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ORIGINAL ARTICLE

Radical Conformal Radiotherapy versus Two Dimensional Radiotherapy in Oligometastatic Breast Cancer Patients: Response, Toxicity and Survival

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ABSTRACT

Background: oligometastatic breast cancer patients achieved better progression-free survival without significant toxicity, so this urge patients' subgroups identification who might gain more benefit from aggressive local therapy. In comparison to antro posterior, post anterior, and direct post anterior techniques, 3-dimensional conformal irradiation delivered for treatment of lumbar vertebrae metastasis was much better in the decrease of bowel and spinal cord exposure. Aim of the work: to evaluate clinical outcome gains achieved by 3D radiotherapy versus 2D radiotherapy in certain breast cancer patients with bony oligo metastasis with expected favorable survival.

Methods: In a retrospective cohort, 60 patients were enrolled in 2D versus 3D arm. Treatment and survival outcomes were observed.

Results: Three dimensional radiotherapy offer a significantly better pain response, local control, and lower toxicity than patients were received treatment delivery by 2D radiotherapy with p-value = 0.004,0.002 and 0.004 respectively, patients were delivered 2D radiotherapy had shown a progressive disease than those treated by 3D radiotherapy of statistical significance p-value = 0.01. The 3D arm was better than the 2D arm in the term of better significant PFS and nonsignificant OS, p-value = 0.04, 0.14 respectively.

Conclusion: Three dimensional conformal radiotherapy is of great value in the improvement of local control, pain response, progression-free survival, and overall survival with a tolerable toxicity profile in breast cancer patients diagnosed with bony oligo metastasis.

Keywords; Conformal radiotherapy, 2-dimensional radiotherapy, oligometastatic, breast cancer

INTRODUCTION

Breast cancer frequency patterns in Egyptian females in lower, middle, and upper Egypt were 33.8%, 26.8%, 38.7% respectively [1]. 25-40% of breast cancer patients diagnosed initially by bone distant metastasis, 60 – 80 % of recurrent breast cancer patients developed skeletal metastasis [2]. Systemic therapy is the standard of care in metastatic breast cancer, many metastatic patients enrolled in breast cancer trials have a limited metastatic site [3-8]. The clinical scenario of oligometastasis describes a limited metastatic site in the absence of full metastatic potentiality [9], hence the usefulness of local therapy purposes such as surgery, ablative radiotherapy in hope for better local control and overall favorable outcome achievement [10]. Despite that, the majority of breast cancer patients have proposed chemotherapy in positive hormonal receptor condition signifying the systemic therapy intensity hypothesis rather than radiotherapy strategy, oligometastatic breast cancer patients achieved better progression-free survival without significant toxicity, so this urge patients' subgroups identification who might gain more benefit from aggressive local therapy [11].

Conventional radiotherapy is important in primary symptomatic bony metastatic site treatment, high conformal irradiation strategies such as three-dimensional conformal radiotherapy, stereotactic body radiotherapy, and intensity-modulated radiotherapy were allowed for treatment delivery [12].In comparison to antro posterior, post anterior, and direct post anterior techniques, 3-dimensional conformal irradiation delivered for treatment of lumbar vertebrae metastasis was much better in the decrease of bowel and spinal cord exposure. Application of treatment delivery by stereotactic body radiation as well as intensity-modulated radiation therapy is associated with resource expenditure and complexity of clinical evaluation [13].Improvement of isodose distribution and spare

of organ at risk achievements are considered as an advantage of high conformal irradiation techniques, obtained for treatment planning and delivery in comparison to conventional irradiation because of inevitable reachable doses to organ at risk in the treatment portals unselectively, but in contrary high conformal treatment advances allow better conformality as well as dose escalation in the favor of tumor control and local pain improvement [14]. Costly modern linear accelerators with image guidance, immobilization devices, competent expertise, quality assurance measures for treatment implementation are essential as high conformal radiotherapy requirements, some patients with severe pain cannot tolerate the rigid immobilization devices [14], treatment time is long, 45 minute or more so this is difficult in an emergency scenario as well as an organ at risk may suffer from the probability of dose complication uncertainties [15,16].

Aim of the study was to evaluate the clinical outcome gains achieved by 3D radiotherapy versus 2D radiotherapy in certain breast cancer patients with bony oligo metastasis.

