease; preoperative pneumonia; cardiac comorbidities including newly diagnosed or worsening congestive heart failure within 30 days prior to surgery, myocardial infarction 6 months prior to surgery, angina, and a history of cardiac surgery or percutaneous coronary intervention; peripheral vascular disease including revascularization and rest pain; liver disease defined as ascites within 30 days prior to surgery or esophageal varices; renal dysfunction defined as acute renal failure within 24 hours prior to surgery or as dialysis dependence (≤ 2 weeks prior to surgery); history of paralysis (hemiplegia, paraplegia, or quadriplegia); altered mental status involving impaired sensorium within 48 hours prior to surgery or non-drug-induced preoperative coma; malignant neoplasm (presence of disseminated cancer or recent history of radiation therapy or chemotherapy); presence of an open wound prior to surgery; preoperative sepsis; and bleeding disorder. Operative characteristics included emergent vs nonemergent surgery, American Society of Anesthesiologists classification, operative wound classification as defined by the primary surgeon, prior operation within 30 days of the index surgery, operation time, and hospital LOS. For operation time and LOS, overall means are provided; in addition, operation time and LOS were defined as prolonged if they were greater than the calculated 75th percentile for any procedure.

Table 1. Frequency of Overall and Postdischarge Complications by Procedure and Type According to the American College of Surgeons National Surgical Quality Improvement Program 2005 Through 2010 Participant Use Data Files

Procedure ^a	Patients, No. (%) (N = 551 510)	%		
		Overall Complication Rate	PD Complication Rate	Proportion of Complications That Occurred PD
Proctectomy	6978 (1.3)	30.3	14.5	47.9
Enteric fistula repair	1985 (0.4)	36.9	12.6	34.2
Pancreas	16 574 (3.0)	35.4	11.4	32.2
Colectomy	94 057 (17.1)	27.7	10.6	38.3
Small bowel	49 684 (9.0)	29.4	10.2	34.7
Hepatobiliary	13 073 (2.4)	24.9	9.7	39.1
Ventral hernia repair	26 881 (4.9)	15.2	9.4	62.0
Other abdominal	10 405 (1.9)	23.5	9.1	38.6
Spleen	3985 (0.7)	22.7	8.6	37.7
Gastrectomy	16 304 (3.0)	27.9	8.3	29.9
Exploratory laparotomy	22 300 (4.0)	28.5	8.0	28.0
Skin	6592 (1.2)	20.6	7.5	36.5
Esophagectomy	4094 (0.7)	28.9	6.0	20.6
Breast	32 979 (6.0)	6.3	5.0	78.7
Anorectal	9612 (1.7)	9.7	4.9	50.3
Other hernia repair	20 433 (3.7)	8.3	4.5	54.6
Appendectomy	59 378 (10.8)	6.9	4.1	59.9
Cholecystectomy	54 242 (9.8)	8.1	4.1	51.1
Bariatric	62 327 (11.3)	5.8	4.0	69.4
Fundoplasty	11 458 (2.1)	7.8	3.2	40.9
Endocrine	28 169 (5.1)	3.2	1.5	47.3
All procedures	551 510 (100)	16.7	6.9	41.5

Abbreviation: PD, postdischarge.

^aProcedures are arranged in decreasing order of PD complication rate.

OUTCOMES

Occurrence of any PD complication was the primary outcome of interest; its association with reoperation and mortality within 30 days of surgery was examined. All 21 types of complications captured in the ACS-NSQIP Participant Use Data File were analyzed. Complications were categorized as surgical site related (superficial, deep, and organ space and dehiscence); infectious (pneumonia, urinary tract infection, and severe sepsis or shock); venous thromboembolism (pulmonary embolism and deep venous thrombosis or thrombophlebitis); respiratory (reintubation and prolonged ventilator use >48 hours or failure to wean); renal (acute renal insufficiency or failure); cardiovascular (myocardial infarction, cardiac arrest, stroke, and bleeding requiring ≥5 units of blood); and other (flap, graft, or prosthesis failure, peripheral neuropathy, and coma).

STATISTICAL ANALYSIS

Bivariate analyses were performed using a 2-tailed χ^2 or *t* test for categorical and continuous variables, respectively. A multivariate logistic regression model was created to determine risk factors that were independently associated with occurrence of a PD complication. Odds ratios with 95% CIs were calculated. *P* < .05 was considered statistically significant for all analyses.

