MedCrave
Step into the World of Research

Journal of Cancer Prevention & Current Research

Waiting Times as a Quality Indicator for IMRT/VMAT Cases in the Radiotherapy Department: A Retrospective Study from a Tertiary Hospital in Saudi Arabia

Abstract

Aim: To analyze the feasibility process and the compliance of our workflow to our protocol for cases treated with IMRT and VMAT.

Material and Methods: A retrospective analysis of IMRT cases treated between October 2010 and December 2014. Waiting times from the radiotherapy request to treatment start (REQ-ST), from the radiotherapy request to CT Simulation (REQ-CT) and from CT Simulation to treatment start (CT-ST), were computed. To assess the compliance of our performance with the protocol of ≤10 WD, we calculated two indicators: mean waiting times and compliance rates. The cut-off of compliance for CT-ST is defined by our protocol. Using ≤10 WD, the two other cut-offs were respectively calculated using a linear equation of REQ-ST and REQ-CT as a function of CT-ST, giving a REQ-CT=9 weekdays (WKD) and REQ-ST=26 WKD.

Results: A total of 245 cases of IMRT were included. The mean duration and standard deviation ±SD CT-ST, REQ-ST and REQ-CT was 13.80 ± 5.07 WD, 30 ± 10 WKD, 11.26 ± 8.33 WKD, respectively. The compliance rate of CT-ST, REQ-ST and REQ-CT with the protocol timeline was 16%, 33% and 49%, respectively. Due to the low compliance rates; we proposed to update our protocol with more feasible timelines: CT-ST ≤ 15 WD; REQ-ST ≤ 31 WKD; REQ-CT ≤ 12 WKD. Consequently, the respective compliance rates were raised to 79% for CT-ST, 68% for REQ-CT and 60% for REQ-ST.

Conclusion: In order to conciliate quality of care standards and practicable goals, it seems appropriate to adjust the protocol timeline whilst simultaneously trying to improve procedural and patient compliance.

Keywords: Waiting times; Quality indicator; IMRT; VMAT cases; Radiotherapy treatment; H&N cancers

Research Article

Volume 5 Issue 3 - 2016

Mulla Z[1]*, El Sayed ME[1,2], Soaida SM[1,3], AlHebshiA[1], Bayoumy M[1], Mohammed Khasim A H[4] and Youssef O[1,2]

[1]*Department of Oncology, King Faisal Specialist Hospital & Research Centre, Saudi Arabia*
[2]*Department of Radiotherapy and Nuclear Medicine, National Cancer Institute, Egypt*
[3]*Department of Clinical Oncology, Cairo University, Egypt*
[4]*Department of Radiology, King Abdulaziz University Hospital, Saudi Arabia*

***Corresponding author:** Zaheeda Mulla, Supervisor, Radiation Therapist, KFSHRC Jeddah, KSA, PO Box 40047 21499; Tel: +966 506618421; Email: mulla.zaheda@gmail.com; zmulla68@kfshrc.edu.sa

Received: August 7, 2016 | **Published:** August 18, 2016

Abbreviations: WD: Working Days; WKD: Weekdays; CTST: Waiting Times From the Date of CT Simulation to the Start of Radiotherapy Treatment; REQST: Waiting Times from the Radiotherapy Request to the Start of Radiotherapy Treatment; REQCT: Waiting Times from the Radiotherapy Request to the Date of CT Simulation

Background

Radiotherapy (RT) continues to be one of the most important treatment modalities for cancer patients [1], with an increasing demand in parallel with rising incidence of cancer [2]. It is estimated that approximately 50%-60% of all patients with cancer will receive radiotherapy as part of their treatment within a defined time period [1].

Delay in Radiotherapy treatment is associated with a risk of tumor progression and an increase in local recurrence rate [3-7], resulting in poor prognosis [8-10]. Increase in local recurrence rate is mostly observed in patients with H&N cancers [5,7,9,10,] as well as cervix cancer [3], lung [4], breast [8] and brain. [11]. In brain tumors, for example, Irwin et.al. reported that a six-week delay in post-operative RT reduced survival by 11 weeks and, every additional week of delay before the start of RT increases the risk of death by 8.9% [11].

