Original Investigation

# Incidence and Predictors of Bowel Obstruction in Elderly Patients With Stage IV Colon Cancer
## A Population-Based Cohort Study

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**IMPORTANCE** Research has been limited on the incidence, mechanisms, etiology, and treatment of symptoms that require palliation in patients with terminal cancer. Bowel obstruction (BO) is a common complication of advanced abdominal cancer, including colon cancer, for which small, single-institution studies have suggested an incidence rate of 15% to 29%. Large population-based studies examining the incidence or risk factors associated with BO in cancer are lacking.

**OBJECTIVE** To investigate the incidence and risk factors associated with BO in patients with stage IV colon cancer.

**DESIGN AND SETTING** Retrospective cohort, population-based study of patients in the Surveillance, Epidemiology, and End Results and Medicare claims linked databases who were diagnosed as having stage IV colon cancer from January 1, 1991, through December 31, 2005.

**PATIENTS** Patients 65 years or older with stage IV colon cancer (n = 12 553).

**MAIN OUTCOMES AND MEASURES** Time to BO, defined by inpatient hospitalization for BO. We used Cox proportional hazards regression models to determine associations between BO and patient, prior treatment, and tumor features.

**RESULTS** We identified 1004 patients with stage IV colon cancer subsequently hospitalized with BO (8.0%). In multivariable analysis, proximal tumor site (hazard ratio, 1.22 [95% CI, 1.07-1.40]), high tumor grade (1.34 [1.16-1.55]), mucinous histological type (1.27 [1.08-1.50]), and nodal stage N2 (1.52 [1.26-1.84]) were associated with increased risk of BO, as was the presence of obstruction at cancer diagnosis (1.75 [1.47-2.04]). A more recent diagnosis was associated with decreased risk of subsequent obstruction (hazard ratio, 0.84 [95% CI, 0.72-0.98]).

**CONCLUSIONS AND RELEVANCE** In this large population of patients with stage IV colon cancer, BO after diagnosis was less common (8.0%) than previously reported. Risk was associated with site and histological type of the primary tumor. Future studies will explore management and outcomes in this serious, common complication.

*JAMA Surg*. 2013;148(8):715-722. doi:10.1001/jamasurg.2013.1
Published online June 5, 2013.

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As cancer treatments have improved, so has cancer survival. Nevertheless, neoplastic disease remains the second leading cause of death in the United States.[1] Although palliative medicine has gained recognition as an important aspect of care, little research has focused on the incidence and risk factors for problems commonly affecting patients with terminal cancer.

One such problem is bowel obstruction (BO), which occurs when a cancerous growth or adhesions block intestinal flow; the resulting nausea, vomiting, pain, and dehydration usually require inpatient hospitalization.[2,3] Although untreated BO can be fatal,[4] most patients receive treatment because onset is typically progressive rather than acute,[5,6] and symptoms are too severe to be ignored.[7] The prognosis of patients with BO is poor; life expectancy is typically measured in weeks to months,[8,9] in part because the circumstances that typically give rise to BOs herald the end of life.[9]

The incidence of BO among patients with colon cancer is not precisely established. Most estimates cite a range of 15% to 29%[2,3,8,10,11]; these figures derived from small, hospital-based studies[12,13] that variously include rectal and anal cancers with colon cancers, partial with complete obstructions, and benign with malignant obstructions.[6,12,14-19] To our knowledge, no large-scale, population-based study has examined the incidence or risk factors associated with BO in patients with cancer.

In this study, we estimated the incidence of hospitalization for BO in patients with stage IV colon cancer using the Surveillance, Epidemiology, and End Results (SEER) and Medicare claims linked databases. We investigated factors associated with BO, including patient demographics, cancer presentation and treatment, and tumor features.

## Methods

### Data Source

We analyzed data from the SEER-Medicare database, which links the detailed registry data of the SEER database with Medicare claims.[20] The SEER database contains records of patients diagnosed as having cancer in approximately 14% of the US population; in 2000, this database was expanded to include approximately 26% of the US population.[21] Medicare claims files include Medicare eligibility status and all inpatient and outpatient claims.

