Original Contribution

Tumor Board Participation Among Physicians Caring for Patients With Lung or Colorectal Cancer

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Abstract

Purpose: Multidisciplinary tumor board meetings are common in cancer care, but limited evidence is available about their benefits. We assessed the associations of tumor board participation and structure with care delivery and patient outcomes.

Methods: As part of the CanCORS study, we surveyed 1,601 oncologists and surgeons about participation in tumor boards and specific tumor board features. Among 4,620 patients with lung or colorectal cancer diagnosed from 2003 to 2005 and seen by 1,198 of these physicians, we assessed associations of tumor board participation with patient survival, clinical trial enrollment, guideline-recommended care, and patient-reported quality, adjusting for patient and physician characteristics.

Results: Weekly physician tumor board participation (*v* participation less often or never) was not associated with patient survival, although in exploratory subgroup analyses, weekly participation was associated with lower mortality for extensive-stage small-cell lung cancer and stage IV colorectal cancer. Patients treated by the 54% of physicians participating in tumor boards weekly (*v* less often or never) were more likely to enroll onto clinical trials (odds ratio [OR], 1.6; 95% CI, 1.1 to 2.2). Patients with stage I to II non–small-cell lung cancer (NSCLC) whose physicians participated in tumor boards weekly were more likely to undergo curative-intent surgery (OR, 2.9; 95% CI, 1.3 to 6.8), although those with stage I to II NSCLC whose physicians' meetings reviewed > one cancer site were less likely to undergo curative-intent surgery (OR, 0.1; 95% CI, 0.03 to 0.4).

Conclusion: Among patients with lung or colorectal cancer, frequent physician tumor board engagement was associated with patient clinical trial participation and higher rates of curative-intent surgery for stage I to II NSCLC but not with overall survival.

Introduction

Tumor board conferences allow cancer care providers to discuss patient cases in multidisciplinary settings, and they also serve educational functions.[1,2] These meetings are cornerstones of the American College of Surgeons Commission on Cancer accreditation program.[3] Tumor boards have been prevalent for years.[4] Nevertheless, participation patterns vary; for example, one study of breast cancer providers found that high-volume medical oncologists participated in tumor board meetings more frequently than low-volume surgeons.[5]

Few studies have investigated the nature of tumor board discussions or their impact on patient care and outcomes. One survey of Oregon hospitals found that tumor board recommendations were generally implemented.[6] Two single-institution studies reviewed records of patients discussed at tumor boards and found that the meetings changed surgical recommendations for more than half of patients with breast cancer[7] and overall treatment recommendations in 23.6% of patient cases of pancreatic cancer.[8] In one Veterans Affairs (VA) medical center, for patient cases of rectal cancer presented at tumor boards, guideline-recommended therapy was more likely to be administered.[9] However, a recent national study of VA medical centers found few associations between tumor boards and either patient survival or process measures, such as adjuvant chemotherapy for stage III colon cancer and surgery for stage I to II non–small-cell lung cancer (NSCLC).[10,11] The study ascertained the presence of general or cancer-specific tumor boards at each center, but information about tumor board meeting structure was not available.

In this study, we used data from the CanCORS (Cancer Care Outcomes Research and Surveillance)[12] study to characterize tumor board participation and features of tumor board meetings among physicians caring for a large, population- and health system–based cohort of patients with lung or colorectal cancer. We assessed associations between physician or practice traits and tumor board characteristics. We also examined associations between tumor boards and patient overall survival, clinical trial enrollment, delivery of guideline-recommended treatment, patient-reported quality of care, and patient ratings of health care team communication.

Methods

Study Design

CanCORS is a prospective observational study assessing care patterns and outcomes for patients with lung or colorectal cancer diagnosed between 2003 and 2005.[12] Patients lived within one of five geographic regions (northern California, Los Angeles County, North Carolina, Iowa, or Alabama) or received care in one of five health maintenance organizations or 15 VA cen-

Table 1. Characteristics of Physicians and Patient-Physician Links

Characteristic	Physicians		Patient-Physician Links	
	No.	%	No.	%
Total	1,601	100.0	4,620	100.0
	Physicians			
Tumor board participation				
Never	67	4.2	140	3.0
< Quarterly	132	8.2	407	8.8
Quarterly	132	8.2	346	7.5
Monthly	408	25.5	1,301	28.2
Weekly	862	53.8	2,426	52.5
Tumor board serves pretreatment planning function*				
No	258	17.6	828	19.4
Yes	1,207	82.4	3,434	80.6
Tumor board includes evaluation of treatment decisions*				
No	113	7.7	315	7.5
Yes	1,351	92.3	3,898	92.5
Tumor board reviews only challenging patient cases*				
No	602	41.3	1,688	39.7
Yes	856	58.7	2,563	60.3
Tumor board reviews variety of cancer sites*				
No	189	13.0	399	9.5
Yes	1,271	87.1	3,820	90.5
Tumor board serves only as teaching session*				
No	1,278	87.9	3,740	89.0
Yes	176	12.1	461	11.0
Age, years				
< 40	356	22.2	617	13.4
40 to 49	459	28.7	1,512	32.7
50 to 54	253	15.8	999	21.6
55 to 59	250	15.6	788	17.1
≥ 60	276	17.2	691	15.0
Not ascertained	7	0.4	13	0.3
Sex				
Male	1,312	82.0	3,913	84.7
Female	272	17.0	659	14.3
Not ascertained	17	1.1	48	1.0
Specialty				
Medical oncologist	529	33.0	1877	40.6
Radiation oncologist	235	14.7	450	9.7
Thoracic surgeon	130	8.1	491	10.6
Colorectal surgeon or surgical oncologist	111	6.9	433	9.4
General surgeon	596	37.2	1369	29.6
Practice structure				
HMO	272	17.0	1,223	26.5
VA or government	241	15.1	88	1.9
Office				
Solo practice	179	11.2	427	9.2
One-specialty group	357	22.3	1,305	28.3
≥ Two-specialty group	106	6.6	398	8.6
Hospital	446	27.9	1,179	25.5