Extended waiting time before RT was also evidenced to affect patient's satisfaction and quality of life [12]. Therefore, waiting time is one of the good measures of RT output. The above-mentioned studies procure the need to reduce waiting times. However, in reality, reducing waiting times to the ideal is not always possible, due to clinical demand that often outweighs the capacity of the setting [1].

Aim

The aim of this study is to retrospectively analyze the feasibility process and the compliance of our workflow to our protocol for cases treated with IMRT and VMAT.

Material And Methods

This is a retrospective study. All the records of patients treated with either IMRT or VMAT between October 2010 and December 2014 in the joint-section of Radiation Oncology, King

Faisal Specialist Hospital and Research Center and King Abdul Aziz University Hospital, Jeddah, Saudi Arabia, were extracted and analyzed. Cases that had the IMRT in their second phase of treatment after 3-D conformal radiotherapy were excluded from the study. Approval of the institutional review board was obtained before the start of the study.

Waiting times

The waiting times from the date of the request to the start of treatment (REQ-ST), from the date of request to CT Simulation (REQ-CT) and from CT simulation to the start of treatment (CT-ST) were assessed and analyzed. The date of the request (REQ) is defined as the day when the radiation therapy is decided by the radiation oncologist after confirmed diagnosis (i.e. decision-to-treat date).

Before the introduction of IMRT in our department, a workflow was established in order to avoid unnecessary delays in treatment and to implement a standard of practice. The workflow is described as follows (all days represent working days) (Table 1).

Table 1: Workflow (all days represent working days).

Time Line	Action
Day 0	Immobilization followed by CT Simulation
Day 1-3	Physician Contouring and final approval of all contours
Day 4-6	Dosimetry planning – Followed by plan/ prescription approval
Day 7	Physics plan verification (Physics Quality Assurance)
Day 8	Documentation & Plan verification. RT Chart Check
Day 9	First treatment day

Indicators

For each waiting time; REQ-CT, CT-ST and REQ-ST, two indicators were calculated to assess the compliance of our timely performance with the protocol, which were: 1) the mean waiting time and 2) the compliance rate. The compliance rate for a given waiting time represents the proportion of patients whose actual waiting time was within (less or equal to) the protocol timeline. For the waiting time CT-ST, protocol timeline (or benchmark) is given at 10 working days (WD). For the other waiting times REQ-ST and REQ-CT, related benchmarks are not given by the protocol and were thus estimated from respective linear equations of REQ-ST and REQ-CT as a function of CT-ST for a value of CT-ST=10 WD. The estimations gave a cut-off of 26 week days (WKD) for REQ-ST and a cut-off of 9 WKD for REQ-CT. Consequently, we obtained the following set of benchmarks: CT-ST ≤ 10 WD, REQ-CT ≤ 9 WKD and REQ-ST ≤ 26 WKD, based on which the compliance rates were assessed.

In addition, the study period was divided into 4 sub-periods: (A): from October 2010 to December 2011; (B): from January to December 2012; (C): from January to December 2013 and (D): from January to December 2014. Similarly, tumor sites were divided into 4 subgroups: 1) Head & Neck (H&N); 2) Central Nervous System (CNS); 3) Abdomen & Pelvis, including gynecological (Gyne), genitor-urinary (GU) and Gastro-intestinal tract (GIT) tumors and 4) Others, including lymphomas, sarcomas, breast, skin, lung and eye tumors. Indicators were analyzed across sub-periods and tumor sites.

Statistical Methods

Statistical analysis was performed using IBM SPSS Statistics for Windows, Version 20.0. Armonk, NY: IBM Corp. Means and standard deviations of quantitative variables, as well as frequencies of qualitative variables were calculated using descriptive statistics. Mean waiting times were compared across years and tumor sites using one way Anova. Compliance rates were compared across years and tumor sites using Chi-square test.

Results

The study included 245 cases, 98 (40%) of which were female. Seventy-four cases were treated by the IMRT technique, while the remainder was treated by the VMAT technique. Distribution of the number of cases over the sub-periods as well as distribution in tumor sites is shown in Table 2.

Assessment of waiting times: means and compliance rates

CT-ST

The mean ± SD time from the date of CT to the start of treatment (CT-ST) for the entire population was 13.80 ± 5.07 days. The yearly variation of mean CT-ST showed no significant changes (p=0.254) and is presented in Table 3. Assessment of the total compliance rate in CT-ST showed that 16% of CT-ST waiting times were in compliance with the protocol timeline (≤10 WD), (Table 4).