METHODS

In a retrospective cohort study, 60 patients with oligometastatic bony lesion who conducted at Clinical Oncology Department, Zagazig University Hospitals from January 2016 to January 2020 to receive radiotherapy for bony oligometastatic lesions, The patient's data were collected from the patient's records. Written informed consent was obtained from all participants. The study was done according to the Code of Ethics of the World Medical Association (Declaration of Helsinki) for studies involving humans. (Approval no: 6623-23-12-2020, Date: 23.12.2020). Patients were enrolled in two groups of treatment: Group 1; 30 patients who received two-dimensional radiotherapy group (2D), group 2; 30 patients who received three-dimensional conformal radiotherapy (3DCRT). Inclusion criteria: Histopathological confirmation of breast cancer, Eastern Cooperative Oncology Group (ECOG) score ≤ 2, confirmed oligometastatic lesions by positron emission tomography (PET CT) scan ± computed tomography with a bone window or magnetic resonance imaging and treatment was delivered at a linear accelerator machine. Exclusion criteria: Presence of visceral metastasis, previously irradiated lesions, data shortage and suboptimal follow up.

In radiotherapy all patients were simulated, comfortably positioned, and fixed by a thermoplastic mask. For the 2D group, field arrangement obtained from simulation, one vertebral body above, and one below the lesion identified by PET CT. field coverage either by a direct field with lateral film to determine the depth for dose calculation or sometimes antero-posterior and post-anterior in lumbar vertebral lesions with the estimation of patient separation proposed in 30 Gy in 10 fractions while in long bone opposing antero-posterior and post anterior with the estimation of patient separation. In the 3DCRT arm, the visible lesion on PET CT imaging was encompassed to create gross target volume, clinical target volume included the involved vertebral body as well those above and below immediately, planning target volume encompassed clinical target volume plus 1 cm margin, mostly arranged to be delivered with 3 or 4 anteroposterior/ posteroanterior beams (figure 1). Treatment of long bone lesion was covered by at least 2 cm margin proximal and distal to the evident lesions, mostly by opposed fields, encompassing of the target in irradiation portals with collimator angulations and multileaf collimator configurations minimize dose to the organ at risk such as spinal cord, esophagus, bowel, both lungs, kidneys... etc which were delineated, with treatment dose of 30 Gy in 10 fractions, verification of treatment delivery was done by digitally reconstructed radiographs. Anti-inflammatory, corticosteroids, and antiemetics were given to minimize symptoms.

Our patients underwent proper follow-up to assess response, toxicity, and survival outcome. evaluation of local control was through the performance of PET at 12 months post-radiotherapy. Local progression was defined as > 25% of measurable lesion size increase evaluated by the MDA response criteria [17] with the use of Response Criteria in Solid Tumours (PERCIST 1.0)[18].Pain response evaluation was according to chow et al [19]: Complete (no increase in analgesic intake such as tramadol or morphine, partial (reduction of 25% of analgesic dose from base line) , pain progression (increase of 25% of analgesic dose from base line), and intermediate (not fill full CR,PR and PP criteria). pain response was assessed prior to radiotherapy and 3 months later via horizontal visual analog scale. Toxicity assessment was scaled according to different grades RTOG and EORTC [20],[21].

STATISTICAL ANALYSIS

Continuous variables were expressed as the mean ± SD & median (range), and the categorical variables were expressed as a number (percentage). Percent of categorical variables were compared using Pearson's Chi-square test or Fisher's exact test when was appropriate. The trend of change in the distribution of relative frequencies between ordinal data was compared using the Chi-square test for trend. Overall Survival (OS) was calculated as the time from diagnosis to death or

the most recent follow-up contact (censored). Progression-free survival (PFS) was calculated as the most recent follow-up contact that patient was known as progression free. All tests were two-sided. A p-value <0.05 was considered significant. All statistics were performed using SPSS 16.0 for windows (IBM Inc., Chicago, IL, USA).

RESULTS

1-Patients characteristics:

Fifty (83%) of the studied patients were > 40 years old, 42 (70%) patients were scaled 2 ECOG, 38(70%) of patients shown grade III disease, 52 (86.7%) patients had IDC histopathology, 43 (71.7%) patients had positive ER and 44 (66.7%) patients had negative HER2, 43 (71.7%) of patients shown ≥ 2 metastatic lesions demonstrated by PET study, during treatment we observed that 51(58%) of patients became metastatic and only 9 (15%) of patients presented by oligometastatic bony lesions at the initial diagnosis, 34 (56.7%) of patients were on hormonal therapy (Table 1).

