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ORIGINAL ARTICLE

Radiotherapy Technique can be Important on Survival in Patients with Gastric Cancer Treated with Postoperative Chemoradiotherapy

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OBJECTIVE

This study aims to investigate the clinical and pathological features of gastric carcinoma and to evaluate the survival of the patients with gastric carcinoma receiving postoperative chemoradiotherapy.

METHODS

In this study, two hundred and four patients who received postoperative chemoradiotherapy for gastric cancer in our clinic from 1999 to 2014 were evaluated retrospectively. Clinical prognostic factors affecting survival were studied.

RESULTS

The median follow-up period was 30.52 months. Overall survival time was 80.47±5.04 months, and the 5-year survival rate was 47.0±4.1%. Overall disease-free survival (DFS) time was 84.58±5.38 months. A lower number of dissected lymph nodes and a higher number of metastatic lymph nodes were found to be related to increased risk of death and also a higher risk for recurrence. Stage 3 cancer was found to have a higher recurrence risk than stage 1 and 2. Recipients of three-dimensional conformal radiotherapy (3DCRT) treatment had a lower risk of death compared to the patients that received 2D treatment.

CONCLUSION

Postoperative chemoradiotherapy should be considered for all the patients with a high risk of recurrence after gastrectomy. In addition to the well-known prognostic factors, such as stage, lymph node metastasis, lymphatic dissection type, radiotherapy technique, was also found to be an important prognostic factor in our study. These results suggest that there is a long-term survival benefit for the patients treated with 3DCRT.

Keywords: Chemoradiotherapy; gastric cancer; prognostic factors; radiotherapy; survival.

Introduction

Gastric cancer (GC) is one of the most common malignancies worldwide. The incidence of gastric cancer varies in different geographic regions. The highest incidence rates are in Eastern Asia, the Andean regions of South America, and Eastern Europe, while the lowest rates are in North America, Northern Europe, and most countries in Africa and South-Eastern Asia. There is also a substantial difference in the incidence among different ethnic groups within the same region.[1,2] Despite recent improvements in therapeutic methods, gastric cancer still has high mortality rates, in part due to the asymptomatic nature of the disease,

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which causes the majority of patients with gastric cancer to be diagnosed at an advanced stage.[3] Despite this, Asian gastric cancer patients have a better prognosis than Western patients, probably due to an active screening program or to a more aggressive therapeutic approach.[4,5]

Surgery remains the only curative therapy in gastric cancer, while perioperative and adjuvant chemotherapy, as well as chemoradiation have been shown to improve outcomes in patients who undergo surgical resection with extended lymph node dissection.[6] The high rate of local-regional recurrence after resection is the main factor accounting for mortality. Therefore, it is important to consider adjuvant treatment in gastric cancer. For patients with stage Ib-IV with M0 gastric cancer, postoperative radiotherapy (RT) plus concurrent chemotherapy (CT) is recommended.[3,4] Because of the critical organs in the vicinity, the planning of RT in gastric cancer is crucial for sufficient treatment without severe side-effects.[7] Furthermore, as local-regional failures occur commonly within the gastric bed, regional lymph nodes and the anastomosis line, these areas should also be covered in the RT field. Target volumes for irradiation are defined based on the site, T-stage, and N-stage of the primary tumor. With the advances in radiotherapy techniques, two-dimensional radiotherapy (2DRT) has been replaced with 3-dimensional conformal radiotherapy (3DCRT), while the intensity-modulated radiotherapy (IMRT) technique has also emerged as an option. These modalities are recognized for their ability to reduce complication rates.[8]

Many studies have shown that lymph node metastasis is the most important prognostic factor in gastric cancer.[9–11] Other prognostic factors in gastric cancer are the presence of distant metastases, lymphatic dissection type, tumor size, localization, histological type, stage, macroscopic type and depth of invasion.[12–14] Radiation therapy affects the prognosis by exhibiting significant survival benefit in patients with gastric cancer.[15] However, data in this field are limited, and there is currently no consensus as to the advantages and limitations of various modalities used as adjuvant therapy in patients who have undergone surgery for gastric cancer. Therefore, to contribute to the relevant literature, in this study, we investigated the clinical-pathological features, the prognostic factors, the survival rates and the importance of radiotherapy techniques in patients with gastric carcinoma receiving postoperative chemoradiotherapy.