REQ-ST

The mean ± SD time from the date of request of radiotherapy to the start of the treatment (REQ-ST) for the entire population was 30 ± 10 days. The yearly variation showed the shortest (27.7 ± 11 WKD) mean ± SD REQ-ST in period A and the longest (34.3± 10 WKD) in period B, (p=0.021), (Table 3). Assessment of the total compliance rate in REQ-ST showed 33% of cases in compliance with the benchmark (≤26 WKD) previously calculated. (Table 4).

REQ-CT

The mean ± SD time from the date of request for radiotherapy to date of CT (REQ-CT) for all cases was 11.26 ± 8.33 days. Similarly with REQ-ST, the yearly variation shows the shortest mean REQ-CT in period A (8.6 ± 7.6 WKD) and the longest in period B (14.3± 10.6 WKD), (p=0.021) (Table 3). Assessment of the total compliance rate in REQ-CT waiting time showed 49% of cases in compliance with the benchmark (≤9 WKD) previously calculated (Table 4).

Subsequently to these findings (low compliance rates and relatively high mean waiting times), the compliance was re-analyzed for a new benchmark of CT-ST waiting time of ≤ 15 WD,

which is likely to be a more practical target with regards to our performance. Similarly, the corresponding new REQ-ST and REQ-CT benchmarks were calculated using a linearization of these REQ-ST and REQ-CT as function of the new value of CT-ST. The new set (set 2) of benchmarks was obtained as follows: CT-ST ≤ 15 WD; REQ-CT ≤ 12 WKD; REQ-ST ≤ 31 WKD. With reference to the previous results, the new compliance rates improved from 16% to 79% for CT-ST, from 33% to 60% for REQ-ST and from 49% to 68% for REQ-CT (Figure 1, Table 3 & 4).

Table 2: Distribution of cases by sub-periods and tumors sites.

Parameter		Period A	Period B	Period C	Period D	Total
		Oct 2010- Dec2011	2012	2013	2014	2010-2014
		N (%)	N (%)	N (%)	N (%)	N (%)
Number of cases		18 (7.3%)	50 (20.4%)	104 (42.4%)	73 (29.8%)	245 (100%)
Technique	IMRT	18 (100)	42 (84.0)	14 (13.5)	0 (0.00)	74 (30.2)
	VMAT	0 (0.00)	8 (16.0)	90 (86.5)	73 (100)	171 (69.8)
Tumor Sites	**Head & Neck**	**15 (83.3%)**	**36 (72%)**	**43 (41.3%)**	**10 (13.7%)**	**104 (42.4%)**
	CNS	**0 (0%)**	**4 (8%)**	**20 (19.2%)**	**24(32.9%)**	**48 (19.6%)**
	Pelvis & Abdomen :	**1 (5.6%)**	**1 (2%)**	**22(21.2%)**	**17(23.3%)**	**41 (16.7%)**
	GU	0 (0%)	0 (0%)	11(10.6%)	11(15.1%)	22 (9%)
	GIT	1 (5.6%)	1 (2%)	10(9.6%)	5(6.8%)	17 (6.9%)
	Gyne	0 (0%)	0 (0%)	1(1%)	1 (1.4%)	2 (0.8%)
	Others :	**2 (11.1%)**	**9 (18%)**	**19 (18.3%)**	**22 (30.1%)**	**52 (21.2%)**
	Lymphoma	1(5.6%)	3 (6%)	10 (9.6%)	10(13.7%)	24 (9.8%)
	Sarcoma	0 (0%)	5 (10%)	4(3.8%)	3(4.1%)	12 (4 .9%)
	Breast	0 (0%)	0 (0%)	3 (2.9%)	5 (6.8%)	8 (3.3%)
	Skin	0 (0%)	1 (2%)	0 (0%)	2 (2.7%)	3 (1.2%)
	Lung	0 (0%)	0 (0%)	1 (1%)	2 (2.7%)	3 (1.2%)
	Ophthalmic	1(5.6%)	0 (0%)	0 (0%)	0 (0%)	1 (0.4%)
	Neuroendocrine	0 (0%)	0 (0%)	1 (1%)	0 (0%)	1 (0.4%)

Table 3: The mean waiting times progression over time.

