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Race disparities attributed to volumetric tumor burden in patients with head and neck cancer treated with radiotherapy

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Abstract

Background—The purpose of this study was to evaluate how gross tumor volume (GTV) affects treatment outcome among different race/ethnic groups in patients with head and neck cancer receiving definitive radiotherapy (RT).

Methods—Ninety-one patients with head and neck cancer were treated to a median RT dose of 69.96 Gy in 33 fractions. The patient's self-reported race/ethnicity, primary tumor, and nodal GTV were obtained. Two-year actuarial local, nodal, and distant control, and overall and disease-free survival were calculated.

Results—The patients were categorized as white ($n = 43$) or non-white ($n = 48$), which included 29 African Americans, 11 Hispanics, 5 Asians, and 3 others. The mean primary GTV was 21.0 cc and 39.9 cc for whites and non-whites, respectively ($p = .011$). White patients reported improved overall survival of 85.4% compared to non-whites (65.8%; $p = .006$). Improvements in local and nodal control and disease-free survival rates were also observed.

Conclusion—White patients demonstrated improved treatment outcomes compared with non-whites, which may be reflective of tumor volume.

Keywords

head and neck cancer; gross tumor volume; race; ethnicity; radiotherapy

INTRODUCTION

Head and neck cancers in the United States accounted for approximately 53,640 new cases and 11,520 deaths in 2013.¹ Despite significant advances in treatment delivery for head and

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neck cancer, including surgery, radiotherapy (RT), and chemotherapy approaches, locoregional failure and poor patient survival remains a continued challenge for the health care community.^{2,3} Further complicating the objective of achieving optimal treatment outcome is existence of health disparities most important of which is racial/ethnic disparity.^{4–11} In an analysis of 1,736 patients from 3 Radiation Therapy Oncology Group (RTOG) head and neck cancer trials, non-white race was shown to negatively impact both locoregional control and overall survival.⁴

National studies on racial health disparities in cancer suggest that differences in survival are principally because of tumor stage at presentation, treatment received, and presence of comorbidities.¹² These factors have also been implicated in the setting of head and neck cancers.^{10,13} Furthermore, in certain head and neck cancers, such as oropharyngeal cancers, prevalence of human papillomavirus (HPV) infection has been identified as a potential contributor to racial disparity.^{14,15} In addition to these tumor and treatment characteristics, other aspects, such as physician decision-making, hospital characteristics, and other cultural and language communication barriers, might also play an important role in determining treatment outcome.

Volumetric tumor burden of the primary tumor site, as reflected in gross tumor volume (GTV), is predictive of treatment outcome in patients with head and neck cancer undergoing radiation-based therapy and has been shown to be superior to Union for International Cancer Control (UICC) tumor node metastasis (TNM) and American Joint Committee on Cancer (AJCC) classification of disease.^{16,17} As such other studies have shown that primary tumor volume is an independent predictor of disease control and survival in patients with head and neck cancer, after accounting for tumor stage and head and neck cancer subsite.^{18,19} There is, however, limited data exploring the role of GTV as a contributing factor to racial/ethnic disparities in patients undergoing radiation-based therapy. Earlier analyses are largely restricted to population-based studies utilizing unidimensional tumor size instead of volume.^{10,11}

Our institution is a private, not-for-profit, academic medical center, which serves a predominantly non-white urban city population. The purpose of the current study was to explore tumor characteristics, including tumor volume, which may contribute to differences in outcome among different race/ethnic groups undergoing definitive RT for head and neck cancer.

MATERIALS AND METHODS

Patient selection

One hundred nine patients with biopsy proven head and neck cancer completed definitive RT at our institution from December 2004 to May 2011. Patients with newly diagnosed nonmetastatic head and neck cancer with a follow-up of at least 3 months (unless recurrence or death) were deemed eligible for the current analysis. A total of 18 patients were excluded for the following reasons: synchronous primary cancers ($n = 6$), recurrent head and neck cancer ($n = 5$), previous malignancy within 5 years of diagnosis ($n = 1$), death before any posttreatment follow-up ($n = 2$), inadequate follow-up ($n = 2$), hepatic complications during

treatment ($n = 1$), and head and neck cancer of the ear ($n = 1$). The final study population consisted of 91 patients with primary, nonmetastatic cancer of head and neck. The institutional review board approved the study with waiver of informed consent.

