Adhesive Bowel Obstruction Following Urologic Surgery: Improved Outcomes with Early Intervention

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Key Words
Intestinal obstruction • Cystectomy • Prostatectomy • Nephrectomy • Longitudinal studies

Abstract

Objective: To describe the long-term incidence of adhesive bowel obstruction following major urologic surgery, and the effect of early surgery on perioperative outcomes.

Methods: The Healthcare Cost and Utilization Project State Inpatient Databases for California and Florida (2006–2011) were used to identify major urologic oncologic surgery patients. Subsequent adhesive bowel obstruction admissions were identified and Kaplan-Meier time-to-event analysis was performed. Early surgery for bowel obstruction was defined as occurring on-or-before hospital-day four. The effects of early surgery on postoperative minor/moderate complications (wound infection, urinary tract infection, deep vein thrombosis, and pneumonia), major complications (myocardial infarction, pulmonary embolism, and sepsis), death, and postoperative length-of-stay were assessed. Results: Major urologic surgery was performed on 104,400 patients, with subsequent 5-year cumulative incidence of adhesive bowel obstruction admission of 12.4% following radical cystectomy, 3.3% following kidney surgery, and 0.9% following prostatectomy. During adhesive bowel obstruction admission, 71.6% of patients were managed conservatively and 28.4% surgically. Early surgery was performed in 65.4%, with decreased rates of minor/moderate complications (18 vs. 30%, \(p = 0.001\)), major complications (10 vs. 19%, \(p = 0.002\)), and median postoperative length of stay (8 vs. 11 days, \(p < 0.001\)) compared with delayed surgery. On multivariate analysis early surgery decreased the odds of minor/moderate complications by 43% (\(p = 0.01\)), major complications by 45% (\(p = 0.03\)), and postoperative length of stay by 3.1 days (\(p = 0.01\)). Conclusion: Adhesive bowel obstruction is a significant long-term sequela of urologic surgery, for which early surgical management may be associated with improved perioperative outcomes.

Introduction

Adhesive small bowel obstruction (ASBO) is a common complication following intra-abdominal surgery which leads to emergency room visits, hospital admissions, and may ultimately require surgical intervention. Despite the many advancements of modern surgery, ASBO can result in significant morbidity and mortality.
The general surgery literature reports that ASBO accounts for 20% of all acute surgical admissions, and as many as 3% of emergency surgical admissions [1, 2]. Reports of ASBO in urologic patient populations are sparse, but ASBO is a known complication of radical cystectomy (RadCx) [3–5], kidney surgery (KS) [6], and radical prostatectomy (RP) [7, 8].

Management strategies of ASBO vary, and are influenced by a host of factors including partial versus complete obstruction, signs of ischemia or perforation, duration of symptoms, time from initial surgery, and even the type admitting service [9, 10]. Historically, surgical practice routinely involved immediate surgical intervention. In the 1980s, several studies changed standard practice and demonstrated the efficacy of initial conservative management with appropriately selected patients who presented with ASBO [2, 11–14]. Urologic practice parallels that of general surgery, and conservative management has been favored in appropriately selected patients.

While early studies suggested that the duration of conservative management could extend up to 10–14 days without increased morbidity and mortality in patients who underwent delayed operative intervention [14], more recent studies suggest extended courses of conservative management could extend up to 10–14 days without increased morbidity and mortality in patients who underwent delayed operative intervention [15, 17].

The optimal timing of surgical management for urologic patients who are admitted with ASBO has yet to be described. This study aims to describe the long-term incidence of ASBO following major urologic surgery, and the effect of early operative intervention on perioperative outcomes.

### Patients and Methods

A cross-sectional, retrospective review was performed using the Health Care Utilization Project State Inpatient Database (HCUP SID) for the states of California and Florida, between years 2006 and 2011. HCUP SID includes de-identified patient discharge records for all payers, including over 100 clinical and nonclinical variables [18]. Diagnoses may be designated present on admission as of 2007, allowing differentiation of pre-existing conditions and those developing over the course of admission [19]. A unique linkage variable assigned to patients allows longitudinal follow-up after inpatient surgical admission, within the index state [20]. This study was determined to be exempt by the Loyola University Medical Center institutional review board, based on the use of publicly available, de-identified patient data.