	2010-2014	Oct 2010- Dec 2011	Jan 2012- Dec 2012	Jan 2013 – Dec 2013	Jan 2014 – Dec 2014	p-value
Waiting Time	**Mean ± SD**	**Mean ± SD**	**Mean ± SD**	**Mean ± SD**	**Mean ± SD**	**-**
REQ-CT (WKD)	11.3 ± 8.3	8.6 ± 7.6	14.3 ± 10.6	11.0 ± 7.9	10.2 ± 6.9	.021*
CT-ST (WD)	13.8 ± 5.1	14.3 ± 5.3	15.0 ± 7.1	13.4 ± 4.8	13.4 ± 3.4	0.254
REQ-ST (WKD)	30.4 ± 10.3	27.7 ± 10.9	34.3 ± 10.2	29.4 ± 10.6	29.6 ± 9.2	.021*

Comparisons across tumor sites

Table 5 presents the comparison of mean waiting times across tumor sites. As compared with the other tumor sites, CNS patients had significantly the shortest REQ-CT (13.0 ± 4.7 WKD), with p=0.025 and REQ-ST (26.95±7.85 WKD), with p=0.020. Comparative analysis of CT-ST showed no significant difference across tumor sites.

Table 6 presents the comparative analysis of compliance rates between the different tumor sites using the two sets of benchmarks. There was a significant variation in the REQ-CT waiting times across different tumor sites, with H&N tumor having the lowest compliance rate in both set 1 (40%) and set 2 (62%), while Abdomen & pelvis tumors had the highest compliance rate in both set 1 (66%, [p=0.029]) and set 2 (86%, [p=0.033]). Analysis of compliance rate of CT-ST and REQ-ST waiting times showed no significant difference across tumor sites.

Citation: Mulla Z, El Sayed ME, Soaida SM, AlHebshi A, Bayoumy M, et al. (2016) Waiting Times as a Quality Indicator for IMRT/VMAT Cases in the Radiotherapy Department: A Retrospective Study from a Tertiary Hospital in Saudi Arabia. J Cancer Prev Curr Res 5(3): 00163. DOI: 10.15406/jcpcr.2016.05.00163