### Cohort Selection

From the SEER-Medicare database, we identified individuals 65 years or older who had a pathologically confirmed first primary diagnosis of colonic adenocarcinoma from January 1, 1991, through December 31, 2005. We selected patients diagnosed as having adenocarcinoma based on codes 814, 821, 822, 825, 826, 848, and 857 from the *International Classification of Diseases for Oncology, Third Edition* (*ICD-O-3*), which included patients with metastatic disease at diagnosis (stage IV). We excluded subjects diagnosed exclusively by death certificate or autopsy, those with an unknown month of diagnosis, and those who had Medicare coverage for reasons other than being 65 years or older. We also excluded individuals enrolled in a non-Medicare health maintenance organization at any time from colon cancer diagnosis to death because billing claims for these patients may not have been submitted to Medicare for reimbursement.

### Patient Characteristics

Patient characteristics, including age, sex, race, marital status, date of diagnosis, and tumor characteristics, were extracted from the SEER files. We categorized age in 5-year increments and race as white, black, and other/unknown. We considered divorced, separated, single, and widowed subjects to be unmarried. We grouped patients by year of diagnosis (1991-1995, 1996-2000, and 2001-2005) and appointed the diagnosis date as the 15th day of the month of diagnosis. Tumors of the cecum, ascending colon, hepatic flexure, and transverse colon were considered right-sided (proximal) tumors, whereas left-sided (distal) tumors were those of the splenic flexure and the descending and sigmoid colons. We classified tumor histological type as mucinous (*ICD-O-3* code 848) or nonmucinous and grouped tumor grade into low (well or moderately differentiated), high (poorly differentiated or undifferentiated), and unknown according to *ICD-O-3* codes.[22] Cases were grouped by nodal involvement into N0 (no lymph nodes involved by tumor), N1 (1-3 nodes involved), N2 (>3 nodes involved), and unknown according to the American Joint Committee on Cancer staging criteria.[23]

We categorized patients as having had primary tumor resection (PTR) or no PTR on the basis of a Medicare Provider Analysis Review File (MedPAR) (codes 45.7, 45.8, 48.4, 48.5, and 48.6 from the *International Classification of Diseases, Ninth Revision* [*ICD-9*]) or a physician claim (codes 44140-44160, 44204-44212, and 44227 from the Health Care Financing Administration Common Procedural Coding System) for colon resection within 6 months of cancer diagnosis. We considered diagnoses of BO or perforation within 30 days of cancer diagnosis or PTR to be present at diagnosis, and we excluded individuals with a history of BO before the cancer diagnosis. Then, using MedPAR claims data, we identified a subset of patients who were hospitalized after the cancer diagnosis at an acute care hospital in which we used an *ICD-9* diagnosis code for BO (560.81, 560.89, or 560.9). For subset analysis, we identified patients for whom the diagnosis code specific to adhesive BO (*ICD-9* code 560.81) was ever used in a MedPAR claim; this group was designated *ever adhesive*. Under the assumption that an obstruction with an adhesion might be coded as a nonspecific obstruction but a malignant obstruction was unlikely to be coded as adhesive, analysis of this subset gave us a view of potential differences in factors affecting the cause of the obstruction, albeit a view diluted by likely misclassification. We identified patients who received chemotherapy after cancer diagnosis but before the date of first hospitalization for obstruction based on codes in MedPAR, physician, and outpatient claims files as recommended by Warren et al.[24] Finally, we identified a set of hospitalization records that did not include diagnosis codes for BO but in which associated physician claims files included 2 or more obstruction diagnosis codes (we required 2 on the basis that 1 code might be used only



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for a rule-out test). In sensitivity analyses, we included these hospitalizations as events of interest.

