Functional Status After Colon Cancer Surgery in Elderly Nursing Home Residents

Emily Finlayson, MD, MS,[a,b] Shoujun Zhao, MD, PhD,[b] W. John Boscardin, PhD,[c,d,e] Brant E. Fries, PhD,[f] C. Seth Landefeld, MD,[d,e] and R. Adams Dudley, MD, MBA[a,g]

OBJECTIVES: To determine functional status and mortality rates after colon cancer surgery in older nursing home residents.

DESIGN: Retrospective cohort study.

SETTING: Nursing homes in the United States.

PARTICIPANTS: Six thousand eight hundred twenty-two nursing home residents aged 65 and older who underwent surgery for colon cancer in the United States between 1999 and 2005.

MEASUREMENTS: Changes in functional status were assessed before and after surgery using the Minimum Data Set Activity of Daily Living (MDS-ADL) summary scale, a 28-point scale in which score increases as functional dependence increases. Regression techniques were used to identify patient characteristics associated with mortality and functional decline 1 year after surgery.

RESULTS: On average, residents who underwent colectomy had a 3.9-point worsening in MDS-ADL score at 1 year. One year after surgery, rates of mortality and sustained functional decline were 53% and 24%, respectively. In multivariate analysis, older age (≥80 vs 65–69, adjusted relative risk (ARR) = 1.53, 95% confidence interval (CI) = 1.15–2.04, P < .001), readmission after surgical hospitalization (ARR = 1.15, 95% CI = 1.03–1.29, P = .02), surgical complications (ARR = 1.11, 95% CI = 1.02–1.21, P = .01), and functional decline before surgery (ARR = 1.21, 95% CI = 1.11–1.32, P < .001) were associated with functional decline at 1 year.

CONCLUSION: Mortality and sustained functional decline are common after colon cancer surgery in nursing home residents. Initiatives aimed at improving surgical outcomes are needed in this vulnerable population. **J Am Geriatr Soc 60:967–973, 2012.**

Key words: functional decline; nursing home residents; surgery

The decision to undergo major surgery for cancer involves weighing its potential benefit in ameliorating symptoms or prolonging life against its risks. In frail older adults with limited life expectancy, the benefits of cancer surgery are often unclear, and the use of cancer-directed surgery for technically resectable tumors declines as patients age.[1] For this reason, a realistic and comprehensive assessment of surgical outcomes is essential to inform decision-making.

The risks of surgery are often defined in terms of short-term morbidity and mortality and not long-term function. There is evidence that, although individuals with limited life expectancy are willing to undergo procedures with a high risk of perioperative mortality, they are reluctant to accept interventions with a risk of sustained functional impairment.[2] Some studies suggest that functional declines after surgery in elderly adults are transient and reversible.[3,4] Other studies using multiple measures of functional independence have found that functional recovery after major surgery in community dwelling elderly adults can be protracted. A prospective study of functional independence after abdominal surgery in individuals aged 60 and older found that protracted disability after surgery was common.[5] More than half of participants had a decrease in objective measures of strength and mobility 6 months after surgery. Functional recovery in the frailest elderly adults—nursing home residents—is likely to be substantially worse.

Functional outcomes after major cancer surgery in nursing home residents are poorly understood, so the current

study used data from national Medicare claims and the Minimum Data Set for Nursing Homes to assess functional status and survival in elderly nursing home residents in the United States undergoing surgery for colon cancer.

METHODS

Subjects and Databases

To identify a cohort of long-term nursing home residents undergoing surgery, data from 100% of national Medicare Inpatient Files (2000–2005) were linked with those from the Minimum Data Set for Nursing Homes (MDS, 1999–2006). The Medicare Inpatient File contains discharge abstracts for all fee-for-service inpatient hospitalizations for Medicare beneficiaries. The MDS is a mandatory assessment of all nursing home residents who reside in facilities participating in Medicare or Medicaid programs. Nursing staff administer MDS assessments of patient health and function, which are completed at admission, re-admission, quarterly, and when the resident experiences a change in clinical status.