To assess the 5-year risk of ASBO admission, patients were included if they were ≥18 years of age and underwent RP, RadCx, or KS (including radical or partial nephrectomy, or nephroureterectomy) for urologic malignancy between 2006 and 2010. A minimum of 1 year of follow-up was available for all patients using 2011 inpatient hospitalization data. Patients of interest were identified using International Classification of Diseases, Ninth Revision, Clinical Modification (ICD-9-CM) procedure and diagnosis codes. Table 1 lists the specific ICD9 codes used in this study. Other patient clinical characteristic variables are available in the HCUP SID database and used for analysis included age at admission, race (Caucasian, African American, Hispanic, and other), primary insurance provider (Medicare, Medicaid, Private, and Self-Pay), and chronic medical conditions of chronic renal insufficiency, obesity, congestive heart failure, valvular heart disease, liver disease, chronic lung disease, peripheral vascular disease, hypertension, and diabetes mellitus. Charlson Comorbidity Indices, a measure of risk of mortality secondary to medical comorbidities over time, were calculated for each patient [21].

For assessment of bowel obstruction management, admission with a diagnosis of ASBO in patients who had previously undergone urologic surgery, as above, were likewise identified. Management during the ASBO admission was considered surgical or conservative, dependent on if the patient was discharged with or without having undergone operative intervention (included surgical interventions listed in table 1). Among surgical patients, based on existing literature demonstrating improved perioperative outcomes with early surgical intervention [15, 17], patients were considered to have undergone early surgery or delayed surgery. As patients managed conservatively had a median (interquartile range) length of stay of 4 (range 3–8 days) days, surgical patients

| Table 1. ICD9 Codes |
|---------------------|
| Diagnosis/procedure | ICD9 code |
|---------------------|-----------|
| Urinary tract infection | 599 |
| Sepsis | 995.9× |
| Bladder cancer | 188.× |
| Adhesive bowel obstruction | 560.81, 560.9 |
| Surgical intervention | 17.1×, 17.2×, 43.1×, 43.5, 43.6, 43.7, 43.8×, 43.9×, 45.5×, 45.6×, 45.7×, 45.8×, 46.1×, 46.2×, 48.5×, 48.6×, 53.0×, 53.1×, 53.2×, 53.3×, 53.4×, 53.5×, 53.6×, 54.1×, 54.21, 54.5×, 53.4×, 53.5×, 53.6×, 53.9× |
| Abdominal procedures | 43.××, 44.××, 45.××, 46.××, 47.××, 48.××, 49.××, 50.××, 51.××, 52.××, 53.××, 54.×× |
| Small bowel resection | 45.5×, 45.6× |
| Myocardial infarction | 410.×× |
| Prostate cancer | 185 |
| Renal cell carcinoma | 189.× |
| Deep venous thrombosis | 453.4× |
| Pulmonary embolism | 415.1× |
| Pneumonia | 481, 482.××, 483.×, 484.×, 485, 486 |
| Nephrectomy | 55.5, 55.52, 55.54 |
| Partial nephrectomy | 55.4 |
| Nephroureterectomy | 55.51 |
| Radical prostatectomy | 60.4, 60.5 |
| Radical cystectomy | 57.71, 57.79 |
| Wound complication | 998.31, 998.32, 998.51, 998.59, 998.83 |
were considered early surgery if they underwent intervention on-or-before hospital day four, and delayed surgery if performed on day five or later.

For surgical patients, postoperative length of stay was calculated from the day of surgery to date of discharge. Additional perioperative outcomes were identified based on previously described methodologies [22], including minor/moderate complications of urinary tract infection, deep venous thrombosis, wound infection, and pneumonia; major complications of myocardial infarction, pulmonary embolism, and sepsis, as well as in-hospital mortality. Complications were identified by ICD9 codes (table 1), and excluded from analysis if present on admission. Analysis of minor/moderate and major complications was limited to ASBO hospitalization in 2007 or later, given the presence of the present on admission variable.

We performed several analytic steps. First, we used Kruskal-Wallis analysis of variance test and Chi-Square tests to compare baseline patient characteristics for continuous and categorical variables, respectively. Second, we performed a Kaplan-Meier time-to-event analysis to determine cumulative risk of ASBO following several urologic procedures. Patients were right-censored at date of death. Patients were also right-censored at the time of readmission for abdominal surgery without a concurrent diagnosis.