### Comorbid Disease

To assess comorbid disease in our cohort, we used the adaptation by Klabunde et al[25] of the Charlson Comorbidity Index. We weighted Medicare inpatient and outpatient claims for *ICD-9* diagnostic codes for each of 19 health conditions in which the appearance of the code predated the diagnosis of colon cancer. We computed a composite comorbidity score for each patient.[25] Individuals with no claims before the cancer diagnosis (0.5%) were given a score of 0.

### Statistical Analysis

We assessed associations between predictors using $\chi^2$ and Mann-Whitney tests and used univariable Cox proportional hazards regression models to compare associations between demographic and clinical variables and time to hospitalization for BO. Time-to-obstruction models used the date of PTR or the cancer diagnosis (if no PTR) as time 0 and treated death and loss to follow-up as censoring events. We created a multivariable Cox model to examine the effects of statistically and clinically significant explanatory variables on time to obstruction and, in a stepwise backward selection, removed predictors that were nonsignificant. We used commercially available software (SAS, version 9.2; SAS Institute, Inc) for statistical analyses.

## Results

We identified 12 669 individuals 65 years or older with a diagnosis of stage IV colon adenocarcinoma from January 1, 1991, through December 31, 2005, and with Medicare coverage from 1 year before the diagnosis through death or the end of follow-up. We excluded 116 patients who had a diagnosis of BO before the cancer diagnosis. The final cohort contained 12 553 individuals (5645 men and 6908 women) with a median survival of 185 (interquartile range, 57-491) days. We calculated that 94.0% of the cohort had died by the last follow-up. Of the final cohort, 1004 (8.0%) were hospitalized with BO after cancer diagnosis.

**Table 1** shows the demographic and clinical characteristics and tumor features of the patients with stage IV colon cancer stratified by hospitalization for BO after the cancer diagnosis. Because the incidence of BO was closely tied to the time of survival with stage IV disease, associations between demographic and clinical features and obstruction were assessed with univariable Cox proportional hazards regression models. Hospitalizations for BO were less frequent in the later years of observation: BO was identified in 9.0% of the patients diagnosed in 1991 through 1995 compared with 8.4% in 1996 through 2000 and 7.1% in 2001 through 2005 ($P < .001$ for trend). Bowel obstruction was less frequent with increasing age, occurring in 10.1% of those aged 65 to 69 years compared with 10.8%, 8.3%, and 5.2% among those 70 to 74, 75 to 79, and 80 years or older, respectively ($P < .001$ for trend); survival with colon cancer was also largely influenced by age, with a decrease in median survival with increasing age. Sex, race, marital status, and comorbidities were not associated with hospitalization for obstruction.

Cancer presentation and treatments were associated with subsequent hospitalization for BO. Bowel obstruction was more frequent among those with obstruction at the time of the cancer diagnosis than in those without it (10.4% vs 7.6%; $P < .001$). Among the cohort, 71.1% had PTR. The rate of obstruction in this group was higher than in patients without PTR (9.1% vs 5.3%), but so was survival (median, 266 vs 70 days; $P < .001$); as a result, the hazard of BO was lower among those undergoing PTR ($P < .001$). Similarly, proximal vs distal, high-grade vs low-grade, and node-positive vs node-negative tumors had equivalent rates of BO; however, individuals with proximal, high-grade, and node-positive tumors had significantly shorter survival compared with those with distal, low-grade, and node-negative tumors and therefore a higher risk of hospitalization for BO ($P < .001$). Finally, BO was more common among those with mucinous compared with nonmucinous tumors (10.4% vs 7.6%; $P < .001$). The **Figure** shows the cumulative incidence of hospitalization for BO over time stratified by histological tumor type.

In univariable analyses, proximal vs distal colon cancers were more likely to be of high grade (33.3% vs 22.4%; $P < .001$) and of a mucinous type (16.2% vs 10.6%; $P < .001$). Proximal tumors and those of unknown grade increased with the age at diagnosis ($P < .001$ for trend), and proximal tumors and age at diagnosis increased over time ($P < .001$). Finally, a high nodal stage was more common in proximal vs distal tumors (51.5% vs 36.2%; $P < .001$) and in high- vs low-grade tumors (59.9% vs 38.7%; $P < .001$).