Materials and Methods

Study group

In this study, two hundred and four patients who received postoperative chemoradiotherapy for the diagnosis of gastric cancer in the Department of Radiation Oncology, Akdeniz University School of Medicine from 1999 to 2014 were evaluated retrospectively.
Ethical approval was obtained. The current study was conducted according to the principles put forth by the Helsinki Declaration and Good Clinical Practice guidelines.

Measurements

Clinical prognostic factors affecting survival were studied. Pre-treatment evaluation consisted of computed tomography (CT) or 18F-fluorodeoxyglucose positron emission tomography (PET-CT), which were performed on all patients for the purpose of staging. All patients underwent surgery. EBRT was delivered to a total dose of 40-54 Gy (median 46 Gy) in 1.8-2 Gy fraction doses using 10-25 MV X-rays. Until June 2009, two-dimensional conventional radiotherapy (2DRT), after that, the three-dimensional conformal radiotherapy technique (3DCRT) was performed.

For planning with the 2DRT technique, an X-Ray (conventional) simulator was used and performed with intravenous and oral contrast for delineating structures of interest. Parallel-opposed anteroposterior (AP)-poster anterior (PA) fields or a four-field box technique (anterior-posterior (AP)-posterior-anterior (PA)-2 lateral) were the most practical arrangements.

As for planning the 3DCRT technique, computed tomography (CT) simulation images of the patients were taken (adjacent axial slice spacing 2.5 mm; GE-Lightspeed64® computed tomography simulator, GE, Fairfield, USA) with intravenous contrast. The target volumes and critical normal tissues (bowel, liver, kidneys, spinal cord) were outlined on each CT slice. 3DCRT with AP- PA- 2 lateral plus 3 or 4 segments were employed. Lateral fields and segments were used as a component of treatment to spare liver, spinal cord and heart tissues.

Clinical target volume (CTV) included the gastric remnant, anastomosis and stump, tumor bed, regional lymphatics (perigastric, porta hepatis, celiac, suprapancreatic, superior mesenteric, pancreaticoduodenal, splenic hilum) at risk based on sites of adherence of the primary lesion in each of the patients. For planning target volume (PTV), a margin of 1cm was added to CTV in all directions. Most of the patients (92%) re-

ceived 5-fluorouracil (5-FU)-based chemotherapy during radiotherapy (RT).

All analyses in this study were performed in SPSS v21. Survival analyses were conducted with the Kaplan-Meier method. Survival and recurrence time comparisons between groups were evaluated using the Log-Rank test. Pairwise comparisons were made with the Bonferroni correction method. the effects of continuous and categorical variables on survival and recurrence were evaluated with Cox regression analysis with the backward conditional method. $p \leq 0.05$ values were accepted as statistically significant.

Results

We included 204 patients (129 male and 75 female) in our study. The mean age was 56.51±11.35 years. Median follow up time was 30.52 months, and maximum follow up time was 149 months. Most of the patients had stage 3 cancer (67.8%), the most common histologic type was mucinous carcinoma (72.1%), 76 (37.3%) patients had received total gastrectomy while 128 (62.7%) had subtotal. Twenty-nine (14.3%) patients had hematologic toxicity above grade 3, 11 (5.4%) patients had nonhematologic toxicity above grade 3, and 2 of them had passed away because of toxicity. Seventy-nine (40.3%) patients had a recurrence while 14 (%6.9) patients had local metastasis, and 65 (31.9%) patients had distant metastasis. At the end of this study, 83 (40.7%) patients were alive without disease, 6 (2.9%) patients were alive with disease. During this study, 94 (46.1%) patients died due to cancer, while 21 (10.3%) patients died due to other causes.

