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医学放射物理

右乳癌保乳术后瘤床同步X线和后程电子线补量调强放疗剂量学比较

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【摘 要】目的:探讨右乳腺癌保乳术后瘤床银夹标记条件下瘤床同步X射线补量调强放疗(SIB-IMRT)和后程电子线补量调强放疗(IMRT+E)的剂量学特点。 **方法:**选取右乳腺癌保乳术中放置银夹标记患者15例,采用Pinnacle^3 9.6计划系统分别设计SIB-IMRT和IMRT+E两组计划,比较两种放疗计划的剂量学参数。 **结果:**两组计划比较全乳和瘤床靶区的最大剂量、最小剂量、平均剂量(D_{mean})以及剂量均匀性和适形度指数差异无统计学意义;危及器官右肺V_5、V_{10}、V_{20}、D_{mean},左肺D_{mean},全肺V_{20}差异无统计学意义,但SIB-IMRT组右肺V_{20}明显低于IMRT+E组,差异有统计学意义(P<0.05);心脏D_{mean}、左乳腺D_{mean}、瘤床前缘的皮肤组织D_{mean}的两者比较差异均无统计学意义(P>0.05),但SIB-IMRT组瘤床后缘1 cm厚的肺组织D_{mean}高于IMRT+E组,差异有统计学意义(P<0.05)。 **结论:**右乳癌保乳术后瘤床银夹标记调强放疗的两种补量方式大多数剂量学参数差异无统计学意义。在保证全乳和瘤床靶区覆盖率的条件下,虽然SIB-IMRT组瘤床后缘1 cm厚的肺组织D_{mean}偏高,但对肺、心脏和左乳腺等保护整体上明显优于IMRT+E组。在实际执行过程中SIB-IMRT也比IMRT+E更加简单方便,既提高工作效率又减少总的治疗时间,省时又省力,值得临床推广应用。

【关键词】乳腺癌;保乳术;银夹标记;瘤床同步补量;调强放射治疗;剂量学
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Dosimetric comparison of tumor bed synchronons X-ray and late course electron boost intensity modulated radiotherapy for right breast cancer after breast conserving surgery

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Abstract: Objective With silver-clip marked tumor bed, to discuss on dosimetric characteristics of tumor bed synchronons X-ray integrated boost intensity modulated radiotherapy (SIB-IMRT) and the late course electron boost IMRT (IMRT+E) for the right breast cancer after breast conserving surgery. **Methods** Fifteen right breast cancer patients placed with silver-clip markers during operation were selected. Pinnacle^3 9.6 planning system was used to design SIB-IMRT plan and IMRT+E plan, and the dosimetric parameters of two methods were compared. **Results** No significant differences were found between SIB-IMRT and IMRT+E plans in the dose uniformity, conformal indexes, as well as the D_{max}, D_{min}, and D_{mean} of target volumes of tumor bed and the whole breast. No statistical significances were found between the two plans in the V_5, V_{10}, V_{20} and D_{mean} of the right lung, the D_{mean} of the left lung, and the V_{20} of the whole lung. However, the V_{20} of the right lung in SIB-IMRT group was significantly lower than that in IMRT+E group, with statistical significance (P<0.05). No significant differences were found in the D_{mean} of heart, D_{mean} of the left breast and D_{mean} of skin tissue on the leading edge of tumor bed (P>0.05), but the D_{mean} of lung tissue of 1 cm thick after the tumor bed (LTAT) in SIB-IMRT group was significantly higher than that in IMRT+E group (P<0.05). **Conclusion** No significant differences are found in the most dosimetric parameters between the SIB-IMRT plan and IMRT+E plan. Under the condition that the coverage rates of the whole breast and the target volume of tumor bed are assured, although the D_{mean} of LTAT is slightly higher in the SIB-IMRT group, the protections for lung, heart and the left breast in SIB-IMRT group are obviously better than those in IMRT+E group. Compared with IMRT+E plan, the SIB-IMRT plan is simpler and more convenient in practice, improving the work efficiency, reducing the overall treatment time, saving time and effort. The SIB-IMRT plan is worthy of clinical popularization and application.