The multivariable Cox proportional hazards regression model determining predictors of hospitalization for BO is shown in **Table 2**. Bowel obstruction was associated with right-sided tumors (hazard ratio [HR], 1.22 [95% CI, 1.07-1.40]), a high tumor grade (1.34 [1.16-1.55]), and a mucinous tumor type (1.27 [1.08-1.50]). High nodal stage increased the hazard of subsequent BO by more than 50% (HR, 1.52 [95% CI, 1.26-1.84] in N2 vs N0 tumors). In contrast, cancers diagnosed in 2001 through 2005 experienced a lower hazard of BO (HR, 0.84 [95% CI, 0.72-0.98]) compared with those in the earliest years of observation, and those diagnosed at older ages (≥80 years of age) experienced a lower hazard of obstruction (0.88 [0.73-1.06] vs ages 65-69 years). In the multivariable model, BO at presentation remained a significant predictor of hospitalization for obstruction (HR, 1.75 [95% CI, 1.47-2.04]), whereas surgical treatment at diagnosis was no longer significantly associated with BO ($P = .17$) and was dropped from the model.

Of the 1004 individuals hospitalized for obstruction, 164 were diagnosed with BO due to adhesions during a hospitalization after their cancer diagnosis. In a multivariable model of hospitalizations occurring in the ever-adhesive group, mucinous histological type (HR, 1.67 [95% CI, 1.15-2.43]) and obstruction at presentation (2.11 [1.45-3.08]) remained associated with time to obstruction; patient age, year of diagnosis, and tumor grade, site, and node status were no longer associated with BO (data not shown). Perhaps because of an overlap between the risk factors for obstruction or the small



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Table 1. Characteristics of Patients With Stage IV Colon Cancer Stratified by Occurrence of BO[a]

| | No. (%) of Patients | | | |
|---|---|---|---|---|
| | Overall (N = 12 553) | No BO (n = 11 549) | BO (n = 1004) | *P* Value[b] |
| **Patient Characteristics** | | | | |
| Age at diagnosis, y | | | | |
| 65-69 | 1928 (15.4) | 1734 (15.0) | 194 (19.3) | .01 |
| 70-74 | 2933 (23.4) | 2617 (22.7) | 316 (31.5) | |
| 75-79 | 3064 (24.4) | 2810 (24.3) | 254 (25.3) | |
| ≥80 | 4628 (36.9) | 4388 (38.0) | 240 (23.9) | |
| Sex | | | | |
| Male | 5645 (45.0) | 5192 (45.0) | 453 (45.1) | .19 |
| Female | 6908 (55.0) | 6357 (55.0) | 551 (54.9) | |
| Race | | | | |
| White | 10 505 (83.7) | 9662 (83.7) | 843 (84.0) | .87 |
| Black | 1266 (10.1) | 1170 (10.1) | 96 (9.6) | |
| Other/unknown | 782 (6.2) | 717 (6.2) | 65 (6.5) | |
| Marital status | | | | |
| Married | 6162 (49.1) | 5599 (48.5) | 563 (56.1) | .75 |
| Unmarried | 6032 (48.1) | 5616 (48.6) | 416 (41.4) | |
| Unknown | 359 (2.9) | 334 (2.9) | 25 (2.5) | |
| Charlson Comorbidity Index | | | | |
| 0[c] | 8254 (65.8) | 7553 (65.4) | 701 (69.8) | .45 |
| 1 | 2489 (19.8) | 2298 (19.9) | 191 (19.0) | |
| ≥2 | 1810 (14.4) | 1698 (14.7) | 112 (11.2) | |
| **Presenting Features and Treatment** | | | | |
| Year of diagnosis | | | | |
| 1991-1995 | 3512 (28.0) | 3195 (27.7) | 317 (31.6) | .051 |
| 1996-2000 | 3549 (28.3) | 3250 (28.1) | 299 (29.8) | |
| 2001-2005 | 5492 (43.8) | 5104 (44.2) | 388 (38.6) | |
| Obstruction at presentation | | | | |
| No | 10 879 (86.7) | 10 049 (87.0) | 830 (82.7) | <.001 |
| Yes | 1674 (13.3) | 1500 (13.0) | 174 (17.3) | |
| Primary tumor resection | | | | |
| No | 3627 (28.9) | 3435 (29.7) | 192 (19.1) | <.001 |
| Yes, without perforation | 8628 (68.7) | 7841 (67.9) | 787 (78.4) | |
| Yes, with perforation | 298 (2.4) | 273 (2.4) | 25 (2.5) | |
| Chemotherapy[d] | | | | |
| No | 7375 (58.8) | 7021 (60.8) | 354 (35.3) | .16 |
| Yes | 5178 (41.2) | 4528 (39.2) | 650 (64.7) | |
| **Tumor Characteristics** | | | | |
| Cancer site | | | | |
| Left | 4541 (36.2) | 4167 (36.1) | 374 (37.3) | <.001 |
| Right | 6999 (55.8) | 6425 (55.6) | 574 (57.2) | |
| NOS | 1013 (8.1) | 957 (8.3) | 56 (5.6) | |
| Tumor histological type | | | | |
| Nonmucinous | 10 811 (86.1) | 9989 (86.5) | 822 (81.9) | <.001 |
| Mucinous | 1742 (13.9) | 1560 (13.5) | 182 (18.1) | |