Overall survival time was 80.47±5.04 months, and the 5-year survival rate was 47.0±4.1%. N2, N3a and N3b cancers had significantly lower survival times than N0 and N1 ($p<0.001$). Mean survival time was 65.53±5.87 months for stage 3 cancers, while it was 111.40±7.85 months for stage 1 and 2 cancers ($p<0.001$). Patients who underwent R1 resection had lower survival times than other patients ($p=0.018$). Five-year survival rate was 41.7±4.5 % for the patients who had D1 lymphatic dissection, while the five-year survival rate was 62.4±10.8% for the patients who had D2 lymphatic dissection ($p=0.033$). Patients with lymphatic metastasis had lower survival rates compared to the patients who did not ($p=0.002$). Patients who received 3DCRT treatment had higher 5-year survival rates than the patients who received 2DRT ($p<0.001$). Mean survival time was 34.48±3.88 months for the patients with recurrence, while the patients that did not have recurrence had a mean survival time of 129.09±4.70 months ($p<0.001$). Patients with metastasis had significantly lower survival times than patients who did not develop metastasis ($p<0.001$). However, there were no significant differences between patients with local and distant metastasis in terms of survival time ($p=0.784$). Concerning other parameters, there were no significant differences for survival times regarding gender, tumor location, differentiation, histologic type, surgery, chemotherapy treatment, radiotherapy dose, presence of toxicity, and presence of vascular, lymphatic or perineural invasion (Table 1).

Overall disease-free survival (DFS) time was 84.58±5.38 months. N2, N3a and N3b cancers had significantly lower survival times than N0 and N1 ($p<0.001$). Mean DFS time was 70.70±6.48 months for stage 3 cancers, while in the patients with stage 1 or 2 cancers had a mean DFS time of 107.96±8.34 months ($p<0.001$). Patients with lymphatic metastasis had lower DFS times than the patients who did not ($p=0.014$). There were no significant differences between patients with local and distant metastasis ($p=0.690$). Also, there were no significant differences for DFS times regarding gender, tumor location, differentiation, histologic type, surgery, resection type, lymphatic dissection type, radiotherapy type and dose, presence of toxicity, and the presence of vascular, lymphatic or perineural invasion (Table 2).

Cox regression analysis was performed to determine factors that were effective on survival, including factors, such as age, dissected lymph node count, metastatic lymph node count and other significant categorical variables. We found that higher age ($p=0.032$), lower number of dissected lymph nodes ($p=0.044$) and a higher number of metastatic lymph nodes ($p<0.001$) were related to the increased risk of death. Also, patients with stage 3 cancer had 1.995-fold higher risk of death than the patients with stage 1 and 2 cancer ($p=0.032$), receiving 3DCRT treatment was found to cause 0.486-fold lower risk of death compared to 2DRT treatment ($p=0.001$), patients with local metastasis had 3.532-fold higher risk of death than the patients without metastasis, while patients with distant metastasis had 6.640 times higher risk of death compared to the patients without metastasis ($p<0.001$) The other variables we included in the analysis that were not found to be significant concerning survival were as follows: lymphatic metastasis ($p=0.818$), resection ($p=0.293$) and lymphatic dissection ($p=0.175$) (Table 3).

Another Cox regression analysis was performed to determine factors that were effective on DFS; with

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Table 1 Survival times (months) with the Kaplan Meier method and comparisons of groups with long rank test for categorical variables