Data collection of patient characteristics

Data on patient demographics, treatment, and tumor characteristics were collected from a review of electronic medical charts and hospital registration records. At hospital registration, patient's self-reported information on their age and race/ethnicity.²⁰ For the purpose of analysis, race/ethnicity was categorized into 2 groups; white or non-white. Smoking history was obtained from the patient records at initial consultation. Smokers were classified as those who had a current or past smoking history versus never-smokers. Patients were categorized into 3 groups according to their insurance coverage: public insurance (Medicaid/Medicare), private insurance, or uninsured (self-pay or free care). At our institution, HPV testing was not a component of routine treatment workup before 2009 and, therefore, we did not have this information available for the majority of the patient cohort.

Pretreatment workup

A detailed history and physical examination, including a focused head and neck evaluation, panendoscopy with biopsy, and a CT scan was conducted. In addition, 84 patients (92.3%) underwent a staging 2-[18F] fluoro-2-deoxy-D-glucose-positron emission tomography/CT scan (PET/CT). The distribution of patients receiving a staging fluoro-2-deoxy-D-glucose PET/CT was similar for whites (93.0%) and non-whites (91.7%). Disease was staged in accord with the 2002 AJCC classification.²¹ All cases were reviewed at a multidisciplinary head and neck cancer tumor board before the initiation of treatment. The median time from diagnosis to start of treatment (induction chemotherapy, radiotherapy alone, or concurrent radiotherapy) was 42 days (range, 6–150 days).

Gross tumor volume measurement and radiation treatment planning

A single board-certified radiation oncologist with 10 years' experience and expertise in head and neck cancer manually contoured all GTVs for both intensity-modulated radiation therapy (IMRT) and 3D-conformal RT treatment planning. The GTV was carefully assessed using information gathered from clinical examination, examination with the patient under anesthesia, contrast-enhanced CT findings, PET/CT, and MRI. The standard practice was to use the preinduction chemotherapy imaging (CT or PET/CT) to contour the GTV for patients undergoing induction chemotherapy. Primary (GTV-P) and nodal (GTV-N) GTVs were derived from the patient treatment planning dose volume histograms (Philips Pinnacle software suite). PET/CT images were fused using Philips Pinnacle software suite and MIMVista for patients treated after November 2008. GTV-total (GTV-T) was calculated by adding GTV-P and GTV-N to assess overall disease burden. The cohort's mean (SD) GTV-P was 31.1 cc ($n = 88$; SD ± 34.9), GTV-N was 36.3 cc ($n = 62$; SD ± 49.3), and GTV-T was 54.9 cc ($n = 91$; SD ± 54.1). Three patients with unknown primaries did not have a GTV-P, whereas nodal disease (GTV-N) was present in 62 patients.

As part of treatment planning, volumetric expansions from GTV were 7 to 15 mm respecting normal tissue planes to create the clinical target volume, followed by a 3 to 5 mm expansion to the planning target volume.

Treatment

All patients were treated to a median dose of 69.96 Gy (range, 66–72 Gy) to planning target volume-70 in 33 fractions (range, 32–42 fractions) over 49 elapsed days (range, 38–72 days). Elective nodal areas at risk for harboring microscopic disease were treated to a range of 50 to 60 Gy. Seventy-three patients (80.2%) were treated with IMRT and 18 patients (19.8%) received 3D-conformal RT. Concurrent chemotherapy, with or without induction chemotherapy, was administered in 77 patients (84.6%) whereas 14 patients (15.4%) received radiotherapy alone. The distribution of chemotherapy regimen was as follows: 53 (68.8%) received cisplatin, 13 (16.9%) received carboplatin, and 11 (14.3%) received cetuximab. In addition, 25 patients received induction chemotherapy: 13 (52.0%) with docetaxel, cisplatin, and 5-fluorouracil, 5 (20.0%) with carboplatin and docetaxel, 4 (16.0%) with cisplatin and docetaxel, 2 (8.0%) with carboplatin and paclitaxel, and 1 (4.0%) with carboplatin and 5-fluorouracil.

