Published in final edited form as:

Dis Colon Rectum. 2014 December ; 57(12): 1341–1348. doi:10.1097/DCR.0000000000000245.

Adjuvant Chemotherapy for T1 Node-Positive Colon Cancers Provides Significant Survival Benefit

Asvin M. Ganapathi, M.D.¹, Paul J. Speicher, M.D.¹, Brian R. Englum, M.D.¹, Anthony W. Castleberry, M.D., M.M.C.I.¹, John Migaly, M.D.¹, David S. Hsu, M.D., Ph.D.², and Christopher R. Mantyh, M.D.¹

¹Section of Colorectal Surgery, Department of Surgery, Duke University Medical Center, Durham, North Carolina

²Division of Medical Oncology, Department of Medicine, Duke University Medical Center, Durham, North Carolina

Abstract

BACKGROUND—Contemporary treatment of node-positive (N+) colon cancer consists of adjuvant chemotherapy; however, randomized data supporting this practice were derived from lesions T2 or greater. Minimal data exist regarding the use and need for adjuvant chemotherapy in T1N+ disease.

OBJECTIVE—The aim of this study was to determine treatment trends and the effects of adjuvant chemotherapy on T1N+ colon cancers by using the National Cancer Database.

DESIGN—This was a retrospective study. Baseline demographics, tumor, and cancer treatment characteristics were compared. Groups were matched on the propensity to receive chemotherapy. Adjusted long-term survival stratified by chemotherapy use was compared by using the Kaplan-Meier method with the log-rank test. Predictors of not receiving chemotherapy were identified by using a multivariable logistic regression model.

SETTINGS—Data were collected from the National Cancer Database, which collects cancer data from over 1500 cancer centers.

PATIENTS—We identified patients from 1998 to 2006 with T1N+ disease, excluding those with metastatic disease or previous cancer. Patients were stratified based on whether or not they received chemotherapy.

MAIN OUTCOME MEASURES—The primary outcome measure of this study was long-term survival.

© The ASCRS 2014

Correspondence: Christopher R. Mantyh, M.D., Duke University Medical Center, Durham, NC 27710. christopher.mantyh@duke.edu.

Supplemental digital content is available for this article. Direct URL citations appear in the printed text, and links to the digital files are provided in the HTML and PDF versions of this article on the journal's Web site (www.dcrjournal.com)

Financial Disclosures: None reported.

Podium presentation at the meeting of The American Society of Colon and Rectal Surgeons, Hollywood, FL, May 17 to 21, 2014.

RESULTS—Three thousand one hundred thirty-seven patients had T1N+ disease; 70.6% (n = 2216) received chemotherapy, and utilization significantly increased from 1998 to 2011 ($p < 0.001$). Unadjusted analysis revealed that patients treated with chemotherapy were statistically younger and healthier, and had shorter postoperative lengths of stay (all $p < 0.001$). Unadjusted 5-year survival was higher in patients receiving chemotherapy (87.9% vs 63.0% in patients with no chemotherapy; $p < 0.001$) and this persisted after propensity matching with (83.4% and 63.0% in patients with or without chemotherapy; $p < 0.001$). Only age (OR, 0.29; $p < 0.001$) predicted not receiving chemotherapy.

LIMITATIONS—Limitations include potential selection bias as well as the inability to compare disease-free survival/ recurrence.

CONCLUSIONS—Adjuvant chemotherapy appears to significantly improve long-term survival in patients receiving chemotherapy in T1N+ disease. Thus, the use of chemotherapy in T1N+ disease is justified and provides a highly significant survival benefit.

Keywords

Colon cancer; Abdominal malignancy; Outcomes research

Colon cancer represents one of the most common causes of cancer and cancer-related death in the United States and Western countries.¹ Following surgical treatment, the presence of lymph node metastasis has been associated with a poor prognosis, as has inadequate lymph node retrieval.^{2–5} However, the use of adjuvant chemotherapy, particularly oxaliplatin, has been demonstrated to provide a significant survival benefit for patients with lymph node disease.^{6–8}

Although the benefits of adjuvant chemotherapy have been well described, a notable group of patients with node-positive disease often do not receive adjuvant chemotherapy.⁹ In particular, there is a paucity of outcome data concerning the proportion of patients with T1 node-positive disease. Although these patients represent a smaller proportion of patients who have node-positive colon cancer, compared with patients who have T2, T3, or T4 disease, approximately 3% to 17% of patients with a surgically staged T1 tumor will be found to be node positive.^{10,11} It is noteworthy that, in the seminal clinical trial establishing the benefit of the modern chemotherapeutic regimen for stage III disease with oxaliplatin, patients with T1 disease were not included.⁶

Thus, the purpose of this study was to examine the use and effect of chemotherapy in patients with pathologic T1 colon cancer with lymph node involvement by the use of a large national cancer database.