No statistical difference between both groups regards the patient's characteristics except for the treatment condition, there was highly statistical significance between 2D and 3D arm p=0.002**(Fisher test).

2- Assessment of pain and PET CT response and toxicity:

Three dimensional radiotherapy results were highly significantly better than those of 2D radiotherapy in the term of better pain response in the form of complete pain response observed in 17 (56.7%) patients in the 3D arm and only 2 (6.7%) patients had a progressive pain response versus 4 (13.3%) patients had complete pain response, 10 (16.7%) patients had pain progression in the 2D arm, p-value =0.004. Complete PET CT response is noticed in 18 (60%) patients and progression were notified in 3 (10%) patients were treated by 3D versus only 6 (20%) patients shown complete response and 13 (21.7%) had progressive PET results in 2D technique, p-value =0.002. Regards toxicity, the 3D technique had shown better toxicity profiles significantly p-value = 0.004, only 3 (10%) patients had toxicity in the 3D arm versus 13 (43.3%) patients in the 2D arm. In 2D arm 10 (33.3%) patients showed G2 radiodermatitis, 2 (6.6%) patients showed G1 radiodermatitis, 6 (20%) patients exhibited G1 fatigue, 5(16.6%) patients showed G2 emesis, and 4 (13.3%) patients exhibited G2 dysphagia versus 1 (3.3%) patient exhibited G2 radiodermatitis, 2 (6.6%) patients exhibited G2 emesis, 2 (6.6%) patients showed pain in 3D arm (Table 2).

3-Assessment of survival:

Patients were delivered 2D radiotherapy had shown a progressive disease than those treated by 3D radiotherapy with statistical significance p-value = 0.01. The 3D arm was better than the 2D arm in the term of better significant PFS and non-significant OS but, p-value = 0.04, 0.14 respectively (Table 3, figure 2).

Table 1: Patients characteristics

Parameters	
Age	
≤ 40	**10(16.7%)**
>40	**50(83.3%)**
Group	
2D	**30(50%)**
3D	**30(50%)**
ECOG	
0	**6(10%)**
1	**12(20%)**
2	**42(70%)**
Grade	
1	**4(6.7%)**
2	**18(30%)**
3	**38(63.3%)**
Histology	
Ductal	**52(86.7%)**
Lobular	**8(13.3%)**
ER	
Positive	**43(71.7%)**
Negative	**17(38.3%)**
HER2	
Positive	**15(25%)**

Parameters	
Negative	**40(66.7%)**
Not detected	**5(8.3%)**
Number of lesion	
1	**17(28.3%)**
≥ 2	**43(71.7%)**
Oligometastatic status	
At diagnosis	**9(15%)**
Relapsed	**51(85%)**
On treatment	
Chemotherapy	**3(5%)**
Hormonal therapy	**34(56.7%)**
Chemotherapy + trastuzumab	**10(16.7%)**
Trastuzumab	**5(8.3%)**
Non	**8(13.3%)**

ECOG (**Eastern Cooperative Oncology Group)**

Table 2: Assessment of pain and PET response and toxicity

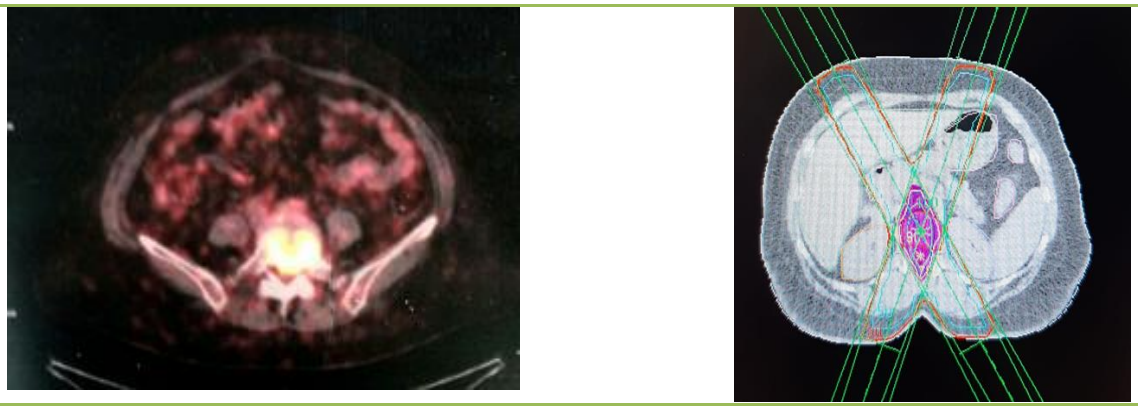
	Total N (%)	**2D**	**3D**	**P value**
Pain response				
CPR	21 (35)	4 (13.3)	17 (56.7)	
PR	13 (21.7)	8 (26.7)	5 (16.7)	0.004**
Intermediate	16 (26.7)	10 (33.3)	6 (20)	‡
Pain progression	10 (16.7)	8 (26.7)	2 (6.7)	
PET response				
CR	24 (40)	6 (20)	18 (60)	
PR	12 (20)	5 (16.7)	7 (23.3)	0.002**
Stable	11 (18.3)	9 (30)	2 (6.7)	‡
Progressive	13 (21.7)	10 (33.3)	3 (10)	
Toxicity				
No	44 (73.3)	17 (56.7)	27 (90)	0.004**
yes	16 (26.7)	13 (43.3)	3 (10)	‡