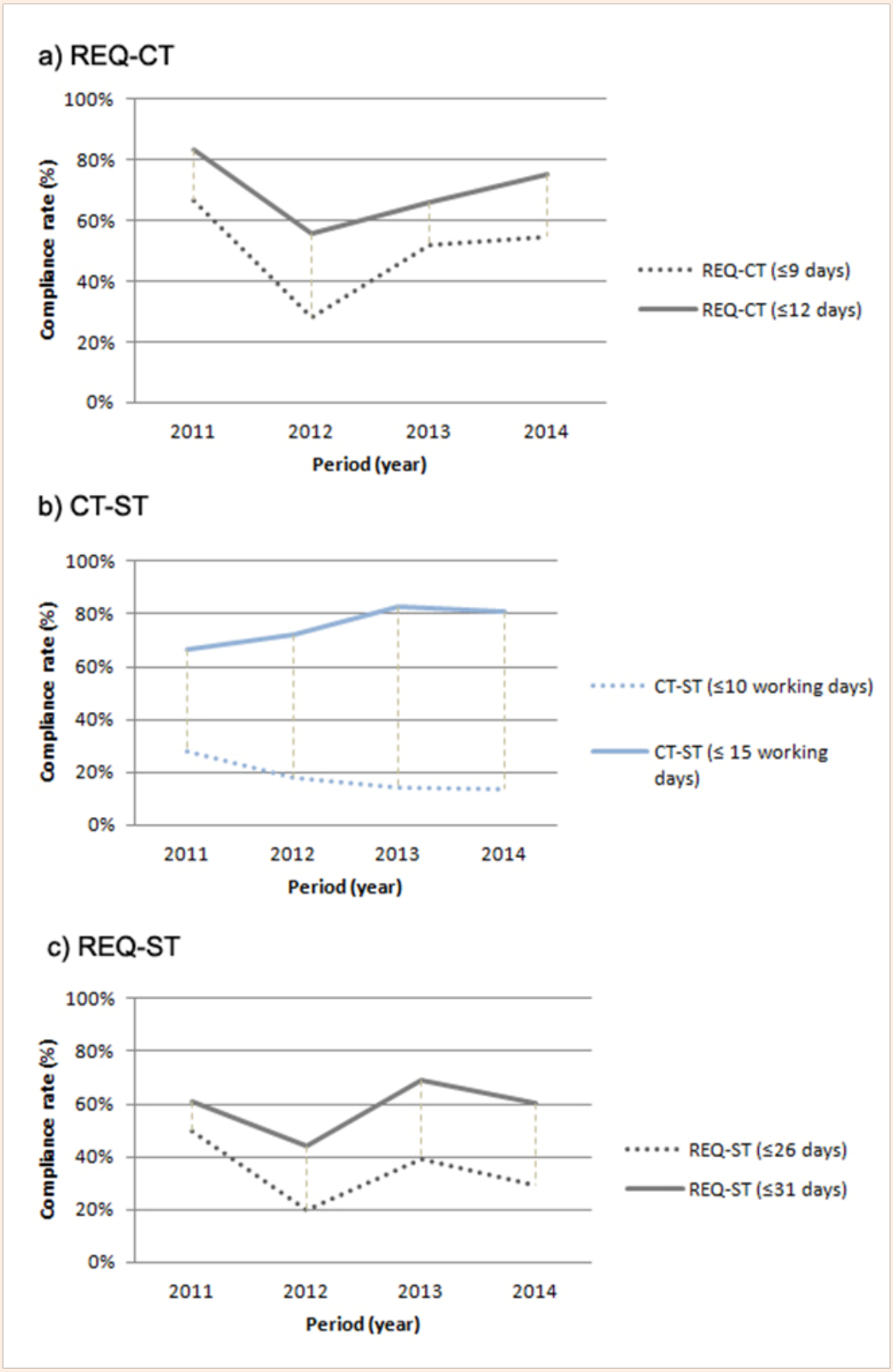

Figure 1: Progression over time of compliance rates using the two benchmarks.

Table 4: Compliance rates progression over time.

		Oct 2010- Dec 2011	Jan 2012- Dec 2012	Jan 2013 – Dec 2013	Jan 2014 – Dec 2014	p-value
Waiting Time	**Benchmark**	**%**	**%**	**%**	**%**	
REQ-CT	≤9 WKD	66.70%	28.00%	51.90%	54.80%	.006*
	≤12 WKD	83.30%	56.00%	66.30%	75.30%	0.066
CT-ST	≤10WD	27.80%	18.00%	14.40%	13.70%	0.257
	≤15WD	66.70%	72.00%	82.80%	80.80%	0.476
REQ-ST	≤26 WKD	50.00%	20.00%	39.40%	28.90%	.034*
	≤31 WKD	61.10%	44.00%	69.20%	60.30%	.029*

Table 5: Mean comparison of waiting times across tumor sites.

	Head & Neck	CNS	Pelvis & Abdomen	Others	p-value
Waiting Time	**Mean ± SD**	**Mean ± SD**	**Mean ± SD**	**Mean ± SD**	
REQ-CT	12.5 ± 8.9	9.4 ±4.9	8.8 ± 5.6	12.4 ± 10.5	.025*
CT-ST	14.1 ± 5.4	13.0 ± 4. 7	13.7 ± 3.8	14.2 ± 5.7	0.63
REQ-ST	31.4 ± 10.7	26.9 ± 7.9	28.8 ± 9.8	32.7 ± 11.2	.020*

Table 6: Compliance rates across tumor sites.

		Head & Neck	CNS	Pelvis & Abdomen	Others	p-value
Waiting Time	**Benchmark**	**%**	**%**	**%**	**%**	
REQ-CT	≤9 WKD	39.40%	54.20%	65.90%	50.00%	0.029*
	≤12 WKD	61.50%	72.90%	85.40%	63.50%	0.033*
CT-ST	≤10WD	18.30%	18.80%	12.20%	11.50%	0.596
	≤15WD	78.80%	81.20%	73.20%	80.80%	0.784
REQ-ST	≤26 WKD	29.80%	43.80%	41.50%	23.10%	0.085
	≤31 WKD	57.70%	77.10%	61.00%	51.90%	0.058

Discussion

IMRT was introduced in our section in October 2010. It consists of a sophisticated technique commonly practiced in over 70% of the radiotherapy (RT) departments in the United States since 2004. [13] In our study, cases treated with VMAT were included as VMAT can be assimilated to IMRT, with the only difference that in VMAT the entire tumor volume is irradiated during one revolution of the machine.