METHODS

Patients and Data Source

This study used the National Cancer Database (NCDB), which is a cooperative data set between the Commission on Cancer, the American Cancer Society, and the American College of Surgeons that collects cancer data from more than 1500 cancer centers in the United States and Puerto Rico. The database collects information on approximately 70% of

all newly diagnosed cancer cases. Our analysis used the NCDB 1998 to 2011 Participant Use File for colon and rectal cancer.

We identified all patients in the Participant Use File with colon cancer and histologic diagnosis of adenocarcinoma (*International Classification of Diseases for Oncology*, 3rd Edition histology codes of 8140, 8210, 8211, 8261, 8262, 8263, 8480, and 8481). Patients with previous malignancies and positive surgical margins were excluded. All patients undergoing major surgical resection and having a pathologic tumor stage of T1 were identified and then classified as node negative (T1N0) or node positive (T1N+). Of the patients with T1N+ disease, further stratification was done based on whether or not the patient received adjuvant chemotherapy. Only patients with a cancer location of the cecum, right colon, hepatic flexure, transverse colon, splenic flexure, descending colon, or sigmoid colon were included to eliminate any lesions that had potential small-bowel or rectal involvement. Because survival data were only available for cases from 1998 to 2006, only cases from these years were included for patient and survival analysis. However, all patients from 1998 to 2011 were included when estimating the use of adjuvant therapy and trends over time. Because our primary variable of interest was the use of adjuvant chemotherapy, all patients who died within 30 days of their operation were excluded from all analyses to avoid bias against the surgery-only group owing to the inclusion of patients who were never considered for adjuvant therapy.

Outcomes

The primary outcome of interest was long-term survival, defined as the time interval between diagnosis of colon cancer and death. Secondary outcomes that were analyzed included trends in the usage of adjuvant chemotherapy among patients with T1N+ disease, estimation of independent predictors of not receiving chemotherapy, and a comparison of long-term survival in patients with T1N+ disease (with and without chemotherapy) with patients with T1N0 disease.

Statistical Methods

Following stratification of T1N+ patients into those receiving adjuvant chemotherapy and those not receiving adjuvant chemotherapy, patient and tumor characteristics were compared by using the Kruskal-Wallis analysis of variance and Pearson χ^2 test for continuous and categorical variables. The Cochran-Armitage trend test was used to determine if there were any significant changes in the use of adjuvant chemotherapy over time. To adjust for treatment bias due to measured confounders, propensity scores were developed that we defined as the conditional probability of a patient with T1N+ disease being treated with adjuvant chemotherapy. The clinically relevant variables that were used to calculate the propensity to receive chemotherapy were: age, sex, distance to hospital, Charlson comorbidity score, year of diagnosis, days from diagnosis to surgery, hospital length of stay after surgery, number of positive lymph nodes and nodes examined, surgical margins, tumor size, patient location (urban, metro, or rural), facility type (academic, comprehensive community, or community cancer center), insurance status, and average income and education level stratified by patient zip code. Patients were then matched on propensity score using a 1:1 nearest neighbor matching algorithm, and balance was assessed. Missing

data present in the propensity model were imputed by using the methods described by D'Agostino and Rubin,¹² in which indicator variables were created for missing values. Characteristics were compared by using standardized differences.¹³ Long-term survival was estimated by using the Kaplan-Meier method, with both unadjusted and propensity-adjusted survival between groups compared with the log-rank test. To examine the independent effect of adjuvant chemotherapy on long-term survival among our study population, a multivariable Cox proportional hazards model was developed.