Table 2. Patient characteristics on admission for urologic surgery

| Patient demographics | Radical prostatectomy (n = 63,429) | Radical cystectomy (n = 7,276) | Kidney surgery (n = 33,659) |
|----------------------|-----------------------------------|-------------------------------|-----------------------------|
| Age at surgery, years, median (IQR) | 62 (57–67) | 71 (62–77) | 64 (55–73) |
| Length of stay, days, median (IQR) | 2 (1–3) | 9 (7–13) | 4 (3–6) |
| Race, n (%) | | | |
| Caucasian | 41,479 (65%) | 5,789 (79%) | 22,530 (67%) |
| African American | 5,631 (9%) | 270 (4%) | 2,242 (7%) |
| Hispanic | 7,381 (12%) | 576 (8%) | 5,271 (15%) |
| Asian | 2,250 (4%) | 260 (4%) | 1,370 (4%) |
| Other/Unknown | 6,688 (10%) | 381 (5%) | 2,282 (7%) |
| Primary insurance provider, n (%) | | | |
| Medicare | 21,097 (33%) | 4,621 (64%) | 16,281 (48%) |
| Medicaid | 1,189 (2%) | 363 (5%) | 1,848 (5%) |
| Private | 28,529 (41%) | 2,023 (28%) | 13,879 (41%) |
| Self-pay | 964 (1%) | 100 (1%) | 499 (2%) |
| Unknown | 1650 (3%) | 169 (2%) | 1,188 (4%) |
| Medical comorbidities | | | |
| Diabetes mellitus, type II | 6,606 (11%) | 1,196 (18%) | 5,934 (19%) |
| Hypertension | 28,275 (47%) | 3,988 (59%) | 16,166 (52%) |
| Chronic renal insufficiency | 941 (2%) | 705 (10%) | 3,175 (10%) |
| Congestive heart failure | 299 (1%) | 354 (5%) | 1,559 (5%) |
| Chronic pulmonary disease | 4,251 (7%) | 1,286 (19%) | 4,695 (15%) |
| Valvular heart disease | 1,030 (2%) | 288 (4%) | 1,206 (4%) |
| Liver disease | 458 (1%) | 102 (2%) | 767 (2%) |
| Peripheral vascular disease | 596 (1%) | 444 (7%) | 1,400 (4%) |
| Obesity | 3,862 (6%) | 483 (7%) | 4,026 (13%) |
| Charlson comorbidity index, median (IQR) | 2 (2–2) | 3 (2–8) | 3 (2–4) |

IQR = Interquartile range.

Fig. 1. Kaplan-Meier estimated incidence of adhesive bowel obstruction following the major urologic surgery. The 5-year cumulative incidence of adhesive bowel obstruction admission was 12.4% following RadCx, 3.3% following KS, and 0.9% following RP.
of ASBO. This step was done to subsequently assess only patients who developed ASBO after urologic surgery alone, and to exclude other intervening surgical etiologies of ASBO. We next performed univariate analysis, again using Kruskal-Wallis and chi-squared tests, to assess perioperative outcomes between early surgery and delayed surgery patients. Finally, to assess the effect of surgical timing on perioperative outcomes, a linear multivariate regression model was fit on the ASBO surgical patients and applied to postoperative length of stay, and a multivariate logistic regression model was fit and applied separately to outcomes of minor/moderate complications, major complications, and in-hospital mortality. Our goal with these models was to isolate the relationship between surgical timing (early surgery versus delayed surgery) and perioperative outcomes, rather than to create a parsimonious prediction model. As such, all covariates were included in the model regardless of statistical significance on univariate analysis.

All significance tests were two-sided, with an α of 0.05 considered statistically significant. All statistical analyses were performed using STATA version 13 (STATACorp).

**Results**

Between 2006 and 2010, 104,400 patients underwent major urologic surgery (RP, n = 63,429; RadCx, n = 7,276; KS, n = 33,695) in the states of California and Florida. Baseline patient demographics and medical co-morbidities are listed in table 2. The 5-year cumulative incidence of ASBO following major urologic surgery (without intervening abdominal surgery) was 12.4% following RadCx, 3.3% following KS, and 0.9% following RP (fig. 1). The median interquartile range days from urologic surgery to first ASBO admission varied between procedures: RadCx 192 days (range 51–417 days), KS 291 days (range 65–671 days), and RP 320 days (range 38–815 days).