The functional outcomes of nursing home residents aged 65 and older who underwent surgery for colon can-cer were examined. This procedure was selected because it is the most frequently performed major cancer operation in the nursing home population (>6,000 performed over the study period) and is associated with substantial mor-bidity and mortality in elderly adults. Participants were identified according to *International Classification of Dis-eases, Ninth Revision* (ICD-9) diagnosis and procedure codes in the Medicare Inpatient File (Appendix S1) and classified as long-term nursing home residents if they underwent two or more consecutive MDS assessments more than 90 days apart during the 6 months before sur-gery, indicating a preoperative nursing home stay of longer than 90 days.

To compare outcomes of nursing home residents undergoing colectomy with benchmark mortality and func-tional decline in the general nursing home population, a cohort of nursing home residents who did not undergo surgery during the same period matched on age, gender, race, year of admission, and comorbidity was identified.

Covariates

Resident characteristics were obtained from the Medicare claims and the MDS. Demographic data were obtained from the Medicare Denominator file. Comorbid diagnoses were obtained from MDS assessments and from the Medi-care Provider Analysis and Review (MEDPAR) file. To assess overall comorbid disease burden, comorbidities were compiled into a Charlson score in the multivariate model.[6,7] Residents were defined as having dementia if they had at least one of the three criteria: disease diagnosis on MDS assessment, ICD-9 diagnosis code in Medicare claim, or MDS Cognitive Performance Scale (CPS) score of 3 or greater. The MDS-CPS is a validated scale of cognitive function,[8] and a CPS score of 3 indicates moderate cogni-tive impairment and has been used to define dementia.[9]

Functional status was measured using MDS assess-ments of self-performance of activities of daily living (ADLs). Data on ADL performance in the MDS include information about mobility in seven activities: mobility while in bed, transferring, ambulation, dressing, eating, toileting, and personal hygiene. The resident's performance of each of these activities is rated using a scoring system of 0 to 4 points, ranging from 0 indicating independence to 4 indicating total dependence. The sum of these seven scores—the MDS-ADL score—has been validated against standardized measures of functional independence.[10,11] Possible total scores range from 0, for independence in all activities, to 28, indicating total dependence in all activities. Baseline functional status was defined as the MDS-ADL summary score reported on the most recent MDS assessment before the surgical hospitalization. To account for the effect of preoperative functional decline, residents were categorized as experiencing preoperative functional decline if they had a 2-point or greater MDS-ADL score increase before their surgical admission. To explore the effect of baseline functional status on death and functional decline, nursing home residents were divided into four approximately equal-sized groups (quar-tiles) based on the most recent MDS-ADL summary score before their surgical admission.

To assess the effect of perioperative events on 1-year mortality and functional decline, postoperative complica-tions in the MEDPAR file were identified using coding algorithms adapted from previous studies[4] (Appendix S1). Thirty-day readmission rates were determined using the MEDPAR file.

Outcome Measures

The primary outcome measures were functional status and mortality. Consistent with prior published studies, func-tional decline was defined as a MDS-ADL score increase of 2 or more points.[12] Residents who had an increase of 1 point, no change, or a decrease in MDS-ADL score were classified as having maintained ADL function. The propor-tion of residents who died, maintained ADL function, or experienced ADL decline was measured at four intervals (0–3, 3–6, 6–9, and 9–12 months). Death was determined using date of death information from the Medicare Denominator file.

Statistical Analysis

Log Poisson regression models were fit to estimate the rela-tive risks of functional decline in survivors 1 year after surgery associated with individual resident characteristics, including an interaction term for age and sex. The analyses were initially performed with functional decline in 1-year survivors as a primary outcome measure. To account for the potential effect of the 410 1-year survivors with miss-ing assessments in the final time interval (9–12 months), the multivariate analysis was performed two ways as a sensitivity analysis: classifying the residents missing post-operative assessments as having declined in function and maintained function.