Patients with H&N cancers were amongst the first patients who benefited from IMRT in our section. This priority was allocated based on several studies that reported the effectiveness of IMRT in reducing side effects of RT in these patients with H&N tumor localizations. [14-16] Therefore, H&N cancer appeared as the exclusive indication of IMRT in the first sub-period (A) and the most frequent one in the following sub-periods.

For patients with other tumor sites, such as cervix and prostate tumors, we initially adopted a two-phase treatment, beginning with the 3-D conformal RT to avoid treatment delays, followed by IMRT. Prostate cancer is not classified among rapidly dividing tumors; however, there is evidence suggesting that delay in start of RT may be associated with a significant increase in prostate specific antigen levels, which may be related to a tumor progression. [17] Consequently, 3-D conformal RT was also proposed for these patients as a first phase before relay by IMRT.

Progression over time showed a 3-fold increase in the number of cases from the first to the 2nd sub-period, and a 2-fold increase from the 2nd to the 3 sub-period, as shown in Table 2. This important increase is probably related to passing through the initial learning curve; however, the introduction of a new LINAC in 2012 and the updating of the planning system in our section

contributed in this increase. VMAT provided shorter treatment times, allowing more patients recruitment; hence the use of IMRT was progressively replaced with VMAT in early 2013, explaining the parallel decrease in the number of cases treated with IMRT.

As compared with 3-D conformal RT, both IMRT and VMAT technique require more personnel and time [18]. Staff shortage represents one of most important factors of underperformance as identified in UK [1]. Similarly, in our section the long waiting times during the period 2012 and 2013 as shown in Table 3, were attributed to staff shortage.

The relatively long waiting times recorded in 2012 are also in relation with the machines downtime, at this period. This emphasizes the importance of implementing contingency arrangements in order to overcome major machine breakdowns and avoid treatment delays resulting from the long waits for replacement parts from abroad.

In an effort to meet the clinical demands, the working hours were extended in limited periods in our Section, which was similarly reported in some centers in the UK [19]. However, the extended working hours were implemented after major machine breakdown and essentially for cases where the delay in RT was less tolerable.

After our resources have been improved (introduction of another LINAC, additional licenses for planning system, and more personnel), we extended the use of IMRT in all tumor sites, where clinically indicated. In this circumstance and in view of the results of this study, the operating protocol timeline should be readapted to meet both the standards of quality and the growing demand.

An additional factor of extended waiting times is the issue of patients not being always punctual with their appointments. Many of our patient's reside in distant regions of the country and may not have enough resources to finance alternative accommodation fees. Other patients, once scheduled, spend significant time hesitating or seeking for alternative medicine, before they accept the treatment. Low education level was another factor met in patients who recurrently missed their appointments. Murphy et.al outlined similar socio-economic factors for delays in time-to-definitive treatment initiation [20].

Moreover, many patients with H&N cancer who are referred for RT require dental clearance beforehand, which may delay the start of the treatment. This delay in the transition of care was identified by Murphy et al. [20] as one of the strongest independent predictors of extended time-to-definitive treatment start in patients with H&N cancer.

After performing in-depth analysis we identified other factors impacting the waiting times in our cohort, such as postpones or re-bookings for additional CT simulation sessions, indicated in several situations. For example, some patients needed to be re-simulated with bolus as the planning system cannot create bolus. A few other patients with rapidly growing tumors needed a new CT simulation before the treatment start; while a couple of others benefited of a tracheostomy after their initial CT simulation and needed to be re-planned.

The aforementioned factors were largely contributing to the long mean waiting times and low compliance rates for H&N cancer, shown in Tables 5 & 6, respectively.

Unfortunately, causes of delay could not be sufficiently documented in all cases; however, in most documented cases the delay was in relation with the patient's condition or attitude. According to Stefanuto et.al, patient-related factors are the most frequent causes of overall delay in treatment of H&N cancers [21]. Delay in cases of re-CT simulation ranked in second position in our study, followed by machine downtime and delay in the transition of care.