Data analyses and management were performed using SPSS for Windows version 19.0 statistical software (SPSS Inc). The ACS-NSQIP Participant Use Data File is a public database with deidentified data; therefore, this study was granted exemption by our institutional review board.

RESULTS

A total of 551 510 patients were abstracted. The mean age of the study sample was 54.6 years. Most patients were female (60.5%), white (74.4%), admitted from home (95.9%), and of independent functional status prior to surgery (92.9%). The most common procedures in the study were colectomy (17.1%), bariatric procedures (11.3%), and appendectomy (10.8%).

ANALYSIS OF PD COMPLICATIONS BY PROCEDURE AND TYPE

The overall complication rate within 30 postoperative days was 16.7%. As shown in **Table 1**, the overall rate of PD complications was 6.9%; therefore, nearly 42% of postoperative complications occurred PD. The rate of PD complications varied by procedure, ranging from 1 in 7 proctectomy patients to 1 in 67 endocrine patients. Procedures with the highest rates of PD complications were proctectomy, enteric fistula repair, and pancreatic operations. Breast surgery, bariatric procedures, and ventral hernia repair had the highest proportions of complications that occurred in the PD period.

When the relative contribution of each procedure to the overall occurrence of PD complications was analyzed, the top 10 procedures accounted for 82.5% of PD complications. The 10 procedures were (in decreasing order of relative contribution) colectomy (26.2%), small-

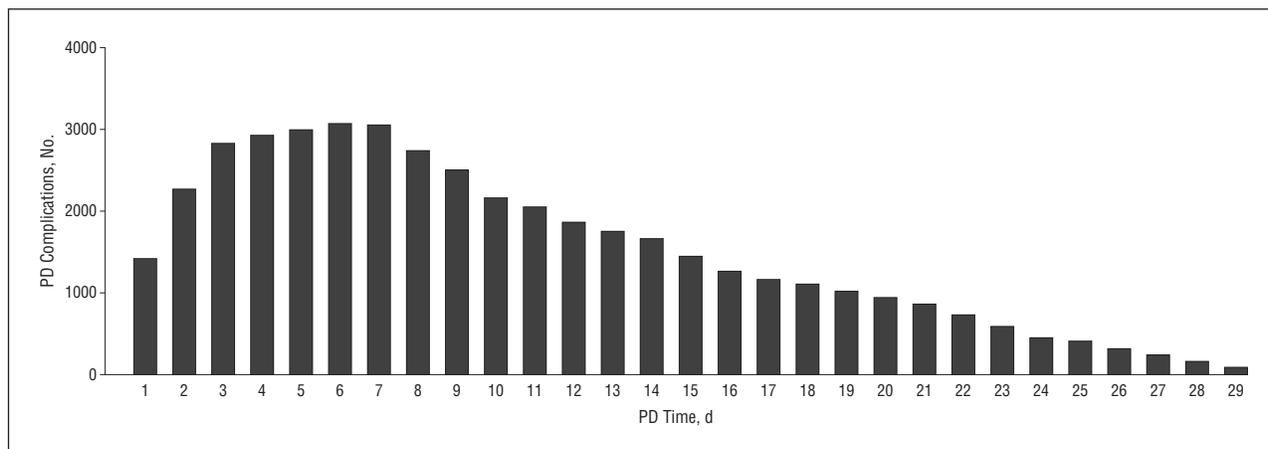


Figure 1. Frequency of postdischarge (PD) complications among general surgery patients who underwent inpatient procedures according to the American College of Surgeons National Surgical Quality Improvement Program 2005 through 2010 Participant Use Data Files.

bowel procedures (13.3%), bariatric procedures (6.6%), ventral hernia repair (6.6%), appendectomy (6.4%), cholecystectomy (5.9%), pancreatic procedures (4.9%), exploratory laparotomy (4.7%), breast procedures (4.3%), and gastrectomy (3.6%).