Functional trajectories before and after surgery were explored using mixed-effects spline models to incorporate the multiple measurements for each subject. Specifically, restricted cubic spline models with five knots placed at

3 months and 1 month before surgery and 1, 4, and 12 months after surgery were used. Knots were chosen based on substantive clinical considerations, although the fitted curves were similar when knots were chosen based on Harrell's quantile-based recommendations.[13] Models included fixed and random effects for the coefficients of the spline, implying that each subject's measurements were scattered around a subject-specific smooth curve; these subject-specific smooth curves were then departures from the average smooth trajectory for the population. Fixed effects for age, sex, race, and comorbidity, were also included, allowing the population trajectory to shift based on the baseline characteristics. To explore the influence of baseline functional status on functional trajectories after surgery, functional trajectories of residents stratified according to their baseline functional status quartile were compared. To account for the 410 nursing home residents who were alive but did not have ADL assessments in Months 9 to 12, the analysis was repeated using multiple imputations to predict MDS-ADL scores at 12 months.

The Kaplan–Meier method was used to estimate cumulative 1-year mortality from the date of surgery. Cox proportional hazards models were then used to estimate the relative risk of mortality associated with individual resident characteristics. Mortality rates were censored at the end of the follow-up period.

In all analyses, the nursing home resident was the unit of analysis. Statistical significance in the Poisson regression and Cox proportional hazards models were defined using $P = .05$ using two-sided significance testing. The University of California at San Francisco Committee on Human Research approved this study.

RESULTS

Resident Characteristics

During the study period, 6,822 long-stay nursing home residents nationwide underwent surgery for colon cancer. These residents had a mean age of 82.9 (Table 1); 68% were female, and 86% were white. The mean MDS-ADL summary scale score before surgical admission was 12.7 ± 8.2, indicating a poorly functioning cohort, and 16% of residents had experienced decline in ADL function (≥ 2-point worsening in MDS-ADL score) in the 6 months before surgery. Sixty-four percent of residents were admitted to the hospital urgently or emergently. Half of the residents had a diagnosis of dementia before surgery, and 30% had a history of congestive heart failure and diabetes mellitus.

One-Year Mortality

Overall, cumulative 1-year mortality was 53% (Figure 1A). In survival analysis stratified according to baseline MDS-ADL score quartile, 1-year mortality increased with increasing ADL impairment—46% for quartile 1, 51% for quartile 2, 53% for quartile 3, and 63% for quartile 4 (Figure 1B). In the matched cohort of nursing home residents undergoing surgery, 1 year mortality was 31% (Appendix S2). In multivariate analysis, age was the strongest predictor of 1-year mortality (Table 2). One-year

Table 1. Characteristics of Nursing Home Residents Undergoing Surgery for Colon Cancer

Characteristic	Cohort
Age, mean ± SD	82.9 ± 7.5
Age, %	
65–69	6
70–79	26
≥ 80	68
Female, %	68
Race, %	
White	86
Black	12
Other	3
Baseline MDS-ADL summary score, mean ± SD	12.7 ± 8.2
Baseline MDS-ADL summary score according to quartile, %	
0–6	24
7–13	25
14–18	24
19–28	27
Functional decline before surgery, %	16
Comorbid diagnoses, %	
Dementia	50
Congestive heart failure	30
Diabetes mellitus	30
Cerebrovascular disease	22
Chronic obstructive pulmonary disease	21
Coronary artery disease	18
Peripheral vascular disease	10
Renal failure	5
Charlson score, %	
0	20
1	20
2	19
≥ 3	42
Admission status, %	
Elective	36
Urgent or emergent	64

SD = standard deviation; MDS-ADL = Minimum Data Set Activity of Daily Living.

mortality was significantly more likely in residents aged 80 and older than in those aged 65 to 69 (adjusted hazard ratio (AHR) = 1.75, 95% confidence interval (CI) = 1.38–2.23). The presence of a surgical complication significantly increased the likelihood of 1-year mortality (AHR = 1.80, 95% CI = 1.65–1.96). Functional decline before surgery (AHR = 1.16, 95% CI = 1.06–1.27) and Charlson comorbidity score of 3 or greater (AHR = 1.12, 95% CI = 1.01–1.23) were also independently associated with death within 1 year after surgery.