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Table 1. (continued)

Characteristic	Physicians		Patient-Physician Links	
	No.	%	No.	%
Teacher (medical students or residents)				
No	756	47.2	2,321	50.2
Yes	821	51.3	2,236	48.4
Not ascertained	24	1.5	63	1.4
NCI cancer center affiliation				
No	853	53.3	2,714	58.7
Yes	434	27.1	1,029	22.3
Do not know	296	18.5	836	18.1
Not ascertained	18	1.1	41	0.9
CCOP affiliation				
No	526	32.9	1,396	30.2
Yes	525	32.8	1,827	39.6
Do not know	532	33.2	1,352	29.3
Not ascertained	18	1.1	45	1.0
No. of patients per month				
Colorectal	1,546		4,445	
Mean	7.9		10.4	
SD	12.0		15.6	
Lung	1,543		4,444	
Mean	8.4		11.6	
SD	16.5		20.1	
Patient's cancer type			4,425	
Mean			14.5	
SD			20.4	
Patients				
Survey type				
Full survey			3,031	65.6
Surrogate				
Living patient			453	9.8
Deceased patient			506	11.0
Brief survey			630	13.6
Age, years				
< 57			1,097	23.7
57 to 64			893	19.3
65 to 71			960	20.8
71 to 78			922	20.0
> 78			748	16.2
Not ascertained			2	0.0
Sex				
Male			2,387	51.7
Female			2,233	48.3
Race				
White			3,279	71.0
African American			490	10.6
Other			851	18.4

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Table 1. (continued)

Characteristic	Physicians		Patient-Physician Links	
	No.	%	No.	%
Marital status				
Unmarried			1,584	34.3
Married or partnered			2,876	62.3
Not ascertained			160	3.5
Educational attainment				
< High school			826	17.9
High school graduate			2,580	55.8
College graduate			1,165	25.2
Not ascertained			49	1.1
Annual income†				
< $20,000			971	21.0
$20,000 to $39,999			1,064	23.0
$40,000 to $59,999			650	14.1
≥ $60,000			962	20.8
Not ascertained			973	21.1
Cancer type				
Colon			1,747	37.8
Rectal			537	11.6
Colorectal (unknown site)			204	4.4
NSCLC			1,908	41.3
SCLC			224	4.9
Stage at diagnosis				
I			1,049	22.7
II			904	19.6
III			1,489	32.2
IV			1,178	25.5
No. of self-reported comorbid conditions				
0			1,742	37.7
1			1,302	28.2
2			592	12.8
3			328	7.1
Not ascertained			656	14.2
Treatments received				
Surgery (prior or planned)			3,360	72.7
Chemotherapy			2,689	58.2
Radiation therapy			1,311	28.4

Abbreviations: CCOP, community clinical oncology program; HMO, health maintenance organization; NCI, National Cancer Institute; NSCLC, non–small-cell lung cancer; SCLC, small-cell lung cancer; SD, standard deviation; VA, Veterans Affairs.

* After excluding 67 physicians who did not participate in tumor boards and 140 patient–physician links where physicians did not participate in tumor boards. Among tumor board participants, missing data varied by tumor board feature (69 physicians and 218 links for pretreatment planning function, 70 physicians and 267 links for evaluation of treatment decisions, 76 physicians and 229 links for review of only challenging patient cases, 74 physicians and 261 links for review of variety of cancer sites, and 80 physicians and 279 links for serves only as teaching session).

† For 626 patients who completed brief survey, income was not imputed, and we included a dummy variable for missing income. For 25 additional patients, multiple imputation was not performed for some items because of partially completed survey versions; these patients were excluded from multivariable analyses.

ters.[13] The CanCORS cohort is representative of US patients with lung or colorectal cancer.[13] Baseline patient surveys were administered to participants approximately 3 to 6 months after diagnosis. Patients who were unable to complete a full survey were offered a brief version; surrogates completed surveys for patients who were deceased by the time of the baseline survey or too ill to participate. A total of 9,732 patients had baseline surveys available (American Association of Public Opinion Research cooperation rate[14] was 58.9% for patients with lung cancer and 61.0% for patients with colorectal cancer).[13] Follow-up surveys were administered to patients or their surrogates approximately 14 months after diagnosis for those alive at the baseline survey (response rate, 81%). Medical record abstraction was performed through 15 months after diagnosis. Medical

Table 2. Associations Between Tumor Board Features and Patient Outcomes, Care Processes, and Ratings of Care*