					95 % Confidence Interval			
	n	Death	Mean	Standard Error	Lower Bound	Upper Bound	5-years Survival Rate (%)	p
Overall Survival	204	94	80.47	5.04	70.59	90.36	47.0±4.1	N.A
Gender								
Male	129	62	81.51	6.06	69.63	93.39	47.7±4.8	0.962
Female	75	32	70.08	7.44	55.50	84.66	45.4±7.5	
Location								
Cardia-Fundus	20	3	107.00	8.41	90.51	123.49	84.4±8.3	0.306
Body	29	8	56.11	4.82	46.67	65.54	55.3±17.4	
Antrum-Pylorus	56	20	80.15	7.02	66.39	93.91	54.3±8.1	
Diffuse	10	3	54.75	9.98	35.18	74.32	61.0±18.1	
T Staging								
T1&T2	16	4	55.39	3.79	47.96	62.81	47.5±21.7	0.106
T3	57	22	71.33	7.62	56.40	86.26	51.0±8.6	
T4	129	68	75.39	6.00	63.62	87.15	43.4±4.7	
N Staging								
N0 (a)	37	9	113.63	9.42	95.16	132.10	75.4±7.6	<0.001*
N1 (a)	41	12	105.67	10.28	85.52	125.82	66.6±8.6	
N2 (b)	57	31	63.89	9.02	46.21	81.58	30.5±8.6	
N3a (b)	38	22	46.85	7.51	32.13	61.56	32.2±8.6	
N3b (b)	28	19	40.63	9.36	22.29	58.98	23.5±8.9	
Stage								
1&2	65	15	111.40	7.85	96.02	126.78	74.7±6.3	<0.001*
3	137	78	65.53	5.87	54.02	77.04	33.9±4.8	
Differentiation								
Well	22	8	95.93	14.14	68.22	123.63	56.3±12.6	0.281
Moderate	65	30	79.03	8.85	61.70	96.37	49.3±7.0	
Poor	110	55	73.34	6.43	60.73	85.95	42.0±5.5	
Histologic Type								
Mucinous adenocarcinoma	147	68	81.61	5.79	70.27	92.95	47.7±4.7	0.246
Signet-ring cell carcinoma	49	24	66.94	9.02	49.26	84.63	41.8±8.5	
Others	8	2	83.37	14.87	54.22	112.51	72.9±16.5	
Gastrectomy								
Total	76	36	66.49	6.77	53.22	79.76	46.1±6.6	0.380
Subtotal	128	58	82.82	6.23	70.62	95.02	47.5±5.1	
Resection								
R0	170	72	81.51	5.33	71.06	91.97	50.5±4.5	0.018*
R1	34	22	61.98	10.86	40.70	83.26	32.7±8.3	
Lymphatic Dissection								
D1	159	81	71.85	5.52	61.03	82.67	41.7±4.5	0.033*
D2	28	9	78.27	8.04	62.51	94.04	62.4±10.8	
Lymphatic Metastasis								
Absent	38	10	110.15	9.72	91.10	129.20	72.8±7.9	0.002*
Present	164	84	73.10	5.54	62.25	83.95	40.4±4.5	
Vascular Invasion								
Absent	70	22	70.40	4.70	61.19	79.61	58.4±7.5	0.789
Present	36	11	56.65	4.85	47.15	66.14	59.1±10.2	

Table 1 Cont.

	n	Death	Mean	Standard Error	95 % Confidence Interval		5-years Survival Rate (%)	p
					Lower Bound	Upper Bound		
Lymphatic Invasion								
Absent	40	11	74.89	5.72	63.69	86.09	62.5±9.7	0.259
Present	66	22	58.43	4.02	50.54	66.31	56.8±7.5	
Perineural Invasion								
Absent	55	15	74.29	5.01	64.46	84.11	61.7±8.5	0.149
Present	51	18	56.63	4.66	47.49	65.77	55.6±8.0	
KT Treatment before RT								
Absent	15	5	53.00	7.14	39.01	66.99	62.9±13.3	0.822
Present	93	28	70.49	4.15	62.36	78.62	58.0±6.7	
RT + KT Treatment								
Absent	16	6	67.11	10.03	47.46	86.76	60.6±12.7	0.375
Present	187	88	78.32	5.27	67.99	88.66	45.2±4.3	
RT Type								
3DKRT	106	33	60.61	3.04	54.66	66.57	57.6±6.2	<0.001*
2D	98	61	63.27	6.55	50.43	76.11	35.4±5.2	
RT Dose								
≤4500	83	44	73.47	7.41	58.94	88.00	44.6±6.0	0.369
4501-4999	53	25	81.55	9.52	62.89	100.21	46.5±7.6	
≥5000	68	25	53.79	3.80	46.34	61.23	49.6±8.1	
Hematologic Toxicity (> Grade 3)								
Absent	174	82	78.55	5.44	67.89	89.21	45.5±4.4	0.603
Present	29	12	51.89	5.94	40.25	63.52	52.5±10.5	
Non-hematologic Toxicity (> Grade 3)								
Absent	192	91	78.67	5.15	68.57	88.76	45.4±4.2	0.328
Present	11	3	49.51	7.12	35.57	63.46	72.7±13.4	
Recurrence								
Absent	117	16	129.09	4.70	119.88	138.30	84.8±3.5	<0.001*
Present	79	71	34.48	3.88	26.88	42.08	10.2±3.6	
Metastasis								
None (a)	125	23	122.32	5.08	112.36	132.28	80.0±3.8	<0.001*
Local (b)	14	12	39.39	11.63	16.59	62.18	14.3±9.4	
Distant (b)	65	59	32.59	3.63	25.48	39.71	9.1±3.8	