*(continued)*



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Table 1. Characteristics of Patients With Stage IV Colon Cancer Stratified by Occurrence of BO[a] (continued)

| | No. (%) of Patients | | | |
|---|---|---|---|---|
| | Overall (N = 12 553) | No BO (n = 11 549) | BO (n = 1004) | *P* Value[b] |
| Tumor grade | | | | |
| Low | 7052 (56.2) | 6473 (56.0) | 579 (57.7) | <.001 |
| High | 3486 (27.8) | 3204 (27.7) | 282 (28.1) | |
| Unknown | 2015 (16.1) | 1872 (16.2) | 143 (14.2) | |
| Lymph node stage | | | | |
| N0 | 1827 (14.6) | 1658 (14.4) | 169 (16.8) | <.001 |
| N1 | 2783 (22.2) | 2544 (22.0) | 239 (23.8) | |
| N2 | 3885 (30.9) | 3533 (30.6) | 352 (35.1) | |
| Missing | 4058 (32.3) | 3814 (33.0) | 244 (24.3) | |

Abbreviations: BO, bowel obstruction; NOS, not otherwise specified

[a] Data are calculated from the Surveillance, Epidemiology, and End Results and Medicare claims linked databases from January 1, 1991, through December 31, 2005. Percentages have been rounded and may not total 100.

[b] Calculated from univariable Cox proportional hazards models of obstruction.

[c] Includes 0.5% of the population with missing comorbidity information.

[d] Defined as a claim for chemotherapy before BO or death.

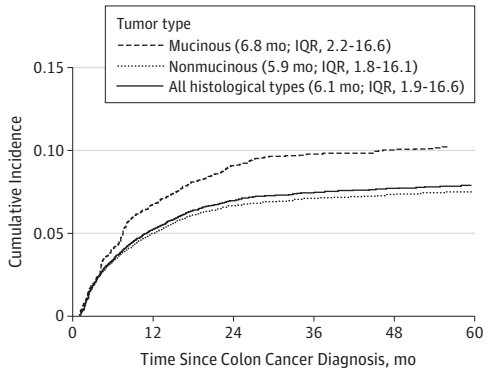
number of patients in the ever-adhesive group, removing the ever-adhesive group from the multivariable model of time to obstruction did not change the results (data not shown). Likewise, associations between patient, treatment, and tumor characteristics and BO incidence did not change when we excluded 1674 individuals with BO at their cancer diagnosis or when we included 116 diagnosed as having an obstruction before their cancer diagnosis (data not shown). When we included 477 patients with postdiagnosis hospitalization for whom BO was identified in physician claims but not in hospitalization codes, the hazard of subsequent obstruction remained higher among right-sided, mucinous, and high-grade tumors and in patients with an obstruction at their cancer diagnosis.