Feature	All-Cause Mortality					Participated in Clinical Trial Within 15 Months of Diagnosis					Adjuvant Chemotherapy for Stage III Colon Cancer†				
	No. of Patients	No. of Physicians	HR	95% CI	P	No. of Patients	No. of Physicians	OR	95% CI	P	No. of Patients	No. of Physicians	OR	95% CI	P
Tumor board participation (weekly *v* < weekly or never)	4,555	1,181	1.0	0.9 to 1.0	.36	**4,595**	**1,195**	**1.6**	**1.1 to 2.2**	**.007**	586	382	1.1	0.6 to 1.9	.74
Among Tumor Board Participants, Tumor Board															
Serves treatment planning function	4,202	1,076	0.9	0.9 to 1.0	.30	4,239	1,089	1.0	0.7 to 1.5	.94	545	352	1.0	0.5 to 2.1	.97
Includes evaluation of treatment decisions	4,156	1,077	1.1	0.9 to 1.3	.19	4,193	1,090	0.9	0.6 to 1.4	.63	541	350	1.0	0.3 to 3.0	.99
Reviews only challenging patient cases	4,191	1,072	0.9	0.8 to 1.0	.07	4,228	1,085	1.0	0.7 to 1.4	.94	**545**	**351**	**1.8**	**1.0 to 3.2**	**.049**
Reviews variety of cancer sites	**4,160**	**1,074**	**1.2**	**1.1 to 1.4**	**.003**	4,197	1,087	0.6	0.4 to 1.0	.05	544	351	0.9	0.3 to 2.6	.84
Serves as teaching session only	4,143	1,070	0.9	0.8 to 1.1	.45	4,180	1,083	0.8	0.5 to 1.2	.27	538	346	1.3	0.4 to 4.2	.64

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NOTE. Bold font indicates statistical significance.

Abbreviations: HR, hazard ratio for mortality; NSCLC, non–small-cell lung cancer; OR, odds ratio; OS, overall survival; VA, Veterans Affairs.

* Unit of analysis is patient-specified link to surgeon, medical oncologist, or radiation oncologist. Each row represents a model including one tumor board feature. Model for tumor board participation included all physicians; models for tumor board features included only physicians who reported ever participating in tumor boards. All models adjusted for physician age, sex, specialty, practice structure, teaching status, No. of patients seen per month with linked patient's cancer type, and National Cancer Institute cancer center affiliation. Also adjusted for patient age, sex, race, marital status, educational attainment, income, and No. of comorbid conditions. OS model was stratified by patient cancer type and stage. Other models adjusted for patient cancer type and stage (when more than one stage was assessed in model). Models in which outcome was clinical trial participation also adjusted for physician community clinical oncology program affiliation and baseline survey version. Models in which outcome was patient rating of care quality or provider team communication also adjusted for patient versus surrogate survey type and reported receipt of (or planned treatment with) surgery, receipt of chemotherapy, and receipt of radiation therapy. For ≤ 25 patients per model, multiple imputation was not performed for some items because of partially completed survey versions; these patients were excluded from multivariable analyses.

† For analysis of adjuvant chemotherapy for patients with stage III colon cancer, radiation oncologists were excluded because of low sample size (n = 5).

‡ For analysis of curative-intent surgery for patients with stage I to II NSCLC, model estimate for VA physician coefficient was unstable, so VA physicians and health maintenance organization physicians were grouped together for practice structure variable.

records were available for 77% of the overall cohort (separate consent was required for medical record review). Vital status was last updated in 2012 for 77% of patients; other CanCORS sites had complete survival information through 2010 or 2011. We excluded 603 patients with unknown cancer stage. The study was approved by human subjects committees of all participating institutions. All patients (or patient surrogates) provided verbal or written consent for participation.

In the baseline survey, patients identified physicians playing key roles in their care. We then surveyed these physicians (participation rate of 61% among physicians with known contact information).[15] Of 4,326 physician respondents, we restricted the sample to 1,648 surgeons, medical oncologists, or radiation oncologists (other physicians were not asked about tumor board participation) and excluded 47 who did not answer the question about participation in tumor board meetings, for a final cohort of 1,601 physicians.

We merged physician and patient data, assigning one key physician to each patient. Where available, we linked to the physician described by patients as the most important in helping them make treatment decisions (38% of patient–physician links). Otherwise, we followed an algorithm according to specialty (Appendix Table A1, online only), because the impact of specialist tumor board participation may vary by disease type and stage. Patients with small-cell lung cancer (SCLC) were categorized as having limited-stage (stage I to III) versus extensive-stage disease (stage IV). We excluded 26 patient–physician links in which thoracic surgeons were linked to patients with colorectal cancer, or surgical oncologists or colorectal surgeons to patients with lung cancer. Physicians could be linked to multiple patients. We thus identified 4,620 patients linked to 1,198 physicians. For survival analyses, we excluded 37 patients enrolled through the Harvard Pilgrim Health Care CanCORS site, for whom vital status data were unavailable, leaving 4,593 patients linked to 1,184 physicians.

Outcome Variables

Physicians were asked whether they participated in tumor boards. Those who did were asked how often they participated and about features of their tumor boards, including whether the meetings served treatment planning functions, evaluated treatment decisions, reviewed only challenging patient cases, reviewed multiple tumor sites (*v* single site), or served as teaching sessions only (without review of specific patient cases).

For analyses of associations between physician tumor board participation and cancer care, outcome variables included: overall survival; patient participation in a clinical trial by 15 months after diagnosis, measured via baseline survey, follow-up survey, and medical record review[16]; delivery of three guideline-recommended therapies (surgery for stage I to II NSCLC, adjuvant chemotherapy for stage III colon cancer, and neoadjuvant or adjuvant chemoradiotherapy therapy for stage II to III rectal cancer)[17-19]; patient-reported overall care quality; and patient ratings of health care team communication.