During ASBO admission, 1,512/2,113 (71.6%) of patients were managed conservatively and 601 (28.4%) surgically, with early surgery performed in 393 (65.4%). Patients who received early surgery trended toward having private insurance (p = 0.056), had lower Charlson co-morbidity indices (p = 0.002), were more likely to have had prior KS (p = 0.02) and less likely to have had RadCx (p < 0.001) than delayed surgery patients (table 3). On univariate analysis, figure 2, early surgery patients had decreased rates of minor/moderate complications (18 vs. 30%, p = 0.001), major complications (10 vs. 19%, p = 0.002), and median postoperative length of stay (8 vs. 11 days, p < 0.001). There was no difference in in-hospital mortality (6 vs. 9%, p = 0.3). On multivariate analysis accounting for potentially confounding factors, early surgery remained associated with improved perioperative
Table 3. Patient characteristics on admission for adhesive bowel obstruction

| Patient demographics | Early surgery (n = 393) | Delayed surgery (n = 208) | p |
|----------------------|-------------------------|--------------------------|---|
| Age at admission, years, median (IQR) | 68 (59–75) | 69 (59–76) | 0.3 |
| Length of stay, days, median (IQR) | 10 (7–14) | 20 (15–28) | < 0.001 |
| Race | | | 0.8 |
| Caucasian | 285 (73%) | 147 (71%) | |
| African American | 33 (8%) | 22 (11%) | |
| Hispanic | 37 (9%) | 17 (8%) | |
| Asian | 26 (7%) | 13 (6%) | |
| Other/unknownb | - | - | 0.056 |
| Primary insurance providerb | | | |
| Medicare | 229 (58%) | 137 (66%) | |
| Private | 139 (35%) | 54 (26%) | |
| Medicare/self-pay/other | 25 (7%) | 17 (8%) | |
| Prior urologic procedurec | | | |
| Radical prostatectomy | 109 (28%) | 70 (34%) | 0.1 |
| Radical cystectomy | 167 (42%) | 123 (59%) | < 0.001 |
| Kidney surgery | 154 (39%) | 61 (29%) | 0.02 |
| Medical comorbidities | | | |
| Diabetes mellitus, type II | 55 (14%) | 28 (14%) | 0.8 |
| Hypertension | 227 (59%) | 109 (53%) | 0.2 |
| Chronic renal insufficiency | 88 (23%) | 55 (27%) | 0.3 |
| Congestive heart failure | 35 (9%) | 16 (8%) | 0.6 |
| Chronic pulmonary disease | 68 (18%) | 42 (20%) | 0.4 |
| Valvular heart disease | 16 (4%) | 12 (6%) | 0.4 |
| Liver disease | - | - | 0.07 |
| Peripheral vascular disease | 28 (7%) | 13 (6%) | 0.7 |
| Obesity | 22 (6%) | 12 (6%) | 0.9 |
| Charlson comorbidity index, median (IQR) | 2 (0–4) | 2 (1–6) | 0.002 |
| Outcomes | | | |
| Postoperative length of stay, days, median (IQR) | 8 (6–13) | 11 (7–17) | < 0.001 |
| Minor/moderate complication | 67 (18%) | 60 (30%) | 0.001 |
| Major complication | 37 (10%) | 38 (19%) | 0.002 |
| In-hospital mortality | 23 (6%) | 17 (9%) | 0.3 |

IQR = Interquartile range. a Values censored given Healthcare Cost and Utilization Project restrictions on publishing data with ≤ 10 patients; b Medicare/self-pay/others combined to avoid reporting data with ≤ 10 patients; c Percentages add up to over 100% as patients may have had more than one prior urologic procedure (particularly prostatectomy and cystectomy).

Table 4. Multivariate analysis. Impact of early versus delayed surgery on perioperative outcomes

| Outcome | OR, 95% CI | p |
|---------|------------|---|
| Moderate/minor complications | 0.57 (0.37–0.89) | 0.01 |
| Major complications | 0.55 (0.32–0.95) | 0.03 |
| In-hospital mortality | 0.78 (0.37–1.64) | 0.5 |
| Postoperative length of stay, coefficient | -3.1 (-4.8) | 0.01 |

Outcomes. Early surgery decreased the odds of minor/moderate complications by 43% (p = 0.01), major complications by 45% (p = 0.03), and postoperative length of stay by 3.1 days (p = 0.01) (table 4).

Discussion

We have demonstrated that following major urologic cancer surgery, the rate of admission for ASBO continues to increase over time, particular for RadCx patients. More importantly, patients who undergo surgery for their ASBO have shorter postoperative length of stay and reduced morbidity when surgery is performed within the first four day after admission.