Functional Decline

The proportion of residents who experienced functional decline from preoperative levels was greatest during the first 3 months after surgery—42% of the entire cohort and 62% of surviving residents (Figure 2). In the following three time intervals, approximately one-quarter of residents had MDS-ADL scale scores 2 points or more worse than baseline scores—28% at 6 months, 24% at 9 months, and 24% at 12 months. Of survivors, approximately half had functional decline at 6, 9, and 12 months
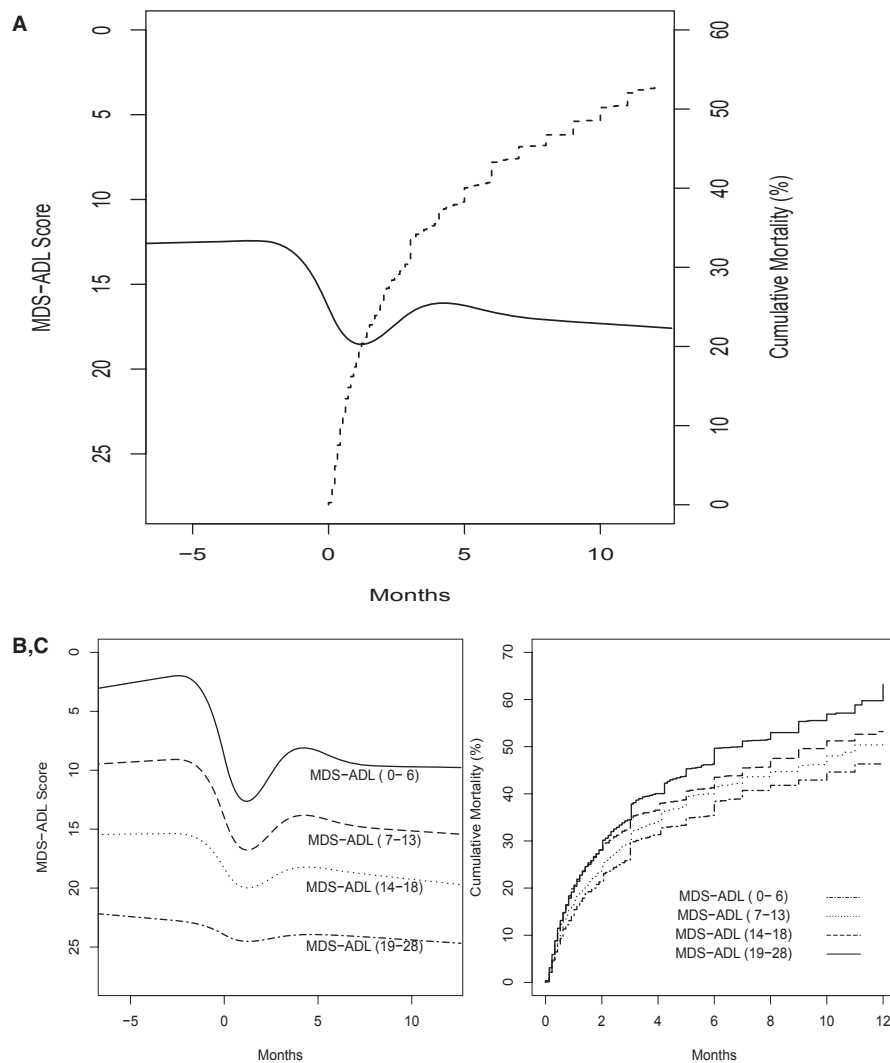
Figure 1. One-year mortality and functional trajectories before and after surgery: (A) all residents and (B) residents stratified according to baseline Minimum Data Set Activity of Daily Living (MDS-ADL) score.