Surgery for stage I to II NSCLC was defined as curative-intent surgery (ie, pneumonectomy, lobectomy, or wedge resection) within 6 months of diagnosis, ascertained via medical record review. Adjuvant chemotherapy for stage III colon cancer was defined as documentation of chemotherapy within 180 days of surgery or patient-reported chemotherapy after cancer surgery on the baseline survey conducted 3 to 6 months after diagnosis. Neoadjuvant or adjuvant chemoradiotherapy for

Table 2. (continued)

Neoadjuvant or Adjuvant Chemoradiotherapy for Stage II to III Rectal Cancer					Surgery for Stage I to II NSCLC‡					Patient-Reported Excellent Quality of Care					Patient-Reported Top Rating of Provider Team Communication				
No. of Patients	No. of Physicians	OR	95% CI	*P*	No. of Patients	No. of Physicians	OR	95% CI	*P*	No. of Patients	No. of Physicians	OR	95% CI	*P*	No. of Patients	No. of Physicians	OR	95% CI	*P*
262	202	1.3	0.5 to 3.3	.60	**528**	**246**	**2.9**	**1.3 to 6.8**	**.01**	4,538	1,192	1.0	0.8 to 1.1	.69	3,903	1,127	0.9	0.8 to 1.0	.10
Among Tumor Board Participants, Tumor Board																			
244	186	3.5	0.8 to 16.0	.10	456	219	2.2	0.99 to 4.8	.05	4,187	1,086	1.0	0.8 to 1.2	.90	3,604	1,030	1.0	0.8 to 1.2	.84
244	185	2.7	0.5 to 14.7	.25	**445**	**217**	**3.6**	**1.0 to 12.5**	**.047**	4,145	1,087	1.1	0.8 to 1.4	.48	3,570	1,032	1.0	0.7 to 1.4	.96
246	187	0.6	0.2 to 1.7	.29	455	218	0.6	0.3 to 1.3	.19	4,175	1,082	1.0	0.9 to 1.2	.97	3,592	1,027	0.9	0.8 to 1.1	.31
241	184	1.3	0.2 to 8.5	.78	**444**	**217**	**0.1**	**0.03 to 0.4**	**.001**	4,144	1,084	1.2	0.9 to 1.5	.24	3,571	1,028	1.3	1.0 to 1.7	.07
245	186	2.7	0.4 to 19.6	.32	446	216	0.5	0.2 to 1.7	.29	4,133	1,081	1.0	0.8 to 1.2	.79	3,553	1,026	1.1	0.9 to 1.4	.49

stage II to III rectal cancer was defined as documentation of treatment within 180 days of surgery or patient-reported treatment or planned treatment on the baseline survey 3 to 6 months after diagnosis.

Patient ratings of cancer care quality were assessed using a 5-point Likert scale (excellent, very good, good, fair, poor); for analysis, we divided responses into excellent versus all other responses. Ratings of health care team communication were based on six questions derived from the Consumer Assessment of Healthcare Providers and Systems survey, as described previously.[20,21] For this analysis, we calculated the mean of the individual scores from these questions (each ranging from 0 to 3) and assessed whether patients reported a top score (51% of ratings) versus any other score. We excluded 709 patients (15%) who responded to < four of the six questions; results were similar in sensitivity analyses that included all patients, using multiply imputed data for missing responses (data not shown).

Independent Variables

Our independent variables included physician age, sex, specialty, practice setting, teaching role, number of patients with lung or colorectal cancer seen each month, National Cancer Institute cancer center affiliation, and Community Clinical Oncology Program affiliation. We also assessed patient age at diagnosis, sex, race/ethnicity, marital status, educational attainment, income, survey type (patient *v* surrogate survey), receipt of surgery or planned surgery, receipt of chemotherapy, receipt of radiation therapy, number of self-reported comorbid condi-

Table 3. Subgroup Analyses of Adjusted Associations Between Physician Tumor Board Participation Patterns and All-Cause Patient Mortality*

	All Respondents					Tumor Board Participants Only									
	Attends Tumor Board Weekly (*v* < weekly or never)					Serves Treatment Planning Function					Includes Evaluation of Treatment Decisions				
Cancer Type	No. of Patients	No. of Physicians	HR	95% CI	*P*	No. of Patients	No. of Physicians	HR	95% CI	*P*	No. of Patients	No. of Physicians	HR	95% CI	*P*
NSCLC, stage															
I	503	226	0.8	0.6 to 1.0	.058	435	201	0.9	0.6 to 1.4	.75	427	200	0.7	0.5 to 1.2	.20
II	187	131	1.0	0.5 to 1.7	.86	162	117	1.8	0.9 to 3.7	.12	158	115	2.3	0.5 to 10.0	.26
III	555	289	0.9	0.7 to 1.1	.42	516	266	0.9	0.7 to 1.1	.32	509	264	1.4	1.0 to 2.1	.08
IV	632	314	1.0	0.9 to 1.3	.69	599	292	1.0	0.8 to 1.3	.82	587	290	1.1	0.8 to 1.4	.64
SCLC															
Limited	105	85	1.4	0.8 to 2.7	.26	98	80	1.5	0.7 to 3.4	.33	94	79	0.4	0.1 to 1.8	.24
Extensive	**116**	**91**	**0.6**	**0.3 to 1.0**	**.04**	115	90	0.8	0.4 to 1.6	.50	113	89	1.8	0.8 to 4.2	.19
CRC, stage															
I	517	318	0.8	0.5 to 1.2	.22	477	289	1.1	0.6 to 1.8	.85	476	289	1.1	0.5 to 2.2	.89
II	696	426	0.9	0.6 to 1.2	.38	636	386	0.9	0.6 to 1.4	.73	636	386	0.7	0.4 to 1.4	.33
III	829	485	1.1	0.9 to 1.5	.32	769	446	1.0	0.7 to 1.3	.87	766	446	1.5	0.9 to 2.4	.10
IV	**415**	**300**	**0.7**	**0.6 to 0.9**	**.007**	395	284	0.9	0.7 to 1.2	.48	390	283	1.2	0.8 to 1.6	.42

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NOTE. Bold font indicates significance.