Model diagnostics and balance were assessed. A p value of <0.05 was considered statistically significant, and we controlled for type I error at the level of each comparison. Missing data were handled with complete case analysis given the substantial completeness of the NCDB for the study population of interest. All statistical analyses were performed by using R version 3.0.2 (R Foundation for Statistical Computing, Vienna, Austria).

RESULTS

Using the aforementioned selection criteria, 36,468 patients with pathologic T1 disease were identified from 1998 to 2006. Of these 8.6% ($n = 3137$) had lymph node involvement, of which more than two-thirds ($n = 2215$; 70.6%) received chemotherapy. Examination of time trends of the use of chemotherapy indicated that a significant increase in use occurred from 1998 ($<65\%$) to 2011 (almost 75%), with the largest increase in use occurring between 2001 and 2003 ($p < 0.001$). The highest rate of administration of adjuvant chemotherapy in T1N+ patients was just above 80% and most recently was closer to 75% (Fig. 1).

Before adjustment with propensity analysis, there were numerous differences between the groups including patients receiving chemotherapy being younger, having less comorbid disease burden, and being more likely to have private insurance. Additionally, patients receiving chemotherapy were more likely to have a shorter postoperative length of stay and a decreased readmission rate as well (Supplemental Tables 1 and 2; <http://links.lww.com/DCR/A163> and <http://links.lww.com/DCR/A164>). Before adjustment, the patients who received chemotherapy had improved long-term survival compared with those who did not receive chemotherapy (Fig. 2A). The 5-year survival with chemotherapy for T1N+ disease was 87.9% (median survival, 171.3 months), whereas only 63.0% of patients who did not receive chemotherapy survived for 5 years (median survival, 92.2 months).

Following propensity matching, the groups were highly similar (Tables 1 and 2). Notably, the readmission rate following surgery remained higher in the nonchemotherapy group. Five-year survival in the chemotherapy group was still significantly higher (83.4%; median survival, 144.9 months) with clear separation of Kaplan-Meier survival curves (Fig. 2B).

Secondary analysis to identify risk factors associated with not getting chemotherapy identified only age (OR, 2.29 per increasing decade; $p < 0.001$) as being significantly associated with no chemotherapy for T1N+ disease. Notably, insurance status, race, and increasing Charlson comorbidity scores were not independently associated with not getting chemotherapy (Table 3). In addition, analysis comparing survival of T1N+ disease, with and without chemotherapy, revealed that patients receiving chemotherapy had a statistically

significant higher long-term survival relative to T1N0 disease, with a Cox-proportional hazard model identifying chemotherapy as beneficial to long-term survival in comparison with patients with T1N0 disease (Fig. 3; HR of death for T1N+ disease with chemotherapy, 0.79; $p = 0.02$).

DISCUSSION

Our study demonstrates that the use of adjuvant chemotherapy for patients with T1N+ disease has increased since 1998 and appears to provide a significant survival advantage. Additionally, it appears that patients with T1N+ disease who receive chemotherapy appear to have equivalent survival to patients with T1N0 disease. Notably, a significant minority of patients with T1N+ disease did not receive adjuvant chemotherapy, even though they should according to the current National Comprehensive Cancer Network guidelines.¹⁴ Based on the results presented, it appears that increasing age is most likely associated with not receiving chemotherapy.

As previously stated, the standard of care for patients with lymph node involvement is adjuvant chemotherapy given its demonstrated survival advantage. The seminal trial by Moertel et al⁷ in 1990 demonstrated that there was a significant survival advantage in patients with nodal involvement who received adjuvant chemotherapy. Additionally, oxaliplatin was demonstrated to provide an added benefit by the MOSAIC trial in 2004⁶; however, in both of these studies, patients with T1 disease were scarce or not included. T1 disease has been estimated to comprise a little over 10% of all colon cancers,¹⁵ with approximately 3% to 17% of these patients having lymph node metastasis,^{16,17} but there is a paucity of data to drive treatment decisions regarding these patients.¹⁸ As a result, other groups have attempted to examine these patients to gain a better understanding of the natural history of their disease. Most efforts on this disease subset have focused on predictors of lymph node metastasis with lymphatic vessel invasion, histologic grade, inflammation around the tumor, as well as high-grade tumor budding being identified as independent predictors of lymph node involvement.^{15,16,18,19} However, given the relatively rare nature of this disease, there has been limited assessment of the survival in these patients particularly in the modern era. Most studies are from single institutions and span long periods, thus limiting the generalizability specifically with regard to the use of modern chemotherapeutic regimens as well as institutional variability in care.¹⁶