after surgery. In multivariate analysis, several resident characteristics were associated with functional decline at 1 year (Table 3). In 1-year survivors, residents aged 80 and older were more than 50% more likely than residents aged 65 to 69 to experience functional decline (adjusted relative risk (ARR) = 1.53, 95% CI = 1.15–2.04). Residents who had experienced functional decline in the 6 months before surgery were more likely to decline after surgery (ARR = 1.21, 95% CI = 1.11–1.32). In general, nursing home residents in the poorest baseline MDS-ADL functional quartile were less likely than residents who had lower (better) MDS-ADL scores to lose function after surgery (ARR = 0.68, 95% CI = 0.60–0.76 for MDS-ADL quartile 4 vs quartile 1). Surgical complications (ARR = 1.11, 95% CI = 1.02–1.21) and hospital readmission after 30 days (ARR = 1.15, 95% CI = 1.03–1.29) were also associated with functional decline. Residents with missing functional status assessments at 1 year were on average 1 year older, had higher Charlson scores, and were more likely to be in the quartiles 2 and 3 of functional status than residents with functional assessments at 1 year (Appendix S3). In sensitivity analysis recoding

missing residents as having declined or maintained function, point estimates for relative risks of functional decline associated with resident characteristics were similar (Appendix S4).

Functional Status Trajectories

On average, MDS-ADL scores increased from 13.4 points (95% CI = 13.1–13.8) 1 month before surgery to 17.3 points (95% CI = 16.9–17.8) 1 year after surgery, indicating a decline in function from baseline (Figure 1A). In the mixed-effects model, the greatest increase (worsening) from baseline mean MDS-ADL scores (4.9 points) occurred between the preoperative and 1-month postoperative assessments (13.4 points to 18.3 points). Average MDS-ADL score 4 months after surgery was 16.0 (95% CI = 15.6–16.3). In the matched cohort of nursing home residents, the average MDS-ADL score increased 1.8 points after 1 year (Appendix S2).

In analysis stratified according to preoperative functional status, the magnitude of decline and recovery was greatest in the residents with MDS-ADL scores between

Table 2. Resident Characteristics Associated with 1-Year Mortality

Characteristic	Unadjusted 1-Year Mortality		Adjusted Hazard Ratio (95% Confidence Interval)	
	%	P-Value		P-Value
Age				
65–69	38.7	<.001	Reference	<.001
70–79	45.5		1.23 (0.96–1.58)	
≥80	51.6		1.75 (1.38–2.23)	
Sex				
Female	48.1	.004	Reference	.68
Male	51.8		0.98 (0.88–1.09)	
Race				
White	48.8	<.001	Reference	.01
Black	55.7		1.08 (0.98–1.20)	
Other	38.2		0.75 (0.59–0.95)	
Functional decline before surgery	52.3	.03	1.16 (1.06–1.27)	.002
Baseline Minimum Data Set Activity of Daily Living summary score according to quartile				
0–6	43.8	<.001	Reference	.003
7–14	47.3		1.07 (0.97–1.18)	
15–18	50.0		1.19 (1.08–1.32)	
19–28	56.1		1.26 (1.14–1.39)	
Charlson score				
0	47.3	.004	Reference	.07
1	46.3		1.01 (0.90–1.13)	
2	49.1		1.08 (0.96–1.20)	
≥3	51.7		1.12 (1.01–1.23)	
Readmitted after 30 days	43.6	<.001	0.38 (0.35–0.41)	<.001
Surgical complication	56.1	<.001	1.80 (1.65–1.96)	<.001
Urgent or emergent admission	54.0	<.001	1.39 (1.29–1.50)	<.001

Table 3. Resident Characteristics Associated with Functional Decline in 1-Year Survivors