Categorical variables were expressed as number (percentage); ‡ Chi-square test; p<0.05 is significant, highly significant (**). CPR (Complete pain response), PR (Partial response).

Table 3: Assessment of survival

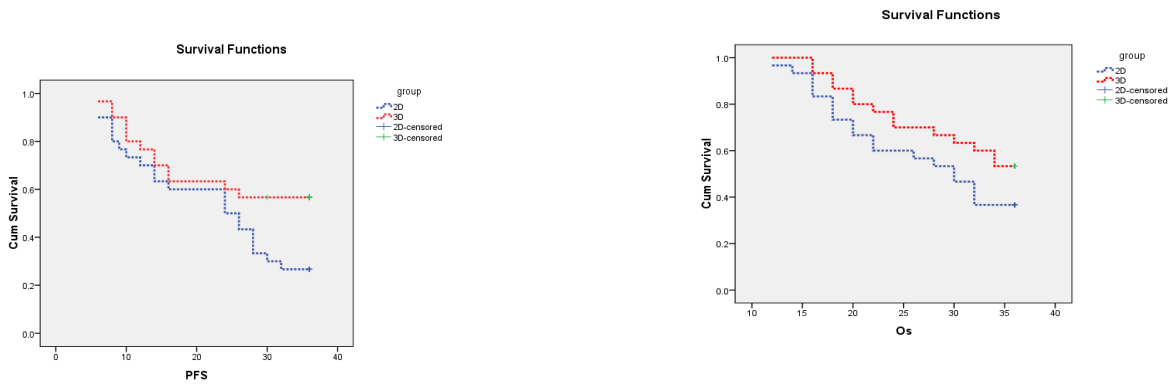
	Total	**2D**	**3D**	
		N= 30 (%)	N= 30 (%)	**P value**
Progression:				
No	25 (41.7)	8 (26.7)	17 (56.7)	0.01 ‡ *
yes	35 (58.3)	22 (73.3)	13 (43.3)	
Progression free survival (months)		◊		
Mean ± SD	24.34 ± 1.5	22.5 ± 2	26.2 ± 2.1	0. 04 †*
Range	21.3 – 27.3	18.4 - 26.5	21.9 – 30.4	
Death:				
No	27 (45)	11 (36.7)	16 (53.3)	0.19 ‡
Yes	33 (55)	19 (63.3)	14 (46.7)	
Overall survival (months)				
Mean ± SD	28.8 ± 1	27.2 ± 1.5	30.4 ± 1.3	0.14 †
Range	26.7 – 30.8	24.2 – 30.2	27.7 - 33	

Categorical variables were expressed as number (percentage); ‡ Chi-square test; † Log rank test; p<0.05 is significant (*).



(A) **(B)**

Figure 1: (A); PET scan shows visible lumbar 5 vertebrae lesion; (B) Isodose distribution of lumbar vertebrae sparing both kidneys.



(A) **(B)**

Figure 2: Kaplan Meier plot shows PFS and OS of the studied patients, 2D versus 3D.

