Pencil Beam Scanning Proton Therapy for Lymphoma Patients with Mediastinal Involvement: A Dosimetric Study and Preliminary Clinical Data

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INTRODUCTION

Proton radiotherapy (PRT)= technique with potential to decrease risk of acute and late toxicity. From dosimetric point of view, PRT seems to be optimal RT technique for most lymphoma patients. Pencil beam scanning (PBS) is a new PRT technique. There is a lack of data for mediastinal lymphoma irradiated via PBS. The aim of this study is to confirm dosimetric advantages of PBS compared to standard RT technique for lymphoma patients (pts) and to evaluate acute toxicity and early control.

METHODS

Overall 30 pts with supradiaphragmatic lymphoma were irradiated using PBS between 5/2013 - 6/2015. The analysis was done for all patients with mediastinal RT more than 3 months after RT (18 pts). PBS was used in the first-line treatment in 15 pts and 3 pts were reirradiated. Target volume definitions in early stages: involved field RT (05/2013 - 02/2015) and involved site RT (from 03/2015). Residual disease was irradiated in advanced stages of lymphoma. Characteristics of pts is summarized in Table 1. Organ motion management: ITV definition according 4D-CT (5/2013 - 3/2015), deep inspiration breath hold technique- DIBH (from 4/2015). The range of total doses (PTV98%): 19.8 - 40 CGE (median 30 CGE). Comparative 3D-conformal photon plan (standard in CZ) was made for all evaluable pts. Dosimetric advantages of PBS over 3D-conformal photon RT are presented in Table 2. and Table 3.

Table 1. Characteristics of patients (n=30)

Characteristics	Number of patients
Gender: males/females	13/17
Histology:	
Hodgkin lymphoma	25
DLBCL	3
T lymphoblastic NHL	1
Peripheral T NHL	1
Evaluable pts (males/females)	18(9/9)
Age: median (range), years	32.5(13-65)
RT volume:	
Involved field	8
Residual disease	9
Involved site	1

Table 3. Dosimetric advantages of PBS over 3D-conformal photon RT (dose-volume param.)

Organs at risk	Photons	Protons	Absolute difference	Relative difference
Lungs bilat. V5Gy	43%	30%	13%	69%
Lung sin. V5Gy	51%	34%	17%	67%
Lung dx. V5Gy	39%	27%	12%	70%
Mamma sin.V4Gy	15%	13%	2%	91%
Mamma dx.V4Gy	10%	4%	6%	38%
Body V4Gy	16%	8%	8%	50%

Table 2. Dosimetric advantages of PBS over 3D-conformal photon RT

Organs at risk (assessed parameter)	Photons (dose Gy)	Protons (dose Gy)	Absolute difference (dose Gy)	Relative difference (%)
Lungs bilat. (Dmean)	10,27	5,92	4,34	58
Lung sin. (Dmean)	12,12	6,88	5,24	57
Lung dx. (Dmean)	9,33	5,35	3,98	57
Spinal cord (Dmax in 2% of volume)	27,61	10,66	16,95	39
Mamma sin. (Dmean)	2,96	2,03	0,92	69
Mamma dx. (Dmean)	1,80	0,56	1,23	31
Ventricle sin. (Dmean)	8,36	3,57	4,78	43
Ventricle dx.(Dmean)	11,43	6,82	4,62	60
Atrium sin. (Dmean)	20,51	12,94	7,57	63
Atrium dx. (Dmean)	16,49	10,14	6,34	62
Valve mitr. (Dmean)	17,77	7,18	10,59	40
Valve tric. (Dmean)	13,71	6,25	7,46	46
Valve aort. (Dmean)	23,34	10,93	12,41	47
Body (Dmean)	3,61	1,31	2,29	36
Esophagus (Dmean)	23,06	19,21	3,85	83

RESULTS

Dose to organs at risk (OAR): the dose to most OAR was **significantly lower** compared to standard photon technique. Relevant sparing of **lungs, spinal cord, cardiac structures, volume of body exposed to radiation** was reached. The sparing of mammary glands (evaluable 9 pts) and esophagus was **individua**l.

Treatment response: 16 pts complete remission, 1 pt disseminated tumor out of RT field (4 months after RT) , 1 pt died from generalized CMV infection 5 months after RT (RT was done after allo-SCT).

Acute RT toxicity: mild, in most pts: dysphagia gr.I, radiodermatitis gr.I/II, asymptomatic neutropenia gr.II in 2 pt and gr.III in 2 pts. Asymptomatic transient postRT changes of lungs occurred on postRT CT scan in 2 pts .

CONCLUSIONS

Proton radiotherapy using PBS technique offers **promising and safe possibility** for most pts indicated **for mediastinal RT**. PBS has a **potential to decrease significantly the dose to important organs at risk** compared to standard photon technique. Early **local control of PBS PRT is comparable to standard photon techniques.**

13icml 174--P

Hodgkin lymphoma

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DOI: 10.3252/pso.eu.13icml.2015

Poster presented at: 13-ICML

Printing supported by: Takeda ONCOLOGY