Follow-up and treatment outcomes

Patients were followed from the conclusion of RT until the last available follow-up or patient death to monitor disease recurrence and survival. Serial clinical examinations were performed every 3 months, including fiberoptic examination and a PET/CT scan at 8 to 12 weeks after the completion of RT. Disease recurrence was defined as site of failure, including local failure, nodal failure, or distant failure. All recurrences were confirmed by biopsy. Overall (death because of any cause) and disease-free (death and/or disease relapse) survival were recorded. The median follow-up was 39 months (range, 2–103 months), whereas surviving patients had a median follow-up of 49 months.

Statistical analysis

Descriptive analyses were performed to obtain patient, tumor, and treatment characteristics. Analysis of variance and chi-square tests (Fisher's exact test for small samples) were conducted to test for differences in continuous and categorical variables by race/ethnicity, respectively. Two-year actuarial control and survival rates were estimated for local, nodal, distant control, overall survival, and disease-free survival using the Kaplan–Meier product-limit method.²² The comparison of rates among the groups were performed using the 2-tailed log-rank test.²³ Crude hazard ratios (HRs) with 95% confidence intervals (CIs) were computed for disease failure and survival outcomes using the Cox regression modeling. Adjusted HRs were calculated in a bivariate analysis accounting separately for GTV (primary and total), AJCC stage (I–III vs IV), tumor (T) classification (T0–T3 vs T4), and nodal (N) classification (N0–N1 vs N2–N3) of the disease. A probability value of less than .05 was considered statistically significant for all analyses. All statistical computations were performed on SAS 9.1 system (SAS Institute, Cary, NC) or GraphPad prism software (version 3.0, GraphPad Software).

RESULTS

Patient and tumor characteristics

Non-white race/ethnicity was reported in 48 patients (52.7% of cohort), which included 29 African Americans, 11 Hispanics, 5 Asians, and 3 others. All patients, except 11 who reported their race/ethnicity as Hispanics at hospital registration, identified themselves as non-Hispanic or non-Latino in origin. The median age of the patient population was 59.4 years (range, 31–86 years) with men comprising of 76.9% of the patient cohort.

Primary tumor sites included 33 oropharynx (36.3%) and 28 larynx (30.8%), 11 hypopharynx (12.1%), 8 oral cavity (8.8%), 7 nasopharynx (7.7%), 1 sinonasal (1.1%), and 3 unknown primary (3.3%) cases. Squamous cell histopathology accounted for 90.1% ($n = 82$) of tumors. AJCC stage I, II, III, and IV presentation was seen in 6.6%, 7.7%, 15.4%, and 70.3% patients, respectively. Complete results are presented in Table 1.

Relationship between race/ethnicity and patient, tumor, and treatment characteristics

No differences in age, smoking status, smoking pack-years, insurance coverage, and sex were identified by race/ethnicity (Table 1). The percentage of AJCC stage IV presentation, T classification T4, and N classification N2 to N3 disease were not significantly different across the 2 race/ethnic groups. T4 disease was present in 37.5% of non-whites compared to 23.3% whites ($p = .142$). Oropharyngeal cancers were present in 17 non-white patients (35.4%) and 16 white patients (37.2%). The distribution of primary tumor site was not different by race/ethnicity ($p = .90$).

A significant difference was noted in mean GTV-P by race/ethnicity. The mean GTV-P was 21.0 cc for whites and 39.9 cc for non-whites ($p = .011$). GTV-N and GTV-T were not significantly different by race/ethnic groups (Table 1). Treatment factors, including overall radiation treatment duration ($p = .665$), total radiation dose received ($p = .266$), use of chemotherapy ($p = .42$), use of induction chemotherapy ($p = .577$), and choice of radiation technique (IMRT vs 3D-conformal RT) were also similar across the race/ethnic groups ($p = .79$).