Our data demonstrate that the survival advantage provided by adjuvant chemotherapy applies to patients with T1 disease. In the significant minority of patients not receiving adjuvant chemotherapy, there was a reduced 5-year overall survival (63.0% vs 83.4% for patients receiving chemotherapy) as well as a significantly diminished median overall survival (92.2 months vs 144.9 months for patients receiving chemotherapy; $p < 0.001$). This is strikingly similar to the MOSAIC trial, which demonstrated an overall mortality reduction of 16% at 6 years with adjuvant chemotherapy.²⁰ Although other factors could have contributed to this mortality difference, our use of a propensity analysis helped to reduce bias, particularly with regard to patient age, tumor location, and tumor size. It was also interesting to note that the overall survival in patients with T1N+ disease who received chemotherapy had 5-year survival that appears to be at least equivalent to patients with

T1N0 disease, even after adjustment with a Cox proportional hazards model. Although the overall survival was higher in the T1N+ group than in the T1N0 group, this is probably the result of bias that we were unable to account for. However, these results further strengthen the importance of adjuvant chemotherapy in patients with T1N+ disease. Further studies would be necessary to confirm that chemotherapy provides comparable survival to T1N0 disease, specifically examining disease-free interval and cancer-specific mortality.

Given this significant advantage, perhaps the most important aspect of our results is that approximately 25% of patients who have T1N+ disease do not receive adjuvant chemotherapy despite randomized evidence regarding adjuvant therapy being available for over 20 years,⁷ and our data demonstrating a 5-year survival rate of nearly 90% with chemotherapy. Although many factors appeared to be associated with not receiving chemotherapy before adjustment, only advancing age was identified to be an independent predictor of T1N+ patients not receiving adjuvant chemotherapy. Notably, insurance status, race, center classification (academic or community), and Charlson comorbidity score were not associated with not receiving chemotherapy. Other factors that might have been associated with the lack of receiving chemotherapy may have been the presence of postoperative complications; however, the NCDB does not offer data about postoperative complications, preventing proper adjustment for this risk factor. It is unclear if advanced age was identified as a risk factor for not receiving chemotherapy because of potential associated comorbidities that may prevent the administration of chemotherapy. However, there are data describing how elderly patients are less likely to receive chemotherapy, in general, and our results likely support these claims.^{9,21,22} Whereas previous studies described a lack of benefit in chemotherapy in elderly patients, recent data have demonstrated that the benefit is not lost and that that elderly patients do not have a different response with regard to chemotherapeutic toxicity.²³ Given this disparity and the associated benefit of chemotherapy, surgeons and medical oncologists must ensure that elderly patients are aware of the implications of not receiving chemotherapy, such that elderly patients and their families can make informed decisions about the use of adjuvant chemotherapy.

Similarly, although other factors were not identified to be independent predictors, given that approximately one-fourth of all T1N+ patients do not receive adjuvant chemotherapy, clinicians must focus on methods to ensure high access to this important therapy. One important barrier to receiving adjuvant chemotherapy is postoperative complications such as wound infections and anastomotic leak.²⁴ As previously mentioned, we were unable to adjust for this potential confounder; however, there was a higher readmission rate in the propensity-matched cohort of patients who did not receive chemotherapy. It is important to note, however, that we were unable to adjust for readmission rate in our propensity match because of the significant amount of missing data for this variable. Another factor that clinicians must consider in the treatment of these patients is the optimization of patient health to allow these patients to receive postoperative chemotherapy. Moreover, although not specifically examined here, minimally invasive options such as laparoscopic or robotic surgery may provide opportunities to improve the use of adjuvant chemotherapy. Although neither distance to cancer center nor patient location (metro, urban, or rural) were identified as risk factors, they may still be contributing factors for a lack of chemotherapy in these patients. Additionally, treating physicians must be sure to emphasize the drastic benefit that

chemotherapy offers so that patients understand the consequences and decreased survival associated with not getting adjuvant chemotherapy.