Abbreviations: CRC, colorectal cancer; HR, hazard ratio for mortality; NSCLC, non–small-cell lung cancer; SCLC, small-cell lung cancer.

* Unit of analysis is patient-specified link to surgeon, medical oncologist, or radiation oncologist. Each set of columns represents a set of models including one tumor board feature, and each row represents model results for specific stage and disease type. Models adjusted for physician age, sex, specialty, practice structure, teaching status, No. of patients seen per month with linked patient's cancer type, and National Cancer Institute cancer center affiliation. Also adjusted for patient age, sex, race, marital status, educational attainment, income, and No. of comorbid conditions. Models for CRC also adjusted for disease site (colon, rectal, or other [eg, both colon and rectal]). For ≤ 25 patients per model, multiple imputation was not performed for some items because of partially completed survey versions; these patients were excluded from multivariable analyses.

tions,[22] cancer type, and stage.[23] Physician and patient variables were categorized as listed in Table 1.

Statistical Analyses

Item nonresponse for physician and patient surveys was < 10%, except for patient questions not included in the brief survey version, including income (21% missing) and number of comorbid conditions (14% missing). For multivariable analyses, multiple imputation was used to impute missing data.[24] For survival analyses, we used Cox proportional hazards models, stratified by cancer type and American Joint Committee on Cancer stage. Additionally, because the impact of tumor board participation on patient outcome may vary according to cancer type and stage, we conducted subgroup analyses in which these associations were tested separately within each stratum. For analyses of clinical trial participation, treatments delivered, and ratings of care quality and care team communication, we used multivariable logistic regression, adjusting for physician and patient characteristics as listed in Tables 2 and 3.

We used robust SE estimates to account for repeated measures among physicians. Significance tests were two sided. Analyses were performed using SAS software (version 9.2; SAS Institute, Cary, NC) and STATA software (version 13; STATA, College Station, TX).

Results

Physician and patient characteristics are listed in Table 1. Overall, 53.8% of physicians reported participating in tumor boards weekly, 42.0% less frequently, and 4.2% not at all. Among tumor board participants, a pretreatment planning function was described by 82.4% of physicians, evaluation of treatment decisions by 92.3%, review only of challenging patient cases by 58.7%, review of a variety of cancer sites by 87.1%, and an educational function without review of participant cases by 12.1%. After adjustment for all physician characteristics included in Table 1, radiation oncologists were more likely than medical oncologists to participate weekly versus less than weekly or never (odds ratio [OR] 2.3; 95% CI, 1.5 to 3.5); cardiothoracic surgeons, general surgeons, and surgical oncologists or colorectal surgeons were less likely than medical oncologists to participate weekly (all $P \leq .02$; Appendix Table A2, online only).

Weekly tumor board participation was not associated with overall survival (hazard ratio [HR] for all-cause mortality, 1.0; 95% CI, 0.9 to 1.0), although patients of physicians whose tumor boards reviewed a variety of cancer sites (*v* only one) had slightly higher mortality (HR, 1.2; 95% CI, 1.1 to 1.4). No other tumor board features were associated with patient survival (Table 2). Overall, 7% of patients had evidence of enrollment onto clinical trials by 15 months after diagnosis. In adjusted analyses, patients whose physicians participated in tumor boards weekly (*v* less than weekly or never) were more likely to report enrollment onto trials (OR, 1.6; 95% CI, 1.1 to 2.2).

Rates of guideline-recommended treatments were high; 79% of patients with stage III colon cancer received adjuvant chemotherapy, 83% of those with stage II to III rectal cancer received neoadjuvant or adjuvant chemoradiotherapy, and 85% of patients with stage I to II NSCLC underwent curative-intent surgery. In adjusted analyses, patients with stage I to II NSCLC whose physicians attended tumor boards weekly were more likely to undergo

Table 3. (continued)

Tumor Board Participants Only														
Reviews Only Challenging Patient Cases					Reviews Variety of Cancer Sites					Serves As Teaching Session (no patient case review)				
No. of Patients	No. of Physicians	HR	95% CI	*P*	No. of Patients	No. of Physicians	HR	95% CI	*P*	No. of Patients	No. of Physicians	HR	95% CI	*P*
435	201	1.1	0.8 to 1.5	.44	424	199	1.4	1.0 to 1.9	.06	427	199	1.1	0.6 to 2.2	.71
162	117	0.9	0.5 to 1.7	.75	160	116	0.8	0.4 to 1.7	.54	159	115	0.7	0.3 to 1.8	.52
514	264	0.9	0.7 to 1.1	.38	514	264	0.9	0.7 to 1.2	.47	510	262	0.9	0.7 to 1.2	.63
595	**289**	**0.8**	**0.7 to 1.0**	**.03**	598	292	1.2	1.0 to 1.6	.09	585	289	0.9	0.6 to 1.2	.37
97	79	1.8	1.0 to 3.3	.06	98	80	4.1	1.0 to 17.2	.06	**93**	**78**	**3.0**	**1.1 to 8.6**	**.04**
113	**88**	**0.6**	**0.3 to 1.0**	**.04**	115	90	1.1	0.3 to 4.0	.84	**110**	**86**	**3.9**	**1.8 to 8.3**	**< .001**
480	290	0.8	0.5 to 1.2	.35	464	286	2.4	0.7 to 8.6	.16	476	290	0.9	0.4 to 1.8	.74
633	386	1.2	0.9 to 1.7	.15	630	385	1.8	0.8 to 4.0	.13	633	386	1.3	0.8 to 2.0	.32
773	447	0.9	0.7 to 1.1	.33	766	445	0.9	0.5 to 1.5	.56	764	442	0.8	0.5 to 1.2	.30
389	282	1.0	0.8 to 1.3	.94	391	281	1.3	0.8 to 2.1	.31	386	282	0.8	0.6 to 1.2	.30