## Discussion

We found that postdiagnosis hospitalization for BO occurred in 8.0% of patients in a SER-Medicare cohort diagnosed as having stage IV colon cancer from 1991 through 2005. The hazard of BO was higher in proximal vs distal cancers, high-grade vs low-grade tumors, mucinous vs nonmucinous tumors, and node-positive vs node-negative disease. Obstruction at diagnosis was also significantly associated with subsequent obstruction. In contrast, social and demographic factors played no role.

Right-sided, high-grade, and mucinous tumors were associated with an approximate 20% to 40% increase in the hazard of BO; this increase has been reported previously.[26-28] In 1990, Bufill[29] proposed that colorectal cancer consisted of 2 categories according to tumor location. Extensive documentation of distinct epidemiologic, clinical, pathological, and molecular phenotypes of right- and left-sided cancers now exists.[30,31] Therefore, the elevated hazard of obstruction we observed among right-sided, high-grade, and mucinous tumors may reflect an elevated hazard of BO associated with an underlying proximal tumor phenotype.

Figure. Cumulative Incidence of Hospitalization for Bowel Obstruction Over Time




| No. Still Alive | | | | | | |
|---|---|---|---|---|---|---|
| Mucinous | 10811 | 3311 | 1400 | 705 | 393 | 226 |
| Nonmucinous | 1742 | 523 | 217 | 115 | 72 | 50 |

Cumulative incidence of hospitalization for bowel obstruction over time in the baseline cohort of 12 553 patients with stage IV colon cancer in the Surveillance, Epidemiology, and End Results and Medicare claims linked databases for January 1, 1991, through December 31, 2005, stratified by tumor histological type. For reference, the median survival of each group is given. We found no significant difference in survival experience by histological type (*P* = .29) in a multivariable model of survival since the cancer diagnosis that included age at and year of diagnosis, sex, marital status, patient comorbidity score, primary tumor surgery, chemotherapy after diagnosis, tumor site and grade, and lymph node status. IQR indicates interquartile range.

We also found that high nodal stage (N2) increased the risk of subsequent obstruction by 50%. Advanced nodal stage was associated with proximal, high-grade, and mucinous tumors; nodal stage might be yet another indicator of a tumor phenotype with a propensity for intraperitoneal spread and BO. A higher burden of nodal disease may also contribute mechanically to luminal obstruction through distortion of the bowel mesentery, by creating a lead point for intussusception, or by causing extraluminal compression on surrounding loops of bowel.



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Table 2. Multivariable Cox Proportional Hazards Regression Analysis of Association Between BO and Clinical and Tumor Characteristics in 12 553 Patients With Stage IV Colon Cancer[a]

| | Adjusted HR (95% CI) | *P* Value |
|---|---|---|
| **Presenting Features and Treatment** | | |
| Age at diagnosis, y | | |
| 65-69 | 1 [Reference] | .01 |
| 70-74 | 1.17 (0.98-1.39) | |
| 75-79 | 1.05 (0.87-1.26) | |
| ≥80 | 0.88 (0.73-1.06) | |
| Year of diagnosis | | |
| 1991-1995 | 1 [Reference] | .047 |
| 1996-2000 | 0.97 (0.83-1.14) | |
| 2001-2005 | 0.84 (0.72-0.98) | |
| Obstruction at diagnosis | | |
| No | 1 [Reference] | <.001 |
| Yes | 1.75 (1.47-2.04) | |
| **Tumor Characteristics** | | |
| Cancer site | | |
| Left | 1 [Reference] | .01 |
| Right | 1.22 (1.07-1.40) | |
| NOS | 1.08 (0.80-1.46) | |
| Histological type | | |
| Nonmucinous | 1 [Reference] | .004 |
| Mucinous | 1.27 (1.08-1.50) | |
| Tumor grade | | |
| Low | 1 [Reference] | <.001 |
| High | 1.34 (1.16-1.55) | |
| Unknown | 1.48 (1.19-1.83) | |
| Lymph node stage | | |
| N0 | 1 [Reference] | <.001 |
| N1 | 1.10 (0.90-1.34) | |
| N2 | 1.52 (1.26-1.84) | |
| Unknown | 1.89 (1.52-2.35) | |