Analysis of mean waiting times and compliance rates enabled us to adjust the protocol timeline and to define a maximal limit (31 WKD) for REQ-ST. In addition, our new protocol timeline defines maximal limits for REQ-CT and CT-ST at 12 WKD and 15 WD, respectively. Different authors from UK reported the use of 31 day benchmark from decision to treat to start for first, second or subsequent cancer treatment [1]. However, a vast majority of radiotherapy is a subsequent rather than a first definitive treatment [1]. We cannot compare these standards to our study which analyzed a specific period catered to measuring radiotherapy waiting time, and did not consider the waiting time before the radiotherapy consultation. In Lee et al. [22] reported a median waiting time in IMRT patients with nasopharyngeal cancer, of 28 WKD for RTT, this is, "Ready for treatment (by radiotherapy) to radiotherapy (RTT)," after logistic re-engineering [22]. RTT in the latter study is defined the same as the time interval from REQ-ST in our study. The median waiting time for REQ-ST for patients with H&N cancer in our study compares favorably, with the same value of 28 WKD.

The best performance in the waiting time for treatment preparation in Radiotherapy (REQ-ST) was reported in Denmark, with a median waiting time for patients with H&N cancer at 19 WKD, attributed to the great expansion in radiotherapy facilities [23]. An interesting finding by Harten V et al. [24] was that the 30 day benchmark set by the Dutch Head and Neck Society has no prognostic value [24].

To our knowledge, there are limited published data on waiting times that assessed CT-ST. One such study from McGill University in Canada analyzed radiation oncology data to predict waiting times from CT to start of RT treatment and reported different CT-ST timelines adapted with respect to the patient diagnosis, priority, primary radiation oncologist, amongst other factors [25]. In our section, we apply a uniform protocol timeline for all cases, except in the initial period where patients with H&N tumors had the exclusive access to IMRT.

The shortest mean waiting times reported in the CNS cases (CT-ST = 13±4.67 and REQ-ST= 26.95±7.85) can be explained by the relatively simple procedure including contouring, planning and obtaining plan approvals in case of CNS tumors, as compared with those of sites.

Conclusion

With regard to the current protocol timeline and disregarding the tumor site, our results showed relatively high mean waiting

times for RT and low compliance rates, indicating an unsatisfactory performance. Qualitative analysis showed patient-related factors, repeated CT simulation sessions, clinical over-demand and machine downtime as the most frequent factors of RT delays.

In order to conciliate quality of care standards and practicable goals, it seems appropriate to adjust the protocol timeline by redefining the CT-ST waiting time at ≤15 WD instead of ≤10 WD and setting 31 WKD as a maximal waiting time from decision-to-treat to start of RT. However, all attempts should be made to improve our procedures to facilitate our workflow, in order to avoid unnecessary delays in commencing patient treatment. Moreover, improving patient's compliance by means of education, in order to raise awareness regarding the negative effects of delays on the prognosis, could also improve the waiting times. The main goal should be to improve quality and patient benefit as opposed to achieving numerically satisfying compliance rates.

Acknowledgement

The authors thank Dr Mohamed Amine Haireche for his kind help in assisting with the statistical analysis and proof reading of this study.