LIMITATIONS

This study does have some notable limitations, primarily the fact that it is retrospective in nature. Additionally, although the NCDB provides comprehensive cancer-specific variables, the lack of disease-free survival as well as cancer-specific survival prevents one from ensuring that the difference observed was solely based on oncologic outcomes. This may confound our interpretation of survival, because patients may have died of non-cancer-related causes, specifically given their advanced age. As a result, the benefit of chemotherapy demonstrated may appear more pronounced than it actually is. However, we used a propensity match to minimize differences, and, following the match, the patient age in both groups was reasonably similar, as was Charlson comorbidity score, and hopefully this method minimized bias. Another potential limitation of the study is that details specific to the surgery are not well described in the NCDB, and, thus, there may have been a group of patients who did not have chemotherapy owing to postoperative complications. We attempted to control for this by excluding any patient who died within 30 days of operation, but patients with wound infections or other complications could not be identified. However, all of these aforementioned factors may have contributed to selection bias, where the observed increase in survival in patients receiving chemotherapy may have been secondary to the selection of patients who were less sick than those who did not receive adjuvant chemotherapy. Finally, it should be noted that the majority of the survival data came from 1998 to 2004, which was before the data on the use of oxaliplatin/5-fluorouracil/leucovorin (FOLFOX) became available, and this may have affected our findings on survival.

CONCLUSIONS

Patients with T1N+ colon cancer have a significant survival advantage when adjuvant chemotherapy is used; however, a significant minority of patients still does not receive adjuvant therapy. Clinicians treating these patients need to make every effort to ensure these patients receive this therapy.

Supplementary Material

Refer to Web version on PubMed Central for supplementary material.

REFERENCES

1. Jemal A, Siegel R, Ward E, Hao Y, Xu J, Thun MJ. Cancer statistics, 2009. *CA Cancer J Clin.* 2009; 59:225–249. [PubMed: 19474385]
2. Sobin LH, Greene FL. TNM classification: clarification of number of regional lymph nodes for pNo. *Cancer.* 2001; 92:452. [PubMed: 11466702]
3. Nelson H, Petrelli N, Carlin A, et al. National Cancer Institute Expert Panel. Guidelines 2000 for colon and rectal cancer surgery. *J Natl Cancer Inst.* 2001; 93:583–596. [PubMed: 11309435]
4. Benson AB 3rd, Arnoletti JP, Bekaii-Saab T, et al. National Comprehensive Cancer Network. Colon cancer. *J Natl Compr Canc Netw.* 2011; 9:1238–1290. [PubMed: 22056656]