Characteristic	Proportion of Residents Who Experienced Functional Decline		Adjusted Relative Risk of Functional Decline (95% Confidence Interval)	
	%	P-Value		P-Value
Age				
65–69	37.8	<.001	Reference	.001
70–79	48.1		1.31 (0.98–1.76)	
≥80	52.8		1.53 (1.15–2.04)	
Sex				
Female	50.8	.70	Reference	.23
Male	50.0		1.07 (0.96–1.21)	
Race				
White	50.4	.56	Reference	.15
Black	50.0		1.08 (0.96–1.21)	
Other	56.0		1.16 (0.97–1.38)	
Functional decline before surgery	59.9	<.001	1.21 (1.11–1.32)	<.001
Baseline Minimum Data Set Activity of Daily Living summary score quartiles				
0–6	54.1	<.001	Reference	<.001
7–14	60.7		1.10 (1.01–1.20)	
15–18	48.8		0.91 (0.82–1.00)	
19–28	35.9		0.68 (0.60–0.76)	
Charlson score				
0	55.4	<.001	Reference	.005
1	52.5		0.94 (0.85–1.03)	
2	52.8		0.92 (0.83–1.02)	
≥3	45.7		0.84 (0.77–0.93)	
Readmitted after 30 days	51.8	.001	1.15 (1.03–1.29)	.02
Surgical complication	55.3	.01	1.11 (1.02–1.21)	.01
Urgent or emergent admission	52.5	.01	1.10 (1.03–1.18)	.007
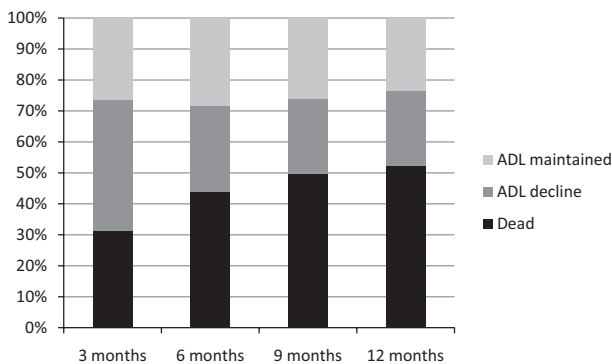
Figure 2. Proportion of residents who experienced activity of daily living (ADL) decline, maintenance of ADLs, and death.

0 and 6 (quartile 1) (Figure 1). Residents in quartile 1 experienced, on average, an increase in MDS-ADL score from 4.2 points (95% CI = 3.8–4.6) before surgery to 13.0 points (95% CI = 12.6–13.4) 1 month after surgery, followed by modest MDS-ADL score improvement to 8.5 points (95% CI = 8.1–9.0). At 1 year, average MDS-ADL scores had worsened to 10.1 points (95% CI = 9.5–10.8). In the most-dependent residents (MDS-ADL score 19–28,

quartile 4), changes in average MDS-ADL scores after surgery were small. Baseline MDS-ADL scores (22.7, 95% CI = 22.4–23.0) worsened on average by 1.2 points at 1 month, improved by 0.5 points at 4 months, and worsened by 0.6 points at 12 months.

DISCUSSION

Nursing home residents with colon cancer experience substantial functional decline after surgical resection. One-year mortality is high, and the majority of survivors do not return even to baseline levels of ADL functioning 1 year after surgery. Advanced age, surgical complications, hospital readmission, and preoperative functional decline were independently associated with decline in function after surgery. The magnitude of worsening and subsequent recovery in MDS-ADL scores after surgery was greatest in residents with the best MDS-ADL scores before surgery. Although the magnitude of recovery from the functional nadir was greatest in residents with the best baseline ADL function, the average decline from baseline at 1 year was greatest in this group, suggesting that residents most independent in performance of ADLs stand to lose the most

functionally after major surgery. Residents with the worst baseline MDS-ADL scores experienced smaller measurable functional decline because of "floor effects." Floor effects occur when scores are grouped at maximal poor functioning, which lowers the ability to detect clinically important changes in functional status.

To the knowledge of the authors, this is the first population-based study examining functional outcomes in a 100% national sample of elderly nursing home residents undergoing major surgery. This study calls into question findings from recent studies reporting that functional declines after cancer surgery in very elderly adults are transient and reversible. A study of 223 individuals aged 75 and older undergoing surgery for gastric and colorectal cancer, found that only 3% had persistent ADL decline 6 months after surgery.[4] Similarly, another study reported that functional status was significantly better 3 and 6 months after surgery than at baseline in community-dwelling elderly adults undergoing major cancer surgery,[3] but many studies include highly selected healthy elderly adults and rely on self-reported measures of functional status after surgery. In the current study, functional status was assessed longitudinally using validated ADL assessment scales performed quarterly by trained evaluators, decreasing the likelihood of follow-up bias.