Reported rates of ASBO following major urologic surgery are currently limited to single-institution series. Our reported 5-year cumulative incidence of ASBO for each procedure is higher than rates currently reported in the literature, even after censoring patients who had subsequent abdominal procedures: RadCx 12.4%, com-
pared to 1.1–11.9% [3–5]; RP 0.9%, compared to open RP (0.4%) [8] and robotic RP (0.09%) [7]; and KS 3.3%, compared to radical nephrectomy (0.6%) [6]. Our higher rates likely provide a more accurate representation of the incidence of ASBO following urologic surgery. By including all admissions in the state, those with fragmented care who do not represent to their initial hospital will be included in the analysis and are less likely to be lost to follow-up.

Conservative management for ASBO with nasogastric decompression for up to 2 weeks has been reported, with retrospective reviews reporting high resolution rates without adverse outcomes with delayed surgery [14]. While conservative management of bowel obstruction has its place, a prolonged trial may result in more morbidity than benefit for the patient. Seror et al. [15] found in their retrospective review that with up to 5 days of non-operative management, 73% of patients experienced resolution of symptoms without an increase in mortality or small bowel resection. Kothari et al. [17] recently reported that in patients admitted with intestinal obstruction, there was a stepwise increase in all complications (myocardial infarction, pulmonary embolism, postoperative sepsis, deep venous thrombosis, pneumonia, and urinary tract infection) and mortality for each day following admission that surgical management is delayed. The results of our study are in line with these reports, with 71.6% of ASBO patients ultimately managed conservatively (non-operatively) with a median length of stay of 4 (range 3–8) days. Using hospital day four as the time point to define early or late surgical intervention, patients who underwent delayed surgery demonstrated an increase in complications and postoperative length of stay compared to those who underwent early operative intervention.

Our report is the first to describe the effect of time to surgery for ASBO on perioperative outcomes in a urologic surgery population. From this study we find that the incidence of ASBO was relatively low when compared to that reported for other intra-peritoneal operations. Also, ASBO following urologic surgery was typically able to be managed conservatively, and when surgery is ultimately required, the majority of patients underwent intervention within the first four hospital days. There is room for improvement in the 34.6% of surgical patients who underwent delayed surgery, as earlier intervention may have improved their perioperative outcomes.

With any retrospective, population-based review of this manner, limitations exist. Foremost, the day-to-day clinical decision-making data to determine at what point a patient requires surgery is not available. Patient-level data such as laboratory values, clinical exam findings, and general improvement or deterioration with conservative management would obviously strengthen this analysis, and more clearly elucidate the rationale for the early or late timing of surgery. While the outcomes of this analysis are suitable for hypothesis generation, we are reliant on the assumption that patients who ultimately underwent surgery either a) progressed to a more ill state necessitating intervention, or b) did not experience improvement with initial conservative management and ultimately required surgery. Application of our results into clinical practice with supplemental patient-level data would more clearly define these patient groups, and to whom the benefit of early surgical intervention would apply.

Second, we recognize that not all prostatectomy and KS procedures are performed through a transperitoneal approach, although all patients were included in our analysis. Lee [23] reported that after robotic prostatectomy was introduced in 2000, up to 60% of all prostatectomies were performed robotically in 2007. Similarly, Ghani et al. [24] reported that, between 2008 and 2010, approximately 30% of partial nephrectomies were performed via a minimally-invasive approach. While the majority of robotic-assisted prostatectomies are performed primarily via a transperitoneal approach, both open and minimally-invasive KS may be performed in either a transperitoneal or retroperitoneal approach. As these operative techniques cannot be adequately delineated in our dataset, all patients were included in the analysis. This may bias our outcomes to underestimate the incidence of ASBO, as presumably extraperitoneal surgery should have a lower risk of ASBO. The subsequent management of patients admitted with ASBO should not be affected, especially as nearly 50% of all ASBO admissions had a history of RadCx.

Conclusion

Adhesive bowel obstruction is a significant long-term sequela of urologic surgery, occurring in up to 0.9% of prostatectomy, 3.3% of KS, and 12.4% of RadCx patients. While conservative management is a reasonable initial option, early surgical management on-or-before hospital day four appears to decrease rates of perioperative complications and postoperative length of stay among urology patients subsequently admitted for adhesive bowel obstruction.
Ethical Approval/Informed Consent

This study was approved by the Institutional Review Board given the low risk for patient identification using of a large, de-identified, administrative dataset.

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