Overall, 25%, 50%, and 75% of PD complications occurred within 5, 9, and 14 days PD (**Figure 1**). The 10 most common complications accounted for 90.9% of all PD complications; these were superficial site infection (31.1%), organ space infection (13.9%), severe sepsis (11.4%), urinary tract infection (9.7%), deep surgical site infection (7.3%), wound dehiscence (4.7%), deep venous thrombosis (4.0%), pneumonia (3.7%), septic shock (2.7%), and pulmonary embolism (2.4%). As shown in **Figure 2**, the proportion of PD occurrence varied by type of complication; surgical site–related events encompassed the 5 complications with the highest proportions of occurrences PD. When analyzed by procedure, surgical site– and infection-related complications and venous thromboembolism accounted for most of the PD complications for each procedure (**Table 2**).

CHARACTERISTICS OF PATIENTS WHO EXPERIENCED PD COMPLICATIONS

Compared with patients who did not experience a PD complication, those who experienced a PD complication were slightly older and more often male (**Table 3**). They had slightly higher rates of diabetes, steroid use, and preoperative sepsis in bivariate analysis; they also had higher rates of American Society of Anesthesiologists class higher than 3 and had longer mean operation times (35 minutes longer) and LOS (3 days longer) (all $P < .001$).

Most patients (80.0%) who experienced PD complications did not experience a complication in the inpatient setting. Overall, the occurrence of a complication in the inpatient setting doubled the likelihood of occurrence of a complication PD (6.2% vs 12.5%, respectively; $P < .001$) (**Table 4**). The likelihood of a PD complication after experiencing an inpatient complication was particularly increased for endocrine (6.4-fold), bariatric (4.0-fold), and cholecystectomy (3.7-fold) patients.

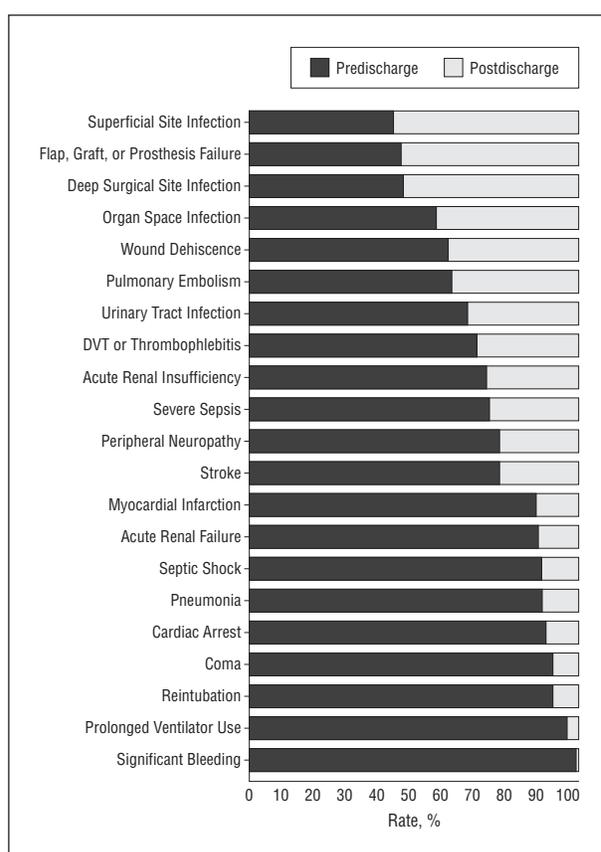


Figure 2. Pre-discharge vs postdischarge rates of complications among patients who underwent inpatient general surgery procedures according to the American College of Surgeons National Surgical Quality Improvement Program 2005 through 2010 Participant Use Data Files. DVT indicates deep venous thrombosis.

The overall reoperation and mortality rates within 30 days of surgery were 5.6% and 2.3%, respectively. Nearly 22% of deaths occurred PD, of which 29.2% occurred among patients who experienced PD complications. Compared with patients who did not experience a PD complication, those who experienced a PD complication had a more than a 3.0-fold likelihood of reoperation (4.6% vs 17.9%, respectively; $P < .001$) and death (2.0% vs 6.9%,

Table 2. Distribution of Postdischarge Complications by Procedure and Type According to the American College of Surgeons National Surgical Quality Improvement Program 2005 Through 2010 Participant Use Data Files