Disease stage and tumor volume

Overall stage and N classification correlated with GTV-T but not GTV-P. The mean (SD) GTV-T was 25.6 cc (36.7) and 67.3 cc (55.6) for stage I to III and IV, respectively ($p = .001$). Similarly, N classification N0 to N1 was associated with smaller GTV-T (mean = 29.6 cc; SD = 38.8) compared with patients with N2 to N3 disease (mean = 72.3 cc; SD = 56.5; $p = .0001$). In contrast, T classification correlated with GTV-P volume and not GTV-T. The mean GTV-P was 22.7 cc (29.6) and 49.1 cc (38.9) for T1 to T3 and T4 classification, respectively ($p = .001$; Table 2).

Overall treatment outcome

Local, nodal, and distant recurrences were reported in 15 patients (16.5%), 9 patients (9.9%), and 17 patients (18.7%), whereas death because of any cause and death and/or disease relapse in 38 patients (41.8%) and 45 patients (49.5%), respectively. The median

time to recurrence for local, nodal, and distant failure was 3.0 months (range, 1.4–35.4 months), 2.2 months (range, 0.3–3.5 months), and 6.4 months (range, 1.9–46.4 months), respectively. The estimated 2-year actuarial local, nodal, distant control, overall survival, and disease-free survival were 83.8%, 89.9%, 80.6%, 74.9%, and 61.7%, respectively.

Treatment outcome and tumor volume

Patients who were locally controlled had a significantly smaller GTV-P (26.8 cc vs 52.2 cc; $p = .009$), whereas a similar pattern was noted for all other treatment outcomes, including overall survival where surviving patients and patients who died during follow-up had a GTV-P of 19.3 cc and 47.4 cc, respectively ($p = .0001$; Table 3). GTV-T correlated with all outcomes except local control (Table 3).

Treatment outcome by disease stage

No differences were identified between AJCC stages I to III versus IV, with respect to local ($p = .128$), nodal ($p = .584$), and distant ($p = .075$) control, and overall ($p = .720$) and disease-free ($p = .731$) survival. No differences in N0 to N1 versus N2 to N3 were found for local ($p = .917$) and nodal ($p = .229$) control, and overall ($p = .283$) and disease-free ($p = .893$) survival. The 2-year actuarial distant control rate for N0 to N1 and N2 to N3 was 93.7% and 72.1% ($p = .011$), respectively. T classification (T1–T3 vs T4) predicted for local control, overall survival, and disease-free survival but no differences were found for nodal ($p = .763$) and distant ($p = .742$) control. The 2-year actuarial local control rate for T1 to T3 and T4 was 90.3% and 67.9% ($p = .003$). Overall survival at 2 years was 81.7% and 59.7% ($p = .018$), whereas disease-free survival was 68.7% and 46.2% for T1 to T3 and T4, respectively ($p = .017$).

Treatment outcome by race/ethnicity

Whites reported an improved local and nodal control, and overall and disease-free survival compared to non-whites. The 2-year actuarial local control rate was 92.4% for whites and 75.9% for non-whites ($p = .014$). Similarly, the 2-year actuarial overall survival rate was 85.4% and 65.8% for whites and non-whites ($p = .006$), respectively. No significant differences were noted in distant control (Table 4). Kaplan–Meier curves for local and nodal control, and overall and disease-free survival are presented in Figure 1.

In an unadjusted analysis, non-whites had an increased risk of local failure (crude HR = 4.31; 95% CI = 1.22–15.32; $p = .024$) compared to white patients. In bivariate analysis, an attenuation was noted in risk of local failure after discretely adding GTV-P (adjusted HR = 3.35; 95% CI = 0.91–12.39; $p = .07$) and T classification (adjusted HR = 3.83; 95% CI = 1.07–13.63; $p = .038$) to the crude model. Adding N classification and AJCC stage did not result in attenuation of crude HR (Figure 2). Similarly, non-whites had an increased risk of death compared with white patients (crude HR = 2.52; 95% CI = 1.27–5.0; $p = .008$). Maximum attenuation in crude HR was observed after adjusting for GTV-P (HR = 2.06; 95% CI = 0.99–4.3; $p = .055$; Figure 2).