Same letter denotes the lack of statistically significant difference between groups.

age, dissected lymph node count, metastatic lymph node count and other significant categorical variables. We found that a lower number of dissected lymph nodes (p=0.007) and a higher number of metastatic lymph nodes (p<0.001) were related to increased recurrence risk. Also, stage 3 cancer was found to cause a 2.474-fold higher recurrence risk than stage 1 and 2 cancer (p=0.002). The other variables we included in the analysis, age (p=0.554) and lymphatic metastasis (p=0.775), were not found to affect DFS significantly (Table 4).

Discussion

Gastric cancer has a very poor prognosis and is still among the most important causes of death due to malignancy. The primary treatment for gastric cancer is surgery, but prognostic factors that determine local and regional recurrence after surgery also determine the need for adjuvant therapy.[16] A study had shown that three-year overall and disease-free survival time was significantly better for patients receiving chemoradiotherapy in addition to postoperative chemotherapy.[15]

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Table 2 Disease free survival times (months) with the Kaplan Meier method and comparisons of groups with long rank test for categorical variables

	n	Recurrence	Mean	Standard Error	%95 Confidence Interval		p
					Lower Bound	Upper Bound	
Overall	196	79	84.58	5.38	74.04	95.13	N.A
Gender							
Male	124	51	86.91	6.43	74.30	99.51	0.737
Female	72	28	67.23	6.44	54.61	79.85	
Location							
Cardia-Fundus	19	5	94.58	10.83	73.35	115.81	0.610
Body	29	8	55.39	5.11	45.37	65.42	
Antrum-Pylorus	56	22	75.49	7.38	61.03	89.95	
Diffuse	10	3	53.42	10.49	32.85	73.99	
T Staging							
T1&T2	16	4	54.07	4.32	45.61	62.54	0.171
T3	56	19	76.16	7.86	60.75	91.56	
T4	122	56	79.17	6.51	66.42	91.93	
N Staging							
N0 (a)	37	10	108.25	10.23	88.20	128.30	<0.001*
N1 (a)	40	11	106.95	10.51	86.34	127.55	
N2 (b)	54	28	69.89	9.52	51.23	88.54	
N3a (b)	36	16	55.20	8.95	37.66	72.73	
N3b (b)	26	14	46.29	11.65	23.46	69.11	
Stage							
1&2	65	16	107.96	8.34	91.62	124.30	<0.001*
3	129	63	70.70	6.48	58.01	83.39	
Differentiation							
Well	21	6	104.47	14.53	76.00	132.95	0.240
Moderate	63	27	81.05	9.46	62.52	99.58	
Poor	105	45	78.93	7.06	65.10	92.76	
Histologic Type							
Mucinous adenocarcinoma	141	58	85.26	6.15	73.21	97.31	0.771
Signet-ring cell carcinoma	47	18	74.13	10.22	54.09	94.16	
Others	8	3	71.54	16.46	39.27	103.81	
Gastrectomy							
Total	72	30	70.31	7.29	56.02	84.61	0.376
Subtotal	124	49	87.22	6.57	74.34	100.09	
Resection							
R0	165	64	84.20	5.76	72.91	95.48	0.379
R1	31	15	74.99	12.87	49.76	100.21	
Lymphatic Dissection							
D1	152	65	78.67	5.97	66.97	90.37	0.314
D2	27	10	72.43	8.81	55.17	89.70	
Lymphatic Metastasis							
Absent	38	10	107.78	10.33	87.55	128.02	0.014*
Present	156	69	78.06	5.97	66.36	89.75	
Vascular Invasion							
Absent	69	25	65.22	5.07	55.28	75.16	0.945
Present	36	12	54.36	5.15	44.26	64.46	

Table 2 Cont.