Procedure	PD Complication Rate	%						
		Proportion of PD Complication ^a						
		SS	Infectious	VTE	Renal	Respiratory	CV	Other
Proctectomy	14.5	73.5	31.0	3.8	4.6	1.9	1.1	0.3
Enteric fistula repair	12.6	68.1	25.9	2.0	5.6	3.2	0.8	2.4
Pancreas	11.4	64.9	32.8	8.1	1.9	4.1	2.7	0.3
Colectomy	10.6	61.9	25.7	6.8	4.3	3.0	2.3	0.4
Small bowel	10.2	63.2	25.5	5.1	3.6	2.9	2.0	0.3
Hepatobiliary	9.7	61.6	28.5	6.5	2.1	2.6	1.7	0.4
Ventral hernia repair	9.4	75.1	23.8	5.4	2.4	2.1	1.1	0.8
Other abdominal	9.1	52.5	28.6	9.7	3.8	4.0	2.4	1.6
Spleen	8.5	37.4	35.6	16.8	2.9	5.0	4.4	0.6
Gastrectomy	8.3	53.9	27.6	7.7	3.0	5.3	3.2	0.3
Exploratory laparotomy	8.0	42.7	26.8	7.0	2.1	3.1	1.9	0.2
Skin	7.5	50.1	26.7	4.0	2.8	3.4	3.4	3.0
Esophagectomy	5.9	49.4	28.4	9.1	3.7	9.9	3.7	2.1
Breast	5.0	75.9	16.5	6.1	1.0	1.1	1.7	10.1
Anorectal	4.9	54.8	34.4	4.7	3.0	3.6	3.2	0.6
Other hernia repair	4.5	50.1	34.8	7.4	3.8	4.7	4.0	0.9
Appendectomy	4.1	78.3	24.5	4.0	0.8	0.9	0.9	0.2
Cholecystectomy	4.1	53.5	32.9	7.4	4.1	4.3	4.1	0.4
Bariatric	4.0	65.1	30.2	8.4	2.9	3.1	1.8	0.6
Fundoplasty	3.2	41.4	42.2	13.6	2.2	6.3	3.8	1.1
Endocrine	1.5	28.5	48.7	11.4	5.9	7.6	4.8	3.3
All procedures	6.9	62.0	27.4	6.6	3.2	3.1	2.3	0.9

Abbreviations: CV, cardiovascular; PD, postdischarge; SS, surgical site; VTE, venous thromboembolism.

^aRows may not total 100% as some patients had multiple PD complications.

respectively; $P < .001$) within 30 days of surgery. The occurrence of an inpatient complication influenced the association between PD complications and rates of reoperation and mortality; a third of patients who experienced both inpatient and PD complications underwent reoperation, and a quarter died within 30 days of surgery (**Figure 3**).

After adjusting for more than 20 risk factors in multivariate analysis, procedure type, in-hospital factors such as a prolonged operation time and occurrence of an inpatient complication, and patient-related factors including a high American Society of Anesthesiologists class (>2) were among the factors independently associated with occurrence of a PD complication (**Figure 4**).

COMMENT

There is a paucity of data describing PD morbidity among surgical patients. Large, population-level databases such as the Nationwide Inpatient Sample and the National Hospital Discharge Survey do not capture PD complications; the generalizability of PD data derived from the Medicare fee-for-service program for patients younger than 65 years is limited. Thus, the ACS-NSQIP offers a rare opportunity to examine PD complications among surgical patients at a multi-institutional level.

To our knowledge, this is the largest study of PD complications among inpatient general surgery patients in the United States. We found that more than 40% of all postoperative complications occurred PD; approximately 1 in 14 general surgery patients who underwent an inpa-

tient procedure experienced a PD complication. Our findings confirm the results of the relatively few studies on surgical PD morbidity, which have consistently demonstrated a significant rate of PD events among their study samples; however, such studies often are complication specific or procedure specific.^{3,8-14}

Types of PD complications in this study did not vary considerably by procedure and most often were surgical site or infection related. Although superficial site and urinary tract infections may be amenable to outpatient management, other common PD complications such as dehiscence and severe sepsis are often life threatening and require readmission. Readmissions have economic implications: a recent analysis estimated a nationwide readmission cost of \$300 million annually for colorectal surgery.¹⁵ Readmissions after pancreatic resections on average cost \$16 000¹⁶; surgical site infections alone add up to \$5000 in health care costs per infection.^{17,18}