DISCUSSION

In this retrospective study of patients with head and neck cancer receiving definitive radiation treatment at an urban tertiary medical center, we report that non-whites had significantly inferior disease control and overall survival compared with white patients. These findings are significant in the context that all patients underwent evaluation in a specialized multidisciplinary setting involving a head and neck surgeon, medical and radiation oncologist, and review of all newly diagnosed head and neck cancers at the multidisciplinary tumor board meetings with treatment recommendations based on National Comprehensive Cancer Network clinical practice guidelines.

We did not identify any disparities in treatment delivery for different race/ethnic groups. There were no differences noted in the quality of treatment delivery with respect to RT techniques using either 3D-conformal RT or IMRT. Furthermore, RT compliance in this study was high. RT duration, total radiation dose, and the percentage of patients receiving IMRT were not significantly different between whites and non-whites. However, there was heterogeneity in the chemotherapy regimens used, partly because of physician preference and patient comorbidities. In general, weekly cisplatin chemotherapy is the preferred agent for concurrent chemoradiotherapy, and other agents are used in the setting of comorbidities or contraindications to the use of cisplatin. The use of concurrent chemoradiotherapy and induction chemotherapy was found to be similar across the 2 groups.

TNM and AJCC are the most commonly applied staging systems for classification and prognosis of the disease. However, studies have pointed toward their weaknesses in accurately predicting treatment outcome in patients with head and neck cancer.^{16,24} In this study, GTV-P was associated with both race/ethnicity and treatment outcomes. Tumor volume was significantly greater in the non-white population compared to whites and correlated with all treatment outcomes with larger volume predicting inferior outcomes. The distribution of AJCC stage, T classification, and N classification were not different by race/ethnicity. AJCC stage did not predict treatment outcome and survival whereas N classification only predicted distant control. T classification predicted for local control, and overall and disease-free survival, but not nodal and distant control. One possible reason for this difference is that staging systems, such as the TNM, focus on a single dimension size criteria and anatomic extent of disease rather than tumor volume factors.

The results observed in this study are similar to earlier studies examining racial/ethnic disparity in treatment outcome in patients with head and neck cancer undergoing chemoradiation. In a pooled analysis of 3 head and neck cancer trials conducted by RTOG, non-white race was associated with inferior locoregional control (HR = 1.22; 95% CI = 1.06–1.41) and poor overall survival (HR = 1.24; 95% CI = 1.09–1.42).⁴ The current study population compared to the RTOG study had a greater proportion of non-white patients (53% vs 26%), received less RT alone (15% vs 68%), and there was greater uniformity in the RT fractionation schema delivered.⁴ Settle et al⁷ reported inferior disease-free survival among African Americans compared to whites in an analysis restricted to patients with advance stage III/IV cancer. In this study, 86% of the patient cohort presented with stage III/IV disease.

Similar race/ethnic disparities have also been observed in studies involving patients undergoing multiple treatment options besides chemoradiation alone. In a single institution analysis, African American patients were noted to have a significant lower 5-year disease-specific survival compared to whites (29.3% vs 54.7%; $p < .0001$) attributed to differences in factors, such as alcohol abuse, insurance status, type of treatment, and advanced disease presentation; with the percentage of patients with stage IV disease: African Americans 65.7%, whites, 46.6% ($p < .001$).⁸ In our study, the patient cohort received chemoradiation, stage IV disease presentation was not significantly different between whites and non-whites, and no differences were noted in insurance coverage.