	n	Recurrence	Mean	Standard Error	%95 Confidence Interval		p
					Lower Bound	Upper Bound	
Lymphatic Invasion							
Absent	39	13	68.48	6.48	55.77	81.19	0.504
Present	66	24	55.26	4.29	46.85	63.66	
Perineural Invasion							
Absent	54	18	68.37	5.55	57.49	79.24	0.396
Present	51	19	54.30	4.93	44.65	63.96	
KT Treatment Before RT							
Absent	15	5	51.84	7.53	37.07	66.60	0.869
Present	92	32	65.65	4.47	56.90	74.40	
RT + KT Treatment							
Absent	16	5	70.70	10.08	50.95	90.45	0.371
Present	179	74	82.34	5.65	71.26	93.41	
RT Type							
3DKRT	105	37	56.62	3.31	50.13	63.12	0.140
2D	91	42	76.72	7.62	61.77	91.66	
RT Dose							
≤4500	77	30	86.65	8.20	70.58	102.72	0.702
4501–4999	51	22	83.83	10.13	63.97	103.69	
≥5000	68	27	50.46	4.08	42.46	58.46	
Hematologic Toxicity (> Grade 3)							
Absent	167	68	82.99	5.84	71.56	94.43	0.837
Present	28	11	52.29	6.24	40.07	64.52	
Non-hematologic Toxicity (> Grade 3)							
Absent	184	76	82.80	5.52	71.98	93.63	0.445
Present	11	3	48.78	7.47	34.15	63.42	
Metastasis							
None	117	0	No statistics are computed because all cases are censored				0.690
Local	14	14	27.30	9.36	8.94	45.65	
Distant	65	65	21.74	2.21	17.42	26.06	

Same letter denotes the lack of statistically significant difference between groups.

Studies have shown that, excluding early stomach cancers and results from Japan, 5-year survival in gastric cancer is 25-40%.[17, 18] In this study, it was found mean overall survival time of patients as 80.47±5.04 months, and 5-year survival rate was 47.0±4.1%, which was higher compared to the literature.

Lymph node metastasis is accepted to be one of the most important prognostic factors in cases of gastric cancer. Siewert et al., in their study, comprised of 1654 patients with gastric cancer, reported that the most important poor prognostic factor was lymph node involvement rate; the authors reported that an involvement rate higher than 20% had significantly shorter survival.[12] Similarly, in this study, patients with lymphatic metastasis had lower survival rates and lower DFS times than the patients who did not. Cox regression analysis for determining important factors on survival also showed that higher metastatic lymph node count was related to increased risk of death.

Adachi et al., in their comprehensive study on patients with gastric cancer, reported that the stage of the disease, the state of the lymph nodes and the degree of penetration of the tumor tissue in the stomach wall, were the most important factors effective on prognosis. In their study, the 5-year survival rate was 90% in stage IA, 80% in stage IB, 65% in stage II, 50% in stage IIIA, 30% in stage IIIB, and 5% in stage IV.[19] Similarly, Ersan et al. also found significant differences

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Table 3 Cox regression analysis results for survival times

	B	SE	Wald	df	P	Exp(B)	95% CI for Exp(B)	
							Lower	Upper
Age	0.020	0.009	4.601	1	0.032	1.020	1.002	1.039
Stage 3	0.691	0.306	5.104	1	0.024	1.995	1.096	3.633
Dissected Lymph Nodes (count)	-0.024	0.012	4.043	1	0.044	0.976	0.953	0.999
Metastatic Lymph Nodes (count)	0.068	0.017	15.753	1	<0.001	1.070	1.035	1.106
RT Type (3DKRT)	-0.722	0.225	10.282	1	0.001	0.486	0.312	0.755
Metastasis			51.037	2	<0.001			
Metastasis (Local)	1.262	0.383	10.87	1	0.001	3.532	1.668	7.477
Metastasis (Distant)	1.893	0.265	51.016	1	<0.001	6.640	3.950	11.163