We identified potential targets for future interventions intended to improve outcomes of surgical patients in the PD period. Based on our results, particular effort should be directed toward patients who undergo procedures associated with the highest rates (proctectomy, enteric fistula repair, pancreatic procedures, colectomy, and small-bowel procedures) or proportion of PD complications (breast surgery, bariatric procedures, and ventral hernia repair). Any patient who experiences an inpatient complication should be considered at increased risk for PD events. Because PD complication risk was associated with baseline complexity of illness and potentially modifiable factors such as diabetes, obesity, and use

Table 3. Demographic, Clinical, and Operative Characteristics of 551 510 Patients Stratified by Occurrence of a Postdischarge Complication According to the American College of Surgeons National Surgical Quality Improvement Program 2005 Through 2010 Participant Use Data Files

Characteristic	%		P Value
	No PD Complication (n = 513 318)	PD Complication (n = 38 192)	
Demographic			
Age, mean (SD), y	54.3 (0.2)	58.0 (0.1)	<.001
Female	60.8	56.4	<.001
Race			<.001
White	74.2	77.3	
Black	10.6	10.5	
Other	15.2	12.2	
Prehospitalization residence			<.001
Home	96.1	94.1	
Acute care	2.5	3.6	
Chronic care	1.1	1.9	
Other	0.3	0.4	
Functional status prior to surgery			<.001
Independent	93.2	87.8	
Partially dependent	4.5	7.7	
Totally dependent	2.2	4.5	
Clinical			
Hypertension	44.2	53.5	<.001
Diabetes	13.1	18.5	<.001
Cardiac disease	8.5	12.8	<.001
PVD	1.2	1.9	<.001
COPD	4.3	7.2	<.001
Liver disease	2.0	3.6	<.001
Acute renal failure	0.7	1.8	<.001
Cerebrovascular disease	4.7	6.6	<.001
Long-term steroid use	3.8	6.9	<.001
Malignant neoplasm	5.2	8.3	<.001
Bleeding disorder	4.9	7.7	<.001
Preoperative sepsis	14.6	19.0	<.001
Operative			
ASA classification			<.001
<3	52.8	38.3	
3	40.9	50.0	
4	5.9	10.8	
5	0.3	0.9	
Operative wound class			<.001
Clean	26.1	16.9	
Clean contaminated	50.5	54.2	
Contaminated	13.1	14.4	
Dirty	10.4	14.5	
Prior surgery in ≤30 d	3.0	4.6	<.001
Operation time			
Mean, min	128.0	162.6	<.001
Prolonged, >75th percentile	24.1	33.5	<.001
Length of stay			
Mean, d	6.5	9.4	<.001
Prolonged, >75th percentile	20.0	29.5	<.001

Abbreviations: ASA, American Society of Anesthesiologists; COPD, chronic obstructive pulmonary disease; PD, postdischarge; PVD, peripheral vascular disease.

of steroids, our findings could facilitate identification of patients at increased risk and allow for targeted preventive interventions.

A number of strategies could decrease the likelihood of PD complications. We found that a prolonged opera-

Table 4. Association Between Occurrence of Inpatient and Postdischarge Complications According to the American College of Surgeons National Surgical Quality Improvement Program 2005 Through 2010 Participant Use Data Files

Procedure	PD Complication Rate, %		P Value
	No Preceding Inpatient Complication (n = 489 901)	≥1 Inpatient Complication (n = 61 609)	
Proctectomy	14.9	12.9	.07
Enteric fistula repair	13.9	9.2	.006
Pancreas	11.3	11.5	.78
Colectomy	10.0	13.0	<.001
Small bowel	9.8	11.6	<.001
Hepatobiliary	8.6	14.8	<.001
Ventral hernia repair	8.9	16.7	<.001
Other abdominal	8.4	12.4	<.001
Spleen	7.3	14.7	<.001
Gastrectomy	7.3	12.0	<.001
Exploratory laparotomy	6.4	13.8	<.001
Skin	7.0	10.7	<.001
Esophagectomy	5.1	8.3	<.001
Breast	4.9	11.6	<.001
Anorectal	4.6	10.4	<.001
Other hernia repair	4.1	13.4	<.001
Appendectomy	4.0	8.8	<.001
Cholecystectomy	3.7	13.5	<.001
Bariatric	3.8	15.1	<.001
Fundoplasty	2.9	9.2	<.001
Endocrine	1.4	8.9	<.001
All procedures	6.2	12.5	<.001

Abbreviation: PD, postdischarge.