Compared to datasets from single cancer institutions, results of head and neck cancer outcome analyses from national and regional tumor registries usually lack detailed information on locoregional control and also represent a more heterogeneous group of patients with respect to treatment characteristics.^{10,11} In a Surveillance, Epidemiology, and End Results database study of 6,338 white and 1,165 African American patients with oral cavity and pharyngeal cancers, the hazard of death from oral cancer was 1.7 times greater among African Americans compared with white patients. Tumor size (categorized as T1, T2, and T3 of TNM classification) had no effect on HR for race. After accounting for socioeconomic status, stage, and treatment, the hazard attenuated to 1.1. The authors concluded that differences in these factors accounted for 86% of the excess hazard of death noted among African Americans.¹⁰ This is unlikely to be a factor in this study as no differences were noted in patient demographics. Larger population studies such as the Surveillance, Epidemiology, and End Results database, however, are limited in the ability to closely evaluate tumor factors, specific details of radiation treatment received in terms of dose, compliance, concomitant use of chemotherapy, and treatment technique.

Not all studies have found racial/ethnic disparities in head and neck cancer treatment outcomes. In an analysis of patients with head and neck cancer undergoing definitive RT with or without planned neck dissection, whites and African Americans had no differences in 5-year locoregional control rates: 76% versus 70%, respectively ($p = .275$), however, cause-specific and absolute survival rates were lower for African American patients, which was attributed to increased risk of distant recurrences among African Americans.⁵ In contrast, we report inferior locoregional control among non-whites compared with white patients and, in our population, the predominant site of failure was locoregional rather than distant failure. In a matched pair study from a large multidisciplinary cancer center in which African American and Hispanic Americans were matched with white Americans on patient, tumor, and treatment-related factors, no differences were noted among recurrence-free, disease-specific, and overall survival.²⁵ Finally, in a recent study by Liu et al,²⁶ race was not associated with locoregional control, freedom from distant metastasis, progression-free survival, or overall survival, which was attributed to similar treatment compliance.

Studies examining race/ethnicity and HPV infection among patients with head and neck cancer suggest a higher prevalence of HPV-related cancer among whites compared to African Americans as a possible cause of higher overall survival rates among whites.¹⁴ In this study, information on HPV status was not available for the majority of the patient cohort and, therefore, we were unable to account for the influence of HPV on treatment outcome.

However, it is speculated that given the high proportion of smokers, that the majority of the head and neck cancer presentation may be attributed to smoking as the predominant risk factor, although relative contribution of HPV in our patient population requires further study. Additionally, for oropharyngeal cancers, it has been found in retrospective studies of PET/CT that the morphologic and metabolic parameters are significantly larger in HPV-negative as compared with HPV-positive patients in the primary tumor, whereas the same parameters were larger in HPV regional nodal disease.²⁷

Although contemporary 6radiation techniques, such as IMRT and the use of concurrent chemoradiotherapy, have improved target coverage with sparing of adjacent normal organs at risk, locoregional failure (within the high dose region) is still a significant cause of treatment failure. In this study, non-white patients demonstrated lower local and nodal control rates compared with whites. Surgical salvage options of the primary head and neck disease site are limited after chemoradiotherapy and a cohort of patients still die as a result of locoregional failure. Identifying non-white patients, targeting communities at risk for head and neck cancer, and improving community awareness is perhaps the only way to reduce disparities in treatment outcome. In this regard, use of community focus groups to target early detection, patient education and awareness, combined with improved access for racial/ethnic minorities, smoking cessation programs, and cancer screening initiatives may result in earlier diagnosis of the disease; improve treatment outcome and overall community awareness of head and neck cancer.

This study had several limitations; while the radiation parameters, including dose and fractionation and tolerance were fairly consistent, different chemotherapy regimens were used based upon physician preference and patient comorbidities. The data on education level and HPV status were not available for all patients in this study. Because of sample size limitations we could not look into each race/ethnic group separately and restricted our analysis to whites versus non-whites. Another potential weakness of the study was that we were not able to assess reliability of GTV contouring and inter-user variability, because a single board certified radiation oncologist of 10 years' experience treating primarily head and neck cancer contoured all the GTVs.

However, when contouring the GTV, it is our practice to incorporate all the available clinical radiological information, including information from the physical examination, operative findings from the examination under anesthesia (EUA), contrast-enhanced CT findings, PET/CT, and/or MRI.