Table 4 Cox regression analysis results for disease free survival times

	B	SE	Wald	df	p	Exp(B)	95% CI for Exp(B)	
							Lower	Upper
Stage 3	0.906	0.296	9.374	1	0.002	2.474	1.385	4.417
Dissected Lymph Nodes (count)	-0.032	0.012	7.218	1	0.007	0.969	0.947	0.991
Metastatic Lymph Nodes (count)	0.064	0.017	13.217	1	<0.001	1.066	1.030	1.103

in mean survival (81.4%/27.1%) and 5-year survival (88.2%/3.7%) when patients with Stage I and IV cancer were compared in their study comprised of 154 patients with gastric cancer who underwent curative resection.[20] Similarly, in the present study, the mean survival times of stage 3 patients (65.53±5.87 months) was significantly shorter than the mean survival times of stage 1 and 2 (114.40±7.85) patients. Having stage 3 cancer resulted in a 1.995-fold higher death risk compared to stage 1 and 2 cancers. In addition, we found that survival time was shorter in patients with metastasis. Local metastasis caused 3.532-fold, and distant metastasis caused a 6.640-fold higher death risk compared to no metastasis. However, there was no statistically significant difference concerning survival between those with local and distal metastasis.

In the literature, some studies have reported high mortality and morbidity rates for patients undergoing D2 dissection.[21,22] However, Ron Lavy et al. reported that mortality and morbidity rates were not high for D2 lymphadenectomy. In addition, they recommended D2 dissection as the standard approach.[23] In another study, it was reported that patients with N+ tumors and pT 2–4 tumors with LN involvement in the D1 arm, had 5-year OS rates of 43% and 35%, respectively.[24] In this study, most of the patients had lymph node metastasis (pN+) and locally-advanced stage (pT2-4). Furthermore, most of the patients had undergone D1 dissection, with a dissected lymph node count of 10 or less. However, results were fairly consistent with the literature. In this study, only 14% of the patients had undergone D2 dissection; however, the 5-year survival rate with D2 dissection (62.4±10.8%) was better than that of the patients with D1 dissection (41.7±4.5%). In terms of age, Gaito et al., in their retrospective study of 1473 gastric cancer patients who underwent curative resection, reported that age is an independent prognostic factor.[25] Our results also showed that higher age was related to increased death risk, confirming this finding.

The use of postoperative combined chemotherapy was suggested to become the standard for patients with locally advanced stage cancer in a study by Macdonald et al. Although this study demonstrated a significant survival benefit, toxicity rates were high. The main reason for high toxicity may have been the use of the 2DRT technique.[3] Therefore, the radiation characteristics of methods were put to the question; however, to our knowledge, there were very few studies that could demonstrate an approach that could reduce toxicity. In one study, it was emphasized that parallel-opposed anteroposterior-posteroanterior fields (AP-PA technique) were the most practical approach in 2D planning because, with this method, the kidneys could be spared from irradiation.[26] In 2014, a study compared conformal and conventional radiotherapy techniques in 36 patients dosimetrically. Dose homogeneity and doses of the organs at risk (left

kidney and spinal cord) were found to be significantly improved by 3DCRT. Therefore, the authors suggested that the 3DCRT method may be beneficial in tumor control while also reducing complications in normal tissues.[27] Similarly, in the current study, we showed that the radiotherapy technique was an important prognostic factor for gastric cancer, and patients receiving 3DCRT were found to have superior survival rates.

To our knowledge, our study is the first in the relevant literature comparing the 3DCRT and 2DRT techniques concerning survival and toxicity in patients with gastric cancer. In light of our results, we believe that the 3DCRT technique provides better results compared to 2DRT. However, our study was retrospective in design and our findings require confirmation through randomized clinical trials involving a higher number of patients. Another limitation of this study is that there was a time-bound difference in the use of 2DRT and 3DCRT, which may have contributed to the difference between the two methods. Furthermore, the effects of advances in other treatment parameters and patient care (from 1999 to 2014) were not evaluated and may have caused differences in patient survival.

Conclusion

In this study, this study aimed to evaluate the results of chemoradiotherapy concerning survival rates and prognostic factors in gastric carcinoma patients who underwent surgical resection. We found that higher age, lower dissected lymph node count, higher metastatic lymph node count, cancer stage (3 vs. 1 and 2), and radiotherapy technique (3DCRT vs 2DRT) are significantly associated with prognosis. We believe that novel technological developments in the field of radiotherapy and their advantages require frequent evaluation and constant research to determine their clinical utility.

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