5. Resch A, Langner C. Lymph node staging in colorectal cancer: old controversies and recent advances. *World J Gastroenterol.* 2013; 19:8515–8526. [PubMed: 24379568]
6. André T, Boni C, Mounedji-Boudiaf L, et al. Multicenter International Study of Oxaliplatin/5-Fluorouracil/Leucovorin in the Adjuvant Treatment of Colon Cancer (MOSAIC) Investigators. Oxaliplatin, fluorouracil, and leucovorin as adjuvant treatment for colon cancer. *N Engl J Med.* 2004; 350:2343–2351. [PubMed: 15175436]
7. Moertel CG, Fleming TR, Macdonald JS, et al. Levamisole and fluorouracil for adjuvant therapy of resected colon carcinoma. *N Engl J Med.* 1990; 322:352–358. [PubMed: 2300087]
8. Zaniboni A. Adjuvant chemotherapy in colorectal cancer with high-dose leucovorin and fluorouracil: impact on disease-free survival and overall survival. *J Clin Oncol.* 1997; 15:2432–2441. [PubMed: 9196159]
9. Steele SR, Park GE, Johnson EK, et al. The impact of age on colorectal cancer incidence, treatment, and outcomes in an equal-access health care system. *Dis Colon Rectum.* 2014; 57:303–310. [PubMed: 24509451]
10. Chok KS, Law WL. Prognostic factors affecting survival and recurrence of patients with pT1 and pT2 colorectal cancer. *World J Surg.* 2007; 31:1485–1490. [PubMed: 17510767]
11. Wang H, Wei XZ, Fu CG, Zhao RH, Cao FA. Patterns of lymph node metastasis are different in colon and rectal carcinomas. *World J Gastroenterol.* 2010; 16:5375–5379. [PubMed: 21072903]
12. D’Agostino RB, Rubin DB. Missing data estimating and using propensity scores with partially missing data. *J Am Statist Assoc.* 2000; 95:749–759.
13. Austin PC. Using the standardized difference to compare the prevalence of a binary variable between two groups in observational research. *Commun Stat Simul Comput.* 2009; 38:1228–1234.
14. [Accessed April 4, 2014] NCCN Guidelines Version 3.2014 Colon Cancer. Available at http://www.nccn.org/professionals/physician_gls/pdf/colon.pdf.
15. Okabe S, Shia J, Nash G, et al. Lymph node metastasis in T1 adenocarcinoma of the colon and rectum. *J Gastrointest Surg.* 2004; 8:1032–1040. [PubMed: 15585391]
16. Wang HS, Liang WY, Lin TC, et al. Curative resection of T1 colorectal carcinoma: risk of lymph node metastasis and long-term prognosis. *Dis Colon Rectum.* 2005; 48:1182–1192. [PubMed: 15793641]
17. Suzuki T, Sadahiro S, Mukoyama S, et al. Risk of lymph node and distant metastases in patients with early invasive colorectal cancer classified as Haggitt’s level 4 invasion: image analysis of submucosal layer invasion. *Dis Colon Rectum.* 2003; 46:203–208. [PubMed: 12576894]
18. Sakuragi M, Togashi K, Konishi F, et al. Predictive factors for lymph node metastasis in T1 stage colorectal carcinomas. *Dis Colon Rectum.* 2003; 46:1626–1632. [PubMed: 14668587]
19. Nakadoi K, Oka S, Tanaka S, et al. Condition of muscularis mucosae is a risk factor for lymph node metastasis in T1 colorectal carcinoma. *Surg Endosc.* 2014; 28:1269–1276. [PubMed: 24281433]
20. André T, Boni C, Navarro M, et al. Improved overall survival with oxaliplatin, fluorouracil, and leucovorin as adjuvant treatment in stage II or III colon cancer in the MOSAIC trial. *J Clin Oncol.* 2009; 27:3109–3116. [PubMed: 19451431]
21. Jorgensen ML, Young JM, Dobbins TA, Solomon MJ. Does patient age still affect receipt of adjuvant therapy for colorectal cancer in New South Wales, Australia? *J Geriatr Oncol.* 2014; 5:323–330. [PubMed: 24656735]
22. Schrag D, Cramer LD, Bach PB, Begg CB. Age and adjuvant chemotherapy use after surgery for stage III colon cancer. *J Natl Cancer Inst.* 2001; 93:850–857. [PubMed: 11390534]
23. Hamza S, Bouvier AM, Rollot F, Lepage C, Faivre J, Bedenne L. Toxicity of oxaliplatin plus fluorouracil/leucovorin adjuvant chemotherapy in elderly patients with stage III colon cancer: a population-based study. *Ann Surg Oncol.* 2014; 21:2636–2641. [PubMed: 24639190]
24. Merkow RP, Bentrem DJ, Mulcahy MF, et al. Effect of postoperative complications on adjuvant chemotherapy use for stage III colon cancer. *Ann Surg.* 2013; 258:847–853. [PubMed: 24169157]

Figure 1.
Use of adjuvant chemotherapy from 1998 to 2011.

Figure 2.

A, Unadjusted long-term survival of T1N+ colon cancer with/without chemotherapy (Chemo). B, Propensity-matched long-term survival of T1N+ colon cancer with/without chemotherapy.

Figure 3. Long-term survival of T1N0 vs T1N+ colon cancer with/without chemotherapy (Chemo; results of Cox proportional hazards model shown below curves).