DISCUSSION

Sixty patients were conducted at the Clinical Oncology and Nuclear Medicine Department and Zagazig University Hospitals were enrolled in a retrospective study. In the current study, we reported that 3D radiotherapy results were highly significantly better than those of 2D radiotherapy in the term of better pain response in the form of complete pain response observed in 17 (56.7%) patients in the 3D arm and only 2 (6.7%) patients had a progressive pain response versus 4 (13.3%) patients had complete pain response, 10 (16.7%) patients had pain progression in the 2D arm. Complete PET CT response is noticed in 18 (60%) patients and progression were notified in 3 (10%) patients were treated by 3D versus only 6 (20%) patients shown complete response and 13 (21.7%) had a progressive PET CT result in 2D technique.

Eighty percent of patients with bone metastasis, exhibited pain relief with up to one-third of reported complete response [22]. Sprave et al evaluated pain response using stereotactic radiotherapy versus 3D conformal radiotherapy, with the assessment of 3-month pain response and revealed that 10(43.5%) patients who had exhibited a complete pain response in stereotactic radiotherapy versus only 4 (7.4%) patients received 3D conformal radiotherapy with significance, this differs with our study due to different some patient characteristics and used technique [23]. David et al studied 15 patients diagnosed with oligometastatic breast cancer treated with stereotactic body Radiotherapy and reported that PET CT overall response was observed in 7(46%) patients and only 2 (13%) patients who exhibited a progressive metabolic study and this nearly agree with our results, may be due to small sample size and different used technique [24].

Three dimensional technique had shown better significant toxicity profiles only 3 (10%) patients had toxicity in 3D arm versus 13 (43.3%) patients in 2D arm. In 2D arm 10 (33.3%) patients showed G2 radiodermatitis, 2 (6.6%) patients showed G1 radiodermatitis, 6 (20%) patients exhibited G1 fatigue, 5(16.6%) patients showed G2 emesis, and 4 (13.3%) patients exhibited G2 dysphagia versus 1 (3.3%) patient exhibited G2 radiodermatitis, 2 (6.6%) patients exhibited G2 emesis in 3D arm.

Treatment delivery by 3DCRT depends on CT simulation, hence, enable visualization of the target and dose constrains properly with accurate calculation of dose volumes [25]. [26] stated that 3DCRT allows beam arrangement optimization and sparing of dose constains dosimetrically such as the heart, esophagus, and spinal cord in patients with dorsal spinal metastasis and this completely agree with our justification for better toxicity profile in the favor of 3D than in 2D treatment technique. Soyfer et al [13] notified that treatment delivery by 3D in lumbar metastasis was of great value in decreasing spinal cord and bowel dose exposure versus the traditional single PA or parallel opposing AP/PA technique.

Seven (47%) patients were presented by bony pain, 3(20%) patients were presented by hyperpigmentation,2(13%) patients were presented by emesis and another 2(13%) patients were presented by skin induration as toxicity profile analyzed by David et al during stereotactic ablative body treatment implementation to breast cancer patients with only bony oligometastatic lesions [24].Sprave et al observed that 7 patients were presented by fatigue, 5 patients were G1 and 2 were G2, 5 patients were presented by G1 radiodermatitis and 3 patients were presented by dysphagia and one patient was presented by emesis in the studied 3DCRT arm and this nearly to our results, the minor difference may be due to different patient characteristics [23].

In our study, we observed that patients who were delivered 2D radiotherapy had shown a progressive disease than those treated by 3D radiotherapy of statistical significance, mean 3 years PFS (months) was 22.5 ± 2 in the 2D arm versus 26.2 ± 2 in the 3D arm, 2 years PFS were 50% and 60% respectively. The 3D arm was better than the 2D arm in the term of non-significant OS, the mean 3 years OS was 27.2 ± 1.5 (months) in the 2D arm in comparison to 30.4 ± 1.3 (months) in the 3D arm, 2 years OS were 60% and 70% respectively.

Coleman et al stated that patients who were presented by only bony metastasis could exhibit a longer survival than those with visceral metastasis at 5 years OS up to 20 % with 3 years median survival in patients with favorable pathology [27-29], so this justifies proper patients' selection for survival improvement intention.

Marco Trovo et al. reported that long progression-free survival could be achieved in breast cancer patients with oligometastatic lesions by radical radiotherapy by individualized recommendations in a study included 44 patients underwent stereotactic radiotherapy and 10 patients underwent intensity-modulated radiotherapy, 2 years PFS and OS were 53% and 95% respectively [11]. This agrees with our objectives, although some differences due to the patient's characteristics and other vary comorbidities.