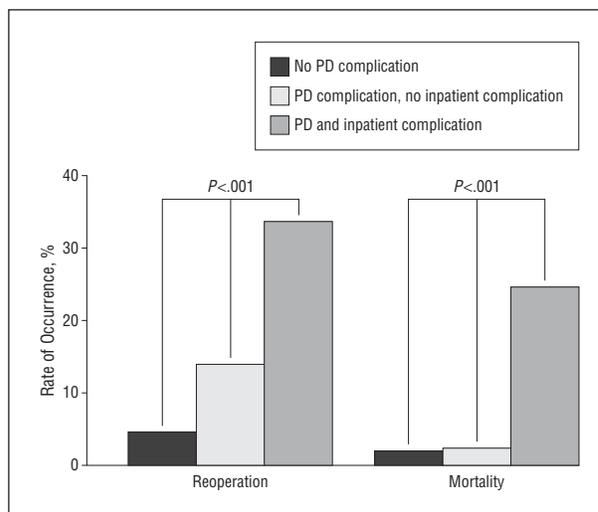


Figure 3. Reoperation and mortality rates stratified by occurrence of a postdischarge (PD) complication according to the American College of Surgeons National Surgical Quality Improvement Program 2005 through 2010 Participant Use Data Files. The mortality rate among patients who experienced inpatient but not PD complications was 12.6%.

tion time and occurrence of an inpatient complication increased the risk of a PD complication. Regenbogen et al¹⁹ showed that intraoperative surgical Apgar scores—a metric derived from intraoperative estimated blood loss, lowest mean arterial pressure, and lowest heart rate—correlate linearly with the likelihood of PD complica-

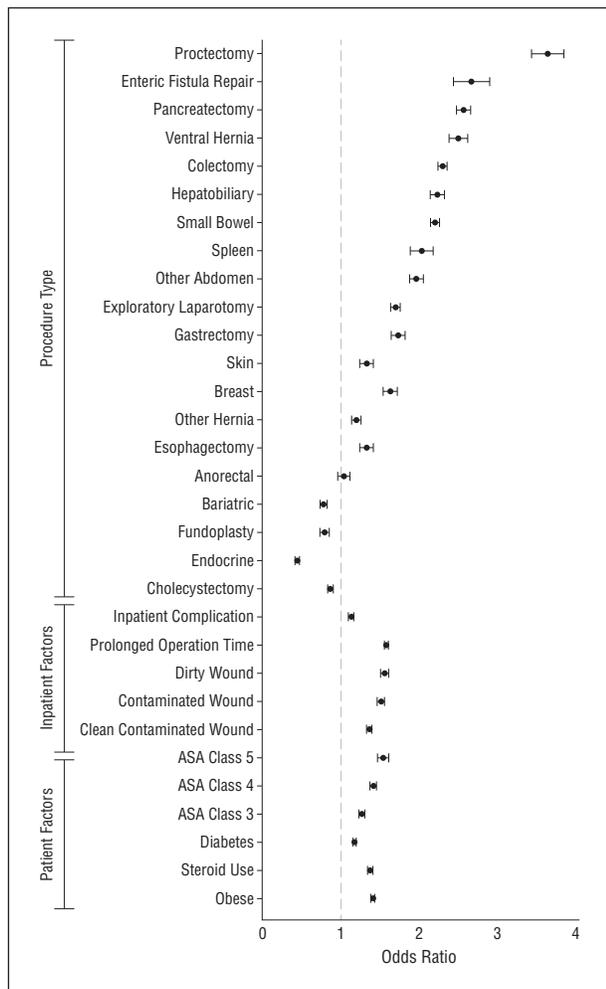


Figure 4. Multivariate analysis of factors independently associated with occurrence of a postdischarge complication according to the American College of Surgeons National Surgical Quality Improvement Program 2005 through 2010 Participant Use Data Files. The multivariate model adjusted for more than 20 risk factors. The reference groups were American Society of Anesthesiologists (ASA) class lower than 3; operative wound classification of clean; procedure type of appendectomy; and, for all other references, no or not present. Error bars indicate 95% CIs.

tions after colorectal surgery. These results support efforts to prevent PD complications that start preoperatively with refined patient selection and optimization of their comorbid conditions and continue in the operating room with fastidious surgical technique.