Finally, the study was performed at a single institution, therefore, external validity (generalizability) of results observed must be considered. There exists cultural and potential genetic differences in patients of same race/ethnic group across various regions of the United States; therefore, it is possible that differences in tumor volume presentation may only be true for the region where this study was performed.

CONCLUSION

In patients with head and neck cancer receiving definitive radiation-based treatment, white patients demonstrate improved locoregional control and overall survival compared to non-whites, a finding which may be reflective of the volumetric tumor burden at the primary site. No differences were noted in radiation treatment technique and delivery by race/ethnicity. Tailoring effective treatment intensification strategies in these patients at highest risk of recurrence, while improving early detection of head and neck cancer for racial and ethnic minorities are needed to reduce disparities in outcome.

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FIGURE 1.

Treatment outcome by race/ethnicity. (A) local control, (B) nodal control, (C) disease-free survival, and (D) overall survival.

FIGURE 2.

Univariate and bivariate analysis of (A) local failure and (B) death by race/ethnicity. The adjusted hazard ratios (HRs) are for risk of local failure and death adjusting discretely for gross tumor volume (primary, GTV-P), T classification, N classification, and American Joint Committee on Cancer (AJCC) stage. Note: The GTV-P model is based on 88 patients after excluding 3 cases with unknown primary. After excluding 3 unknown primaries, the crude HR for local failure and death was 4.21 (95% confidence interval [CI] = 1.19–14.94) and 2.66 (95% CI = 1.31–5.38), respectively.

TABLE 1

Patient, tumor, treatment characteristics by race/ethnicity.

	All (n = 91)	Whites (n = 43) N = 28	Non-whites (n = 48) N = 28	p value
Mean (SD)				
Age, y	59.4 (10.8)	57.9 (10.0)	60.7 (11.3)	.220
Smoking, pack-years [*]	36.0 (26.5)	37.6 (27.1)	34.4 (26.2)	.576
GTV, cc [†]				
Primary	31.1 (34.9)	21.0 (18.6)	39.9 (42.8)	.011
Nodal	36.3 (49.3)	38.2 (52.8)	34.2 (46.0)	.750
Total	54.9 (54.1)	48.5 (52.4)	60.7 (55.5)	.284
Days from diagnosis to treatment	48 (28)	50 (30)	45 (25)	.425
Radiation treatment duration, d	50 (8)	50 (8)	51 (8)	.665
Median (range)				
Total radiation dose, Gy	69.96 (66–72.0)	69.96 (66–72.0)	69.96 (66–72.0)	.266
No. (column %)				
Sex				.646
Male	70 (76.9)	34 (79.1)	36 (75.0)	
Female	21 (23.1)	9 (20.9)	12 (25.0)	
Smoking status				.899
Nonsmokers	11 (12.1)	5 (11.6)	6 (12.5)	
Smokers	80 (87.9)	38 (88.4)	42 (87.5)	
Insurance coverage				.977
Public insurance	65 (71.4)	31 (72.1)	34 (70.8)	
Private insurance	22 (24.2)	10 (23.3)	12 (25.0)	
Uninsured	4 (4.4)	2 (4.7)	2 (4.2)	
AJCC stage IV	64 (70.3)	31 (72.1)	33 (68.8)	.727
T classification T4	28 (30.8)	10 (23.3)	18 (37.5)	.142
N classification N2–N3	54 (59.3)	29 (67.4)	25 (52.1)	.137
Radiation technique				.790
IMRT	73 (80.2)	35 (81.4)	38 (79.2)	
3D-CRT	18 (19.8)	8 (18.6)	10 (20.8)	
Chemotherapy				.420
No chemotherapy	14 (15.4)	8 (18.6)	6 (12.5)	
Concurrent chemotherapy	77 (84.6)	35 (81.4)	42 (87.5)	

Abbreviations: GTV, gross tumor volume; AJCC, American Joint Committee on Cancer; IMRT, intensity-modulated radiation therapy; 3D-CRT= 3D conformal radiation therapy.