The current study has several limitations. Mortality was high in the first year after surgery, and the number of nursing home residents who underwent functional assessments decreased over time. It is likely that average MDS-ADL scores improved as more disabled residents died. For this reason, functional recovery after surgery may have been overestimated. The fact that neither the MDS nor Medicare claims have information about cancer stage also limited the survival analysis. Because the Medicare Inpatient file and the MDS do not have information about outpatient services, complete information about adjuvant cancer treatments that may influence functional status was not available, although the use of adjuvant therapy in this frail population is probably infrequent. Prior research has found that only 6% of nursing home residents with cancer receive radiation or chemotherapy.[14] Because functional decline is common in the general nursing home population[15] and in elderly adults hospitalized for medical illnesses,[16] it is difficult to determine with certainty the contribution of surgery to the functional impairment observed 1 year after surgery, although a previous study found that, on average, the change in ADL dependence over 1 year in long-stay nursing home residents is 1 point or less.[17] In the current matched benchmark group of nursing home residents, functional decline was 1.8 points. Despite this limitation, the finding that rates of mortality and functional decline are high in residents selected for surgery—particularly the oldest old—should inform patient selection for surgery and provide realistic expectations about outcomes after surgery. Finally, because the analysis was limited to long-stay nursing home residents, the findings may not be generalizable to community dwelling elderly adults.

This study has important implications for surgical decision-making in nursing home residents. The majority of residents were admitted urgently or emergently for surgery, suggesting that they presented with an acute complication of their cancer (e.g., bleeding or obstruction). For truly life-limiting conditions, the mortality observed in this study was not high enough to suggest that surgery is futile, either to lengthen life or to palliate symptoms; nearly half of the nursing home residents who underwent surgery were alive at 1 year. Even when not curative, surgery for colon cancer may be an effective palliative procedure, although use of less invasive therapies may be an effective alternative to surgery for individuals with limited life expectancy. Endoscopic treatment or embolization of bleeding tumors may be a more-appropriate approach than operative therapy. Similarly, selective use of endoluminal stents for large bowel obstruction may be an effective, less-invasive option. Further work is needed to determine whether alternative therapeutic options may benefit individuals with limited life expectancy and to understand the effect of these therapies on physical functioning.

Information about the expected survival benefits and the likelihood of sustained functional decline after surgery will also help patients and caregivers set realistic expectations for surgical outcomes and inform decisions about whether to undergo surgery. Although many individuals with limited life expectancy are willing to undergo palliative procedures that have a high risk of mortality, they are most often reluctant to undergo surgery if there is a high likelihood of protracted postoperative functional decline.[2] Knowledge of expected outcomes can also help patients and physicians anticipate and prepare for difficult care decisions about life-sustaining interventions after surgery.

For nursing home residents who undergo surgery, quality improvement initiatives targeting surgical care in elderly adults may improve outcomes. Because surgical complications and hospital readmission are independently associated with functional decline after surgery, it is likely that improvements in acute surgical care will result in better functional outcomes in this population. Interventions specifically aimed at enhancing postoperative functional recovery may also prevent functional decline after surgery. For elderly adults admitted to the hospital with medical diagnoses, inpatient protocols for rehabilitation and prevention of disability have been shown to improve the ability of older adults to perform ADLs at the time of discharge.[18] It is likely that similar protocols would improve functional recovery in elderly adults undergoing surgery. The success of "fast track" protocols over the past decade in enhancing recovery in individuals undergoing colectomy should serve as a model for "geriatric track" protocols for elderly adults undergoing surgery.[19] Furthermore, the finding that functional recovery is protracted suggests that prolonged rehabilitation and restorative care in the nursing home after hospital discharge is important. Further work is needed to identify interventions targeted at improving functional recovery in nursing home residents after discharge from their surgical hospitalization.