curative-intent surgery (OR, 2.9; 95% CI, 1.3 to 6.8); those whose physicians' tumor boards included evaluation of prior treatment decisions were also slightly more likely to undergo curative-intent surgery ($P = .047$), and those whose physicians' tumor boards reviewed a variety of cancer sites were less likely (OR, 0.1; 95% CI, 0.03 to 0.4; Table 2). Patients with stage III colon cancer whose physicians' tumor boards reviewed only challenging patient cases were slightly more likely to receive adjuvant chemotherapy ($P = .049$). Receipt of chemoradiotherapy for stage II to III rectal cancer was not associated with tumor board participation or features.

Just over half (53%) of patients rated overall care quality as excellent, and 51% provided top ratings for communication within their health care teams. There were no significant associations between tumor board features and patient ratings of care quality or health care team communication (Table 2).

In exploratory subgroup analyses, patients with extensive-stage SCLC whose physicians participated in tumor boards weekly had lower mortality (HR, 0.6; 95% CI, 0.3 to 1.0; $P = .04$; Table 3), as did patients with stage IV colorectal cancer (HR, 0.7; 95% CI, 0.6 to 0.9; $P = .007$). Patients with stage IV NSCLC or extensive-stage SCLC whose physicians' tumor boards reviewed only challenging patient cases had lower mortality, but for patients with SCLC, mortality was higher when physicians' tumor boards served only as teaching sessions (all $P \leq .04$).

Discussion

Tumor boards are common, but little evidence is available about associations between tumor board participation, tumor board features, and individual patient care patterns or outcomes. We did not find strong evidence of an association between tumor board participation factors and overall survival. This may reflect the possibility that only a relatively small proportion of patients benefit most from specific multidisciplinary discussions. Indeed, our failure to find evidence that weekly tumor boards improved survival in the overall cohort should not be interpreted as evidence against a benefit for some patients. Our primary analysis of overall survival within the full cohort was statistically conservative and did not allow for heterogeneity of the effect of tumor boards across cancer types and stages of disease; however, in exploratory subgroup analyses, frequent tumor board participation was associated with improved survival among patients with extensive-stage SCLC or stage IV colorectal cancer, which may represent a focus for future research.

We also observed few associations between physician tumor board participation and care delivery or subjective patient outcomes. Tumor boards may be most beneficial for complex patient cases or unusual clinical scenarios, whereas interventions such as curative-intent surgery for early-stage NSCLC or adjuvant chemotherapy for stage III colon cancer are standard therapies for these conditions.[17,18] Nevertheless, even for patients with stage II to III rectal cancer, for which standard therapy includes both chemotherapy and radiation therapy,[19] tumor board participation was not associated with delivery of guideline-recommended therapy, in contrast to one prior analysis.[9] The lack of associations between tumor board participation and subjective patient reports of care quality or provider team communication was somewhat surprising, but this may be related to the behind-the-scenes nature of tumor boards, of which patients may not be fully aware.

We found that weekly tumor board participation was associated with a greater likelihood that patients discussed clinical trial participation or enrolled onto trials. The rate of clinical trial participation in adult cancer populations has historically been $\leq 5\%$,[16,25,26] yet focused multidisciplinary team training can increase awareness, clarity, and enthusiasm regarding clinical trial enrollment.[27] Our findings suggest that physician tumor board engagement may be associated with improved patient clinical trial participation rates. We adjusted for physician characteristics such as practice structure, clinical volume, specialty, and National Cancer Institute cancer center affiliation, but we still cannot exclude the possibility that this finding was in part a result of residual confounding by other institutional characteristics. Nevertheless, this association is clinically plausible and may inform future efforts to optimize clinical trial accrual.

Strengths of our analysis included its representative,[13] population- and health system–based cohort and survey data from treating physicians. To our knowledge, this is the only large multicenter study to have linked tumor board participation patterns among individual physicians to clinical care delivery and outcomes. Nevertheless, there are limitations. We attempted to survey all physicians named by patients as most important in determining their treatment plans, but not all physicians responded, and when the most important physician's survey was not available, we linked patients to physicians with whom they had discussed particular treatments. Thus, nonresponse bias could have affected our findings. Additionally, tumor board attendance records were not available in this study, so we relied on physician self-report regarding both frequency of attendance and features of tumor boards, which could not be independently validated. We also could not assess whether specific patient cases were discussed at a tumor board; however, for tumor boards that reviewed only a subset of patient cases, differential selection of more complex or borderline clinical patient cases for presentation would likely have made it difficult to assess the impact of a multidisciplinary meeting, even after adjustment for cancer type, stage, and comorbidity. Still, this limitation precluded assessment of other potentially important outcomes that could be affected by multidisciplinary collaboration, such as timeliness or cost of care. We examined care for patients whose stage and cancer type had been determined, which did not allow assessment of the important function of tumor boards in reviewing pathology and correctly classifying type and stage of disease. Finally, we did not adjust P values for multiple comparisons.