Abbreviations: BO, bowel obstruction; HR, hazard ratio; NOS, not otherwise specified.

[a] Data are calculated from the Surveillance, Epidemiology, and End Results and Medicare claims linked databases from January 1, 1991, through December 31, 2005.

We found that BO coincident with a colon cancer diagnosis almost doubled the hazard of subsequent hospitalization for obstruction. This increase may reflect an anatomic predisposition to BO, such as a history of abdominal surgery; because we had access to patient claims for only a limited life period (≥65 years of age), we could not fully evaluate surgical history.

Having a later year of diagnosis modestly decreased the hazard of hospitalization for obstruction despite more-frequent proximal tumors diagnosed in later years. One explanation for the association between year and obstruction is the use of more sensitive staging techniques from 1991 through 2005, leading to stage migration (the Will Rogers phenomenon).[32] Under this theory, individuals with a more recent diagnosis of stage IV colon cancer would have less advanced disease compared with those with stage IV disease in the earliest years of observation. Because BO is generally an end-of-life event, this theory would prolong the lead time to obstruction among patients with a recent diagnosis, decreasing the hazard of obstruction in this group in time-to-event analyses.

Older age was also associated with decreased obstruction and decreased overall survival as the only instance in which the hazard of obstruction was inversely related to the hazard of death. In a time-to-event model that censors death—which is an important competing outcome relative to BO in our population—shorter survival time alone could explain lower rates of obstruction observed among older patients.[33]

We observed an incidence rate of BO within the range previously reported. Comparing our results with other studies, we distinguished obstructions that were a presenting feature of colon cancer from those occurring after diagnosis, whereas previous studies have not.[3,5,8,11,34-36] In addition, all studies published to date have been hospital based, and their estimated incidences may reflect referral bias: patients with obstruction may be more likely to choose or be referred to larger-volume centers, which more frequently participate in published studies.[6,14-16,18,19,37] We also restricted our analysis to BO associated with inpatient hospitalization at an acute-care facility. Studies relying on medical record review or patient interview captured partial with complete obstructions[15] and may have included patients who would not be captured in our hospitalized cohort.

Our conclusions are strengthened by the large sample size afforded by use of SEER-Medicare data and by the long period of observation (until death in 94.0% of patients). In addition, because SEER-Medicare data use a population-based sample, our results can be generalized to other populations 65 years or older.

Our results also have limitations. First, BO in patients with colon cancer may be due to benign or malignant conditions,[38] which are not distinguished by *ICD-9* codes. One may argue that there is little use in distinguishing these entities because the cause cannot always be determined, even with the aid of high-quality abdominal imaging.[39-41] However, the distinction between nonmalignant and malignant causes of obstruction can be critical to prognosis and treatment decisions.[41] Given our inability to distinguish obstructions by cause, we included all events in our main analyses. Predictors of BO in patients with stage IV colon cancer were not sensitive to exclusion of the ever-adhesive group.

A second limitation is that the use of obstruction diagnosis codes may not reflect the primary reason for the hospital admission and may instead be incidental to the patient's condition. For this reason, we restricted events of interest to hospitalizations in which BO was 1 of 10 diagnosis codes used in the records of inpatient hospitalizations, although we note that consideration of hospitalizations identified using more liberal criteria had a minimal effect on estimates.