References

1. Cancer Research UK (2009) Achieving a world class Radiotherapy Service across the UK. Cancer Research UK, p. 42.
2. Mackillop WJ, Zhou S, Groome P, Dixon P, Cummings BJ, et al. (1999) Changes in the use of radiotherapy in Ontario Int J Radiat Oncol Biol Phys 44(2): 355-362.
3. Coles CE, Burgess L, Tan LT (2003) An audit of delays before and during radical Radiotherapy for cervical cancer effect on tumor cure probability. Clinical Oncol 15(2): 47-54.
4. Rouke NO, Edwards R (2000) Lung Cancer Treatment Waiting Times and Tumor Growth. Clinical Oncol 12(3): 141-144.
5. Fortin ABI, Albert M, Moore L, Allard J, Couture C, et al. (2002) Effect of treatment delay on outcome of patients with early-stage head-and neck carcinoma receiving radical radiotherapy. Int J Radiat Oncol Biol Phys 52(4): 929-936.
6. Mackillop WJ, Bates JH, O'Sullivan B, Withers HR. (1996) The effect of delay in treatment on local control by radiotherapy. Int J Radiat Oncol Biol Phys 34(1): 243-250.
7. Jensen AR, Nellemann HM, Overgaard J (2007) Tumor progression in waiting time for radiotherapy in head and neck cancer. Radiother Oncol 84(1): 5-10.
8. Huang J, Barbera L, Browers M, Browman G, Mackillop WJ, et al. (2003) Does delay in starting treatment affect the outcomes of radiotherapy? A systemic review J Clin Oncol 21(3): 555-563.
9. O'Sullivan B, Mackillop W, Grice B, Christopher G, Deanna R, et al. (1998) The influence of delay in the initiation of definitive radiotherapy in carcinoma of tonsillar region. Int J Radiat Oncol Biol Phys 42(1): 323.
10. Chen Z, King W, Pearcey R, Kerba M, Mackillop WJ, et al. (2008) The relationship between waiting time for radiotherapy and clinical outcomes: a systematic review of the literature. Radiother Oncol 87(1): 3-16.
11. Irwin C, Hunn M, Purdie G, Hamilton D (2007) Delay in radiation therapy shortens survival in patients with high grade glioma. Journal of Neuro Oncology 85(3): 339-343.
12. Robinson KM, Christensen KB, Ottesen B, Krasnik A (2012) Diagnostic delay, quality of life and patient satisfaction among women diagnosed with endometrial or ovarian cancer. A nationwide Danish study Qual Life Res 21(9): 1519-1525.
13. Mell LK, Mehrotra AK, Mundt AJ (2005) Intensity-modulated radiation therapy use in the United States., 2004. Cancer 104(6): 1296-1303.
14. Guadagnolo BA, Liu CC, Cormier JN, Du XL (2010) Evaluation of trends in the use of intensity-modulated radiotherapy for head and neck cancer from 2000 through 2005. socioeconomic disparity and geographic variation in a large population based cohort. Cancer 116(14): 3505-3512.
15. Sher DJ, Neville BA, Chen AB, Schraq D (2011) Predictors of IMRT and conformal radiotherapy use in head and neck squamous cell carcinoma a SEER-Medicare analysis. Int J Radiat Oncol Biol Phys 81(4): e197-e206.
16. Nutting CM, Morden JP, Harrington KJ, Bhide SA, Clark C, et al. (2011) Parotid-sparing intensity modulated versus conventional radiotherapy in head and neck cancer (PARSPORT). A phase 3 multicentre randomised controlled trial. Lancet Oncol 12(2): 127-136.
17. Nguyen PL, Whittington R, Koo S, Schultz D, Cote KB, et al. (2005) The impact of a delay in initiating radiation therapy on prostate-specific antigen outcome for patients with clinically localized prostate carcinoma. Cancer 103(10): 2053-2059.
18. Ezzell GA, Galvin JM, Low D, Palta JR, Rosen I, et al. (2003) Guidance document on delivery, treatment planning, and clinical implementation of IMRT report of the IMRT Subcommittee of the AAPM Radiation Therapy Committee. Med Phys 30(8): 2089-2115.
19. White L, Beckingham E, Calman F, Deehan C (2007) Extended working Hours in Radiotherapy in the UK. Clinical Oncol 19(4): 213-222.
20. Murphy CT, Galloway TJ, Handorf EA, Wang L, Mehra R, et al. (2015) Increasing Time to Treatment Initiation for Head and Neck Cancer An Analysis of the National Cancer Database. Cancer 121(8): 1204-1213.
21. Stefanuto P, Doucet J, Robertson C (2014) Delays in treatment of oral cancer: a review of the current literature. Oral Surg Oral Med Oral Pathol Oral Radiol 117(4): 424-429.
22. Lee CCY, ACK Cheng, NKH Lam, DCW Chan, LCY Lui, et al. (2010) Improving Waiting Times for Radical Radiotherapy Treatment of Nasopharyngeal Cancer Based on Logistics Re-engineering. J Hong Kong Col Radiol 13: 181-188.
23. Lyhne NM, Christensen A, Alanin MC, Bruun MT, Jung TH, et al. (2013) Waiting times for diagnosis and treatment of head and neck cancer in Denmark in 2010 compared to 1992 and 2002. Eur J Cancer 49(7): 1627-1633.
24. Harten VMC, Hoebers FJ, Kross KW, Werkhoven VED, van den Brekel MW, et al. (2015) Determinants of treatment waiting times for head and neck cancer in the Netherlands and their relation to survival. Oral Oncology 51(3): 272-278.
25. Leung A (2014) COMP 396 Final Reports - fall 2014 Analyzing Radiation Oncology Data for Prediction of Radiotherapy Patient Wait Time. McGill University, USA, p. 26.