Table 1

Propensity-matched patient characteristics

Variable	T1N+ no chemo (N = 921)	T1N+ chemo (N = 921)	Standard difference ^a
Age in years (IQR)	73 (63–80)	72 (63–77)	13
Female, n (%)	482 (52.3)	468 (50.8)	3
Distance to hospital, miles (IQR)	6.6 (3–13.6)	6.6 (3.2–13.8)	7
Location type, n (%)			2
Metro	745 (85.5)	741 (85.7)	
Urban	109 (12.5)	109 (12.6)	
Rural	17 (2)	15 (1.7)	
Charlson score, n (%)			8
0	261 (67.1)	270 (70.9)	
1	97 (24.9)	83 (21.8)	
2	31 (8)	28 (7.3)	
Race, n (%)			4
White	754 (82.8)	762 (83.6)	
Black	131 (14.4)	121 (13.3)	
Other	26 (2.9)	29 (3.2)	
Education above median, n (%)	535 (61.3)	540 (61.9)	1
Income above median, n (%)	587 (67.2)	601 (68.8)	3
Insurance status, n (%)			5
Private	279 (31)	293 (32.5)	
Medicare	589 (65.4)	573 (63.5)	
Medicaid	23 (2.6)	23 (2.5)	
Government	1 (0.1)	1 (0.1)	
Uninsured	9 (1)	12 (1.3)	
Academic vs community cancer center			1
Academic/research program, n (%)	236 (27)	234 (26.7)	
Community program, n (%)	639 (73)	643 (73.3)	

IQR = interquartile range; chemo = chemotherapy.

^aStandard differences are displayed in percent. Standard differences of less than 20% indicate a negligible difference for a particular covariate between groups.

Table 2

Propensity-matched surgery and tumor-specific characteristics

Variable	T1N+ no chemo (N = 921)	T1N+ chemo (N = 921)	Standard difference ^a
Days to surgery ^b	4 (0–22)	8 (0–24)	2
Number of positive nodes	1 (1–2)	1 (1–2)	3
Number of nodes examined	10 (6–16)	10 (6–16)	2
Tumor grade			3
Well differentiated	135 (15.6)	118 (13.7)	
Moderately differentiated	580 (67.2)	587 (68.3)	
Poorly differentiated	143 (16.6)	149 (17.3)	
Undifferentiated/anaplastic	5 (0.6)	5 (0.6)	
N stage			2
N1	862 (93.6)	866 (94)	
N2	59 (6.4)	55 (6)	
Site of tumor			8
Cecum	198 (21.5)	193 (21)	
Descending colon	48 (5.2)	57 (6.2)	
Hepatic flexure of colon	31 (3.4)	26 (2.8)	
Right colon	166 (18)	172 (18.7)	
Sigmoid colon	412 (44.7)	409 (44.4)	
Splenic flexure of colon	23 (2.5)	17 (1.8)	
Transverse colon	43 (4.7)	47 (5.1)	
Tumor size			5
<5 cm	594 (86.2)	598 (87.7)	
5–9.9 cm	87 (12.6)	75 (11)	
10.0–19.9 cm	6 (0.9)	7 (1)	
>20.0 cm	2 (0.3)	2 (0.3)	
Postoperative length of stay (days)	6 (4–8)	6 (4–7)	9
Readmission (30 day)	31 (8.2)	27 (7.3)	3

All values displayed as median (interquartile range) or number (%).

chemo = chemotherapy.

^aStandard differences are displayed as percent. Standard differences of less than 20% indicate a negligible difference for a particular covariate between groups.^bDays to surgery represents the number of days from diagnosis to definitive oncologic resection.

Table 3

Predictors of not receiving chemotherapy

Predictor	OR	Lower 95% CI	Upper 95% CI	p
Age (per decade)	2.29	1.89	2.76	<0.001
Female	0.90	0.66	1.23	0.52
Race (ref = white)				
Black	1.32	0.83	2.10	0.25
Other	0.81	0.31	2.12	0.67
Charlson score (ref = 0)	1.10	0.86	1.42	0.45
Insurance status (ref = private)				
Medicare	0.86	0.56	1.31	0.48
Medicaid	2.23	0.81	6.14	0.12
Government	0.00	0.00	100.00	0.98
Uninsured	0.50	0.06	4.12	0.52
Education above median	0.74	0.51	1.07	0.11
Income above median	0.97	0.66	1.42	0.87
Tumor size (per mm)	1.00	1.00	1.00	0.29
Academic program (vs community)	1.04	0.74	1.48	0.82
Tumor grade (ref = well differentiated)				
Moderately differentiated	1.06	0.68	1.65	0.81
Poorly differentiated	0.75	0.43	1.33	0.33
Undifferentiated	3.22	0.52	20.00	0.21
Number of positive nodes (per node)	1.03	0.93	1.13	0.62