A final limitation is that our findings reflect the incidence and risk of hospitalization for obstruction in patients 65 years or older who received their diagnosis at the metastatic stage. We did not examine the relationship between BO and cancer diagnosed at earlier stages because we were concerned that Medicare billing claims inaccurately convey disease progres-



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sion and that our results would not reflect the incidence and causes of BO specifically in patients with advanced cancer.[42] In addition, more than 70% of patients in our analysis underwent surgery at the time of their cancer diagnosis; it is unclear whether the patterns we identified will persist if surgical management of stage IV cancers becomes less common.[39,43-48]

In conclusion, the present study provides, to our knowledge, the first large-scale, population-based assessment of BO in patients with stage IV colon cancer. Proximal tumor site, high tumor grade, and mucinous histological type were associated with BO in the setting of stage IV cancer, suggesting that obstruction risk may segregate with a proximal tumor phenotype; obstruction at diagnosis also increased the hazard of subsequent BO. The present results advance our understanding of the etiology of BO. An accompanying report focuses on the treatments during and outcomes after hospitalization for BO.[49]

## ARTICLE INFORMATION

**Accepted for Publication:** November 26, 2013.

**Published Online:** June 5, 2013. doi:10.1001/jamasurg.2013.1.

**Author Contributions:** Drs Winner, Hershman, and Neugut and Mr Mooney take full responsibility for the integrity of the data and data analysis.
*Study concept and design:* Winner, Mooney, Neugut.
*Acquisition of data:* Winner, Neugut.
*Analysis and interpretation of data:* All authors.
*Drafting of the manuscript:* Winner, Mooney, Wright.
*Critical revision of the manuscript for important intellectual content:* All authors.
*Statistical analysis:* Winner, Mooney, Wright.
*Administrative, technical, and material support:* Hershman.
*Study supervision:* Hershman, Allendorf, Neugut.

**Conflict of Interest Disclosures:** None reported.

**Funding/Support:** This study was supported in part by fellowships R25-CA094061 (Dr Winner) and T32-CA09529 (Mr Mooney) from the National Cancer Institute.

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Invited Commentary

# Obstructions to Understanding Malignant Bowel Obstruction

Robert S. Krouse, MD

**Malignant bowel obstruction (MBO)** is an important palliative care problem for many patients with colon cancer. Malignant BO may be due to the primary tumor, to metastatic disease, or to previous surgical intervention leading to adhesions or internal hernia. Although many reports have examined MBO in the setting of colon cancer, the true incidence and the outcomes remain unknown. Winner and colleagues[1] attempt to address this deficiency by using the Surveillance, Epidemiology, and End Results and Medicare claims linked databases.

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Such database analyses have clear limitations, including the lack of a defined code for MBO. Thus, multiple assumptions must be made to include patients in the MBO cohort. In addition, unclear definitions for MBO, especially for patients who did not undergo surgery and for whom the source of obstruction remains unknown, may result in disparate patients included in the analysis. In a large database, documentation of outcomes is variable. Hospitalization, as examined by these authors, may be the most important outcome in the setting of MBO because it has tremendous relevance to patients with a limited life span.

Several features make the analyses by Winner and colleagues[1] important. First, this report adds to our knowledge of the natural history of MBO in the setting of advanced colon cancer. Previous reports have limited power to describe this population adequately. Next, their findings indicate a population of survivors of stage IV colon cancer more likely to have a bowel obstruction. Finally, this analysis further directs us that it is imperative to prospectively study MBO with appropriate definition[2] and the fastidious collection of meaningful outcomes, including hospital stay, ability to eat, and patient-reported outcomes. In this way, we will better understand how to best care for MBO patients and their caretakers.

## ARTICLE INFORMATION

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**Published Online:** June 5, 2013. doi:10.1001/jamasurg.2013.15.

**Conflict of Interest Disclosures:** None reported.

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