In conclusion, we found little evidence of an impact of physician tumor board engagement on patient survival, patient-reported quality, or ratings of communication. Nevertheless, higher clinical trial participation rates among patients whose physicians participated actively in tumor boards could represent a focus for future efforts to optimize trial accrual. Patients with stage I to II NSCLC whose physicians participated actively were more likely to undergo curative-intent surgery. Further research into the effects of tumor boards should focus on those aspects of tumor board meetings most likely to benefit patients with complex disease.

Acknowledgment

The CanCORS (Cancer Care Outcomes Research and Surveillance) Consortium was supported by Grant No. U01CA093344 from the National Cancer Institute (NCI) to the Statistical Coordinating Center; by grants to the NCI-supported primary data collection and research centers (Grants No. U01CA093332 to Dana-Farber Cancer Institute/Cancer Research Network, No. U01CA093324 to Harvard Medical School/Northern California Cancer Center, No. U01CA093348 to RAND/University of California Los Angeles, No. U01CA093329 to University of Alabama at Birmingham, No. U01CA093339 to University of Iowa, and No. U01CA093326 to University of North Carolina); by Department of Veterans Affairs (VA) Grant No. CRS-02-164 to the Durham VA Medical Center; and by NCI Grant No. 1R01CA164021-01A1 (N.L.K., M.B.L.). We thank Clifford Y. Ko, MD, MS, for helpful feedback on an early draft of this article.

Authors' Disclosures of Potential Conflicts of Interest

Disclosures provided by the authors are available with this article at jop.ascopubs.org.

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DOI: 10.1200/JOP.2015.003673; published online ahead of print at jop.ascopubs.org on April 28, 2015.

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AUTHORS' DISCLOSURES OF POTENTIAL CONFLICTS OF INTEREST

Tumor Board Participation Among Physicians Caring for Patients With Lung or Colorectal Cancer

The following represents disclosure information provided by authors of this manuscript. All relationships are considered compensated. Relationships are self-held unless noted. I = Immediate Family Member, Inst = My Institution. Relationships may not relate to the subject matter of this manuscript. For more information about ASCO's conflict of interest policy, please refer to www.asco.org/rwc or jop.ascopubs.org/site/misc/ifc.xhtml.

Kenneth L. Kehl
No relationship to disclose

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Honoraria: Aetna (I), VHA (I)
Research Funding: Pfizer (Inst)

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No relationship to disclose

Appendix

Table A1. Algorithm for Assignment of Physicians to Patients When More Than One Physician Linked to Given Patient

Cancer Type	Highest Priority*	Second Highest Priority	Third Highest Priority	Lowest Priority
Stage I NSCLC (n = 511)	Most important, 35.8%	Surgeon, 46.4%	Radiation oncologist, 6.3%	Medical oncologist, 11.6%
Stage II NSCLC (n = 190)	Most important, 30.0%	Surgeon, 37.4%	Radiation oncologist, 11.6%	Medical oncologist, 21.1%
Stage III NSCLC (n = 564)	Most important, 40.1%	Medical oncologist, 26.6%	Surgeon, 16.3%	Radiation oncologist, 17.0%
Stage IV NSCLC (n = 643)	Most important, 39.0%	Medical oncologist, 36.7%	Radiation oncologist, 18.2%	Surgeon, 6.1%
SCLC (n = 224)	Most important, 44.6%	Medical oncologist, 34.8%	Radiation oncologist, 16.5%	Surgeon, 4.0%
Stage I colon cancer (n = 340)	Most important, 35.3%	Surgeon, 57.7%	Medical oncologist, 7.1%	Radiation oncologist, 0.0%
Stage II colon cancer (n = 505)	Most important, 33.3%	Surgeon, 52.5%	Medical oncologist, 13.9%	Radiation oncologist, 0.4%
Stage III colon cancer (n = 596)	Most important, 35.7%	Surgeon, 44.6%	Medical oncologist, 19.1%	Radiation oncologist, 0.5%
Stage I rectal cancer (n = 143)	Most important, 41.3%	Surgeon, 44.8%	Radiation oncologist, 9.1%	Medical oncologist, 4.9%
Stage II rectal cancer (n = 132)	Most important, 50.8%	Surgeon, 27.3%	Radiation oncologist, 11.4%	Medical oncologist, 10.6%
Stage III rectal cancer (n = 181)	Most important, 42.0%	Surgeon, 37.0%	Radiation oncologist, 8.8%	Medical oncologist, 12.2%
Stage I to III colorectal cancer (colon plus rectal or missing site; n = 105)	Most important, 42.9%	All patients linked to only one physician (surgeons, 68.3%; medical oncologists, 23.3%; radiation oncologists, 8.3%)		
Stage IV colorectal cancer (n = 417)	Most important, 35.0%	Medical oncologist, 31.2%	Radiation oncologist, 4.6%	Surgeon, 29.3%

Abbreviations: NSCLC, non–small-cell lung cancer; SCLC, small-cell lung cancer.
* Most important physician was physician specified by patient as one who had been most important in helping patient decide whether to have tests or treatments for his or her cancer.