Our study limitations: Some patients were under systemic therapy such as hormonal, chemotherapy and target therapy which may interfere with our results and may be considered as a bias, urge and emphases the complementary role of such treatments abutting the role of local radiotherapy, the study was a retrospective cohort with small sample size, lack of resources such as stereotactic radiotherapy, although PET CT scan without available fusion advantage, it strength our study because of high sensitivity and specificity, its valuable role on initial patients enrollment and delineation guidance and local control assessment, hence we recommend more studies with more patients inclusion and future promising radiotherapy technological advances with proper patients individualization.

CONCLUSION

Three dimensional conformal radiotherapy is of great value in the improvement of local control, pain response, progression-free survival, and overall survival with tolerable toxicity profile in breast cancer patients diagnosed by bony oligo metastasis at low socioeconomic societies, where lack of more precise high conformal radiotherapy such as intensity-modulated radiotherapy and stereotactic body radiotherapy.

Conflict of interest: None

REFERENCE

1. Ibrahim, A. S., Khaled, H. M., Mikhail, N. N., Baraka, H., & Kamel, H. Cancer incidence in Egypt: results of the national population-based cancer registry program. J.Cancer Epidemiol, 2014. Article ID 437971, 18 pages.
2. Korde LA and Gralow JR; Can we predict who's at risk for developing bone metastases in breast cancer?2011 J Clin Oncol 293600–4.
3. Albain, K. S., Nag, S. M., Calderillo-Ruiz, G., Jordaan, J. P., Llombart, A. C., Pluzanska, A. et al. Gemcitabine plus paclitaxel versus paclitaxel monotherapy in patients with metastatic breast cancer and prior anthracycline treatment. J Clin Oncol, 2008, 26(24), 3950-3957.
4. Bergh, J., Jönsson, P. E., Lidbrink, E. K., Trudeau, M., Eiermann, W., Brattström, D, et al. FACT: an open-label randomized phase III study of fulvestrant and anastrozole in combination compared with anastrozole alone as first-line therapy for patients with receptor-positive postmenopausal breast cancer. J Clin Oncol,2012, 30(16), 1919-1925.
5. Tawfik, H., Rostom, Y., & Elghazaly, H. All-oral combination of vinorelbine and capecitabine as first-line treatment in HER2/Neu-negative metastatic breast cancer. Cancer Chemother.pharmacol, 2013, 71(4), 913-919.
6. Hurvitz, S. A., Dirix, L., Kocsis, J., Bianchi, G. V., Lu, J., Vinholes, J., et al. Phase II randomized study of trastuzumab emtansine versus trastuzumab plus

docetaxel in patients with human epidermal growth factor receptor 2-positive metastatic breast cancer. J Clin Oncol,2013, 31(9), 1157-1163.