ACKNOWLEDGMENTS

REFERENCES

1. O'Connell JB, Maggard MA, Ko CY. Cancer-directed surgery for localized disease: decreased use in the elderly. Ann Surg Oncol 2004;11:951–952.
2. Fried TR, Bradley EH, Towle VR et al. Understanding the treatment preferences of seriously ill patients. N Engl J Med 2002;346:1061–1066.
3. Van Cleave JH, Egleston BL, McCorkle R. Factors affecting recovery of functional status in older adults after cancer surgery. J Am Geriatr Soc 2010;59:34–43.
4. Amemiya T, Oda K, Ando M et al. Activities of daily living and quality of life after elective surgery for gastric and colorectal cancers. Ann Surg 2007;246:222–228.
5. Lawrence VA, Hazuda HP, Cornell JE et al. Functional independence after major abdominal surgery in the elderly. J Am Coll Surg 2004;199:762–772.
6. Deyo RA, Cherkin DC, Ciol MA. Adapting a clinical comorbidity index for use with ICD-9-CM administrative databases. J Clin Epidemiol 1992;45:613–619.
7. Charlson ME, Pompei P, Ales KL et al. A new method of classifying prognostic comorbidity in longitudinal studies: development and validation. J Chronic Dis 1987;40:373–383.
8. Morris JN, Fries BE, Mehr DR et al. MDS cognitive performance scale. J Gerontol 1994;49:M174–M182.
9. van Dijk PTM, Mehr DR, Ooms ME et al. Comorbidity and 1-year mortality risks in nursing home residents. J Am Geriatr Soc 2005;53:660–665.
10. Carpenter GI, Hastie CL, Morris JN et al. Measuring change in activities of daily living in nursing home residents with moderate to severe cognitive impairment. BMC Geriatr 2006;6:7.
11. Hawes C, Morris JN, Phillips CD et al. Reliability estimates for the Minimum Data Set for nursing home resident assessment and care screening (MDS). Gerontologist 1995;35:172–178.
12. Tamura M, Covinsky K, Chertow G et al. Functional status of elderly adults before and after initiation of dialysis. N Engl J Med 2009;361:1539–1547.
13. Harrell FJ. Regression Modeling Strategies. New York: Springer Publishing Company, 2001.
14. Bradley CJ, Clement JP, Lin C. Absence of cancer diagnoses and treatment in elderly Medicaid-insured nursing home residents. J Natl Cancer Inst 2008;100:21–31.
15. Li Y, Cai X, Mukamel DB et al. The volume-outcome relationship in nursing home care: an examination of functional decline among long-term care residents. Med Care 2010;48:52–57.
16. Boyd CM, Landefeld CS, Counsell SR et al. Recovery of activities of daily living in older adults after hospitalization for acute medical illnesses. J Am Geriatr Soc 2008;56:2171–2179.
17. McConnell ES, Branch LG, Sloane RJ et al. Natural history of change in physical function among long-stay nursing home residents. Nurs Res 2003;52:119–126.
18. Landefeld CS, Palmer RM, Kresevic DM et al. A randomized trial of care in hospital medical unit especially designed to improve the functional outcomes of acutely ill older patients. N Engl J Med 1995;332:1338–1344.
19. Gouvas N, Tan E, Windsor A et al. Fast-track vs standard care in colorectal surgery: a meta-analysis update. Int J Colorectal Dis 2009;24:1119–1131.

SUPPORTING INFORMATION

Additional Supporting Information may be found in the online version of this article:

Appendix S1. *International Classification of Diseases, Ninth Revision, clinical modification* (ICD-9-CM) codes used to identify colectomy cohort and complications.

Appendix S2. Functional decline and 1-year mortality in matched nursing home residents not undergoing surgery.

Appendix S3. Baseline characteristics of nursing home residents alive at 1 year.

Appendix S4. Sensitivity analysis: resident characteristics associated with functional decline in 1-year survivors.

Please note: Wiley-Blackwell is not responsible for the content or functionality of any supporting materials supplied by the authors. Any queries (other than missing material) should be directed to the corresponding author for the article.