Table A2. Associations Between Physician Characteristics and Tumor Board Participation and Specific Tumor Board Features (adjusted)*

	All Respondents			Tumor Board Participants Only													
	Tumor Board Participation (weekly *v* < weekly or never; n = 1,601)			Tumor Board Serves Treatment Planning Function (n = 1,465)			Tumor Board Includes Evaluation of Treatment Decisions (n = 1,464)			Tumor Board Reviews Only Challenging Patient Cases (n = 1,458)			Tumor Board Reviews Variety of Cancer Sites (n = 1,460)			Tumor Board Serves As Teaching Session (no case review; n = 1,454)		
Characteristic	**OR**	**95% CI**	***P***	**OR**	**95% CI**	***P***	**OR**	**95% CI**	***P***	**OR**	**95% CI**	***P***	**OR**	**95% CI**	***P***	**OR**	**95% CI**	***P***
Specialty																		
Medical oncologist	1		Ref	1		Ref	1		Ref	1		Ref	1		Ref	1		Ref
Radiation oncologist	**2.3**	**1.5 to 3.5**	**< .001**	**2.2**	**1.3 to 3.6**	**.003**	**2.9**	**1.5 to 5.6**	**.001**	0.8	0.5 to 1.1	.15	**2.3**	**1.3 to 4.0**	**.003**	0.8	0.5 to 1.3	.34
Cardiothoracic surgeon	**0.3**	**0.2 to 0.4**	**< .001**	1.3	0.7 to 2.5	.38	**4.8**	**1.8 to 13.3**	**.002**	**0.6**	**0.4 to 1.0**	**.03**	0.9	0.5 to 1.6	.74	0.7	0.3 to 1.4	.29
Colorectal surgeon/ surgical oncologist	**0.6**	**0.3 to 0.9**	**.02**	1.2	0.6 to 2.1	.63	**4.2**	**1.4 to 12.4**	**.008**	0.7	0.4 to 1.1	.09	1.2	0.6 to 2.2	.61	0.4	0.2 to 1.0	**.046**
General surgeon	**0.2**	**0.2 to 0.3**	**< .001**	1.3	0.9 to 1.97	.13	**2.9**	**1.7 to 5.1**	**< .001**	**0.6**	**0.4 to 0.8**	**.001**	**2.9**	**1.8 to 4.6**	**< .001**	0.7	0.4 to 1.1	.10
Practice structure																		
Hospital based	1		Ref	1		Ref	1		Ref	1		Ref	1		Ref	1		Ref
HMO	0.9	0.6 to 1.3	.54	1.3	0.8 to 2.0	.28	1.0	0.6 to 1.7	.92	**1.8**	**1.3 to 2.5**	**.001**	0.8	0.5 to 1.4	.44	0.7	0.4 to 1.2	.19
VA or government	**1.6**	**1.1 to 2.4**	**.03**	**2.4**	**1.3 to 4.2**	**.004**	1.4	0.8 to 2.7	.27	1.1	0.8 to 1.5	.68	**0.6**	**0.4 to 0.9**	**.02**	0.8	0.5 to 1.4	.54
Solo practice	**0.4**	**0.2 to 0.6**	**< .001**	0.7	0.4 to 1.1	.11	**2.5**	**1.1 to 5.8**	**.03**	1.2	0.8 to 1.9	.35	0.8	0.4 to 1.5	.43	1.4	0.8 to 2.5	.29
Single-specialty group	**0.7**	**0.5 to 0.9**	**.02**	0.9	0.6 to 1.3	.49	**3.4**	**1.7 to 7.0**	**.001**	1.2	0.8 to 1.6	.33	1.0	0.6 to 1.7	.95	1.0	0.6 to 1.6	.99
Multispecialty group	**0.5**	**0.3 to 0.8**	**.003**	0.7	0.4 to 1.2	.17	1.7	0.7 to 4.2	.22	1.3	0.8 to 2.2	.23	0.7	0.3 to 1.4	.28	1.6	0.8 to 2.9	.17
Teachers (medical students or residents)																		
No	1		Ref	1		Ref	1		Ref	1		Ref	1		Ref	1		Ref
Yes	**1.7**	**1.3 to 2.2**	**< .001**	1.3	0.9 to 1.7	.11	1.0	0.7 to 1.6	.86	0.9	0.7 to 1.1	.32	**0.5**	**0.3 to 0.8**	**.001**	1.2	0.8 to 1.7	.37
NCI cancer center affiliation																		
No	1		Ref	1		Ref	1		Ref	1		Ref	1		Ref	1		Ref
Yes	**1.4**	**1.0 to 1.9**	**.03**	1.3	0.9 to 1.9	.12	1.1	0.6 to 1.7	.84	1.2	0.9 to 1.6	.12	**0.7**	**0.5 to 0.97**	**.03**	1.4	0.9 to 2.0	.12
Do not know	0.9	0.7 to 1.3	.70	1.0	0.7 to 1.5	.90	0.8	0.4 to 1.5	.50	**1.4**	**1.0 to 1.9**	**.046**	1.3	0.7 to 2.3	.35	1.2	0.7 to 2.0	.43

NOTE. Bold font indicates significance.

Abbreviations: HMO, health maintenance organization; NCI, National Cancer Institute; OR, odds ratio; Ref, referent; VA, Veterans Affairs.

* Assessed via multivariable logistic regression. Outcome variables were tumor board features in each column, adjusting for all variables in rows of table, plus physician age, sex, reported No. of patients with lung cancer seen per month, and reported No. of patients with colorectal cancer seen per month.