Patient-centered education regarding their continued clinical vulnerability after hospital discharge and focused counseling on proper wound care to prevent surgical site infections could curtail the occurrence of PD complications; complex, obese, diabetic patients as well as those on steroid therapy are in particular need of attention. Aggressive ambulatory measures and evidence-based venous thromboembolism prophylactic therapy of at-risk patients could minimize occurrence of venous thromboembolism after discharge. The far-reaching potential of telemedicine has implications for efforts to improve PD care; for instance, the utility of digital applications already being explored in plastic surgery could aid remote monitoring of impending surgical site PD complications among general surgery patients.²⁰⁻²²

This study revealed that the 2-week period after hospital discharge is a particularly vulnerable time. Jencks et al¹ showed that approximately half of patients who develop PD complications and are rehospitalized are not seen by a physician in the 30-day interval between discharge and readmission. A 58% lower readmission rate for patients who saw an outpatient health care provider after discharge was recently demonstrated in a study of elderly patients with thyroid cancer undergoing thyroidectomy.²³ After recruiting a nurse practitioner to coordinate PD patient care, an inpatient surgery service reported a 50% reduction in emergency department visits.²⁴ Another study demonstrated a 44% reduction in 30-day readmission among patients enrolled in an interactive PD telemonitoring system.²⁵ These findings highlight the need for a triage system geared toward early, methodical, and cost-effective PD follow-up that takes into consideration the index surgical procedure, baseline demographic and clinical factors, and in-hospital events. Such a system may involve a checklist-aided discharge process and centralized electronic record keeping along with multifaceted recruitment of ancillary health care providers such as visiting nurses and expedited PD appointments with primary caregivers.

Limitations of this study include possibility of coding errors in the ACS-NSQIP Participant Use Data File; however, the ACS-NSQIP has been validated.²⁶ Markers of severity of illness and complications are not captured in the database; as such, it was impossible to explore the potential role of “early” hospital discharges on our results. Information on discharge destination, patient follow-up, readmission, long-term outcomes, health care provider volume, and hospital-level and cost-of-care-related data is not included in our study period; thus, assessment of the relative clinical and economic relevance of inpatient vs PD complications was not performed. The database does not specify the timing of reoperation, so it was impossible to examine whether reoperations were pre-discharge events that represent a potential risk factor for PD complication or were PD events that represent a potential outcome of PD complications. A cause and effect relationship between PD complications and reoperations or mortality cannot be deduced. Complication rates may have been underestimated, as complications such as anastomotic leak, ileus, bowel obstruction, dehydration, and postoperative metabolic disturbances are not captured in the database. The strengths of this study include its multi-institutional nature, large sample size, and analyses of several general surgery procedures, all of which attenuate bias related to patient, procedural, and health care provider factors.

In summary, our analysis revealed that PD complications account for a significant burden of postoperative complications and are an important avenue for quality improvement in inpatient general surgery. More research is needed to develop and explore the utility of a cost-effective and fastidious PD follow-up system for surgical patients. Often excluded from databases, these data underscore the need for systematic collection of PD adverse event data to improve postoperative surgical care in the United States.

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Online-Only Material: Listen to an author interview about this article, and others, at <http://bit.ly/L4By6t>.

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INVITED CRITIQUE

Publication of Postdischarge and Readmission Complications

Failure, Folly, or Funding Opportunity?

Good surgeons know when to operate, who to treat conservatively, and how to minimize morbidity. Great surgeons manage complications expediently and well. Every surgeon will read the article by Kazaure et al¹ with interest as complications are the statistics that define us all. They are

increasingly used as quality metrics and will soon carry punitive remunerative consequences from health care insurers. More than one-third of complications arise after discharge and relate mainly to the general patient condition and the specific operative event (ie, classifiable but not remediable variables). There are