7. Gianni, L., Romieu, G. H., Lichinitser, M., Serrano, S. V., Mansutti, M., Pivot, X., et al. AVEREL: a randomized phase III trial evaluating bevacizumab in combination with docetaxel and trastuzumab as first-line therapy for HER2-positive locally recurrent/metastatic breast cancer. J Clin Oncol, 2013, 31(14), 1719-1725.
8. Sledge, G. W., Neuberg, D., Bernardo, P., Ingle, J. N., Martino, S., Rowinsky, E. K., et al. Phase III trial of doxorubicin, paclitaxel, and the combination of doxorubicin and paclitaxel as front-line chemotherapy for metastatic breast cancer: an intergroup trial (E1193). J Clin Oncol ,2003, 21(4), 588-592.
9. Hellman, S., & Weichselbaum, R. R. Oligometastases. J Clin Oncol ,1995, 13(1), 8-10.
10. Alongi, F., Arcangeli, S., Filippi, A. R., Ricardi, U., & Scorsetti, M. Review and uses of stereotactic body radiation therapy for oligometastases. The oncologist,2012, 17(8), 1100.
11. Trovo, M., Furlan, C., Polesel, J., Fiorica, F., Arcangeli, S., Giaj-Levra, N., et al. Radical radiation therapy for oligometastatic breast cancer: results of a prospective phase II trial. Radiother Oncol, 2018, 126(1), 177-180.
12. Lo, S. S., Sahgal, A., Hartsell, W. F., Lutz, S. T., Kardamakis, D., van der Linden, Y., et al. The treatment of bone metastasis with highly conformal radiation therapy: a brave new world or a costly mistake? J Clin Oncol, 2009, 21(9), 662-664.
13. Soyfer, V., Corn, B. W., Shtraus, N., Schifter, D., & Tempelhof, H. The advantage of 3D conformal treatment of lumbar spine metastases in comparison to traditional PA or AP-PA techniques: Restoring an intermediate niche of therapeutic sophistication. J.Radiat. Oncol, 2013, 8(1), 1-8.
14. Sahgal, A., Larson, D. A., & Chang, E. L. Stereotactic body radiosurgery for spinal metastases: a critical review. Int. J.Radiat Oncol. Biol. Phys, 2008, 71(3), 652-665.
15. Chuang, C., Sahgal, A., Lee, L., Larson, D., Huang, K., Petti, P., et al. Effects of residual target motion for image-tracked spine radiosurgery.J. Med. phys, 2007, 34(11), 4484-4490.
16. Wang, H., Shiu, A., Wang, C., O'Daniel, J., Mahajan, A., Woo, S., et al. Dosimetric effect of translational and rotational errors for patients undergoing image-guided stereotactic body radiotherapy for spinal metastases. Int. J.Radiat Oncol. Biol. Phys, 2008, 71(4), 1261-1271.
17. Hamaoka, T., Madewell, J. E., Podoloff, D. A., Hortobagyi, G. N., & Ueno, N. T. Bone imaging in metastatic breast cancer. J Clin Oncol, 2004, *22*(14), 2942-2953.
18. Wahl, R. L., Jacene, H., Kasamon, Y., & Lodge, M. A. From RECIST to PERCIST: evolving considerations for PET response criteria in solid tumors.J.Nucl. Med: official publication, Society of Nuclear Medicine, 2009, 50(Suppl 1), 122S.
19. Chow E, Hoskin P, Mitera G, Zeng L, Lutz S, Roos D, et al. Update of the international consensus on palliative radiotherapy endpoints for future clinical trials in bone metastases. Int J Radiat Oncol Biol Phys, 2012 ,82:1730–7.
20. Cox JD,Stetz J and Pajak TF. Toxicity criteria of the Radiation Therapy oncology group (RTOG) and European Organization for Research and Treatment of cancer (EORTC) Int J radiat Oncol Biol Phys, 1995, 30;31(5):1341-6.
21. National Cancer Institute Cancer Therapy Evaluation Program: Common Toxicity Criteria (CTC), version 2.0. http://ctep. cancer. gov/protocol Development/ electronic_applications/ctc. htm# ctc_20.
22. Lutz, S., Berk, L., Chang, E., Chow, E., Hahn, C., Hoskin, P.,et al. Palliative radiotherapy for bone metastases: an ASTRO evidence-based guideline. Int. J.Radiat Oncol. Biol. Phys, 2011,79(4), 965-976.
23. Sprave, T., Verma, V., Förster, R., Schlampp, I., Bruckner, T., Bostel, T., et al. Randomized phase II trial evaluating pain response in patients with spinal metastases following stereotactic body radiotherapy versus three-dimensional conformal radiotherapy. Radiother Oncol, 2018, 128(2), 274-282.
24. David, S., Tan, J., Savas, P., Bressel, M., Kelly, D., Foroudi, F., et al. Stereotactic ablative body radiotherapy (SABR) for bone only oligometastatic breast cancer: A prospective clinical trial. Breast J, 2020, 49, 55-62.
25. Guadagnolo, B. A., Huo, J., Liao, K. P., Buchholz, T. A., & Das, P. Changing trends in radiation therapy technologies in the last year of life for patients diagnosed with metastatic cancer in the United States. J.Cancer, 2013, 119(5), 1089-1097.
26. Yeo, S. G. Palliative radiotherapy for thoracic spine metastases: Dosimetric advantage of three-dimensional conformal plans. Oncol Lett, 2015, 10(1), 497-501.
27. Coleman, R. E., Smith, P., & Rubens, R. D. Clinical course and prognostic factors following bone recurrence from breast cancer. Br.J.Cancer, 1998 , 77(2), 336-340.
28. Lee, C. G., McCormick, B., Mazumdar, M., Vetto, J., & Borgen, P. I. Infiltrating breast carcinoma in patients age 30 years and younger: long term outcome for life, relapse, and second primary tumors. Int. J.Radiat Oncol. Biol. Phys ,1992, 23(5), 969-975.
29. Vogel, C. L., Azevedo, S., Hilsenbeck, S., East, D. X., & Ayub, J. Survival after first recurrence of breast cancer. The Miami experience. J.Cancer, 1992, 70(1), 129-135.

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