^{*} Pack-year information was not available for 1 non-white patient.

[†] GTV primary and nodal analyses were based on 88 (41 whites and 47 non-whites) and 62 subjects (32 whites and 30 non-whites), respectively.

TABLE 2

Gross tumor volume by American Joint Committee on Cancer stage, tumor, and nodal classification.

	No. (mean ± SD)					
	GTV Primary, cc		GTV Nodal, cc		GTV Total, cc	
AJCC stage						
I–III	27	(22.0 ± 36.4)	5	(16.1 ± 18.7)	27	(25.6 ± 36.7)
IV	61	(33.1 ± 33.7)	57	(38.0 ± 50.8)	64	(67.3 ± 55.6)
<i>p</i> value	.106		.344		.001	
T classification						
T1–T3	60	(22.7 ± 29.6)	41	(43.8 ± 52.6)	63	(50.3 ± 53.6)
T4	28	(49.1 ± 38.9)	21	(21.6 ± 39.1)	28	(65.3 ± 54.6)
<i>p</i> value	.001		.093		.226	
N classification						
N0–N1	37	(28.0 ± 38.9)	8	(5.8 ± 5.1)	37	(29.6 ± 38.8)
N2–N3	51	(33.4 ± 31.8)	54	(40.8 ± 51.3)	54	(72.3 ± 56.5)
<i>p</i> value	.477		.060		.0001	

Abbreviations: GTV, gross tumor volume; AJCC, American Joint Committee on Cancer.

TABLE 3

Gross tumor volume by disease control and survival status of patients.

	No. (mean ± SD)					
	GTV Primary, cc		GTV Nodal, cc		GTVTotal, cc	
Local control	73	(26.8 ± 31.5)	50	(41.0 ± 51.6)	76	(52.9 ± 55.9)
Local failure	15	(52.2 ± 43.5)	12	(16.4 ± 32.7)	15	(65.4 ± 44.1)
<i>p</i> value	.009		.122		.417	
Nodal control	79	(28.0 ± 34.0)	55	(33.1 ± 44.4)	82	(49.3 ± 50.3)
Nodal failure	9	(58.4 ± 32.1)	7	(61.1 ± 78.3)	9	(105.9 ± 63.1)
<i>p</i> value	.012		.158		.002	
Distant control	72	(27.5 ± 32.5)	47	(26.3 ± 35.1)	74	(43.6 ± 41.6)
Distant failure	16	(47.5 ± 41.3)	15	(67.5 ± 71.8)	17	(104.2 ± 73.3)
<i>p</i> value	.037		.004		< .0001	
Overall survival						
Alive	51	(19.3 ± 19.2)	37	(32.3 ± 39.6)	53	(41.4 ± 38.4)
Died	37	(47.4 ± 44.2)	25	(42.1 ± 61.3)	38	(73.9 ± 66.3)
<i>p</i> value	.0001		.445		.004	
Disease-free survival						
Control/alive	45	(18.2 ± 18.8)	31	(33.0 ± 40.5)	46	(40.3 ± 39.3)
Failure/death	43	(44.6 ± 42.2)	31	(39.6 ± 57.3)	45	(69.9 ± 62.8)
<i>p</i> value	.0002		.603		.008	

Abbreviation: GTV, gross tumor volume.

TABLE 4

Treatment outcome by race/ethnicity.

	No. of events (2-y actuarial control rates, %)			<i>p</i> value
	All (<i>n</i> = 91)	Whites (<i>n</i> = 43) <i>N</i> = 28	Non-whites (<i>n</i> = 48) <i>N</i> = 28	
Local control	15 (83.8)	3 (92.4)	12 (75.9)	.014
Nodal control	9 (89.9)	0 (100.0)	9 (80.7)	.003
Distant control	17 (80.6)	5 (87.7)	12 (73.6)	.062
Overall survival	38 (74.9)	12 (85.4)	26 (65.8)	.006
Disease free-survival	45 (61.7)	15 (73.4)	30 (51.4)	.005