Key words: breast cancer; breast conserving surgery; silver-clip marker; tumor bed synchronous boost; intensity modulated radiotherapy; dosimetry

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前 言

从20世纪80年代开始，保乳手术加放疗的综合治疗成为早期乳癌的标准治疗方法，它既能提高局部控制率和降低局部复发率，同时对患者心理影响和体型美观等明显优于根治术。瘤床同步整合补量（SIB）作为术后放疗的一种特殊模式，既改善乳腺靶区剂量的均匀性，又降低肺和心脏等危及器官的受照剂量和体积，并在全乳照射的基础上同步给予瘤床的加量照射，增加瘤床区域的分割照射剂量同时减少了总的照射次数和时间，并进一步降低局部复发率，已成为保乳术后放疗的主流技术[1-3]。本文选取保乳术中瘤床放置银夹标记的患者15例，分别设计瘤床同步X射线补量调强放疗（SIB-IMRT）计划和后程电子线补量调强放疗（IMRT+E）计划，比较两种补量模式的剂量学差异。

1 材料与方法

1.1 病例资料

选取2012年5月至2014年5月在昆明医科大学第三附属医院行早期右乳癌保乳术（术中行瘤床银夹标记）患者15例，其中原发灶位于外上象限1例，内上象限4例，外下象限9例，内下象限1例。

1.2 体位固定和CT扫描

患者采取仰卧位卧于固定板上，双手抱住肘关节放于额头上，呈平静自然呼吸状态，用热塑体膜体位固定后在西门子大口径CT机（Somatom Sensation Open，直径82 cm）上进行CT定位扫描（扫描范围一般为颈2椎体下缘至腰3椎体上缘，自上而下连续扫描，层厚和层间距为0.5 cm，平扫），扫描图像经DICOM网络传至Pinnacle^{3}9.6计划系统。

1.3 靶区勾画

瘤床靶区的确定：全乳腺靶区定义为临床靶区（CTV），包括患侧乳腺组织、胸大肌、胸小肌和肋间肌。以银夹为中心向上下、左右和前后外扩1.5 cm，前界不超过皮下0.5 cm，后界不超过肋骨表面的范围定义为CTV1。靶区勾画的上界为同侧锁骨头下缘水平，下界为乳腺皱褶下2.0 cm，后界为胸壁与肺的交界处，由于考虑剂量建成区，前界勾画在皮下0.5 cm。CTV外扩0.5 cm定义为计划靶区（PTV）。同步勾画出危及器官。

1.4 计划设计

用Pinnacle^{3}9.6计划系统进行计划设计。（1）SIB-IMRT计划：处方剂量6 MV-X线，CTV1:D_T55 Gy/25 F，CTV：D_T50 Gy/25 F，PTV：D_T 50 Gy/25 F。设计5个主野分别是两切线野、1个垂直野和2个斜角野。给予相同的目标函数、权重和子野数，最小跳数为5 MU，最小子野面积为4 cm^2，最终剂量优化结果均要达到100%的等剂量线包绕95%以上的靶区体积。（2）IMRT+E计划：① 6 MV-X线，处方剂量CTV：D_T40 Gy/20 F，PTV：D_T 40 Gy/20 F；② 20次照射完成后再行计划，处方A：6 MV-X线，处方剂量CTV：D_T10 Gy/5 F，PTV：D_T10 Gy/5 F；处方B：用9 MeV电子线单野垂直于瘤床，处方剂量CTV1：5 Gy/5 F。将计划①和②叠加进行优化生成整体计划，最终剂量优化结果均要达到100%的等剂量包绕95%以上的靶区体积。

1.5 评价参数

用PTV的最大剂量（D_{max}）、最小剂量（D_{min}）、平均剂量（D_{mean}）、V_{95}、V_{105}、V_{110}来评价靶区受照体积和剂量，用均匀性指数（HI）和适形指数（CI）评价靶区的均匀性和适形度。右肺用V_5、V_{10}、V_{20}、D_{mean}，左肺用D_{mean}，全肺用V_{20}，心脏用V_5、V_{15}、D_{mean}，左乳腺用D_{mean}来评价危及器官的照射体积和剂量。

1.6 统计学分析

采用SPSS 19.0统计软件包，使用方差分析比较多组间的差异，两组之间比较采用LSD法，各参数用均数±标准差表示。P<0.05结果有统计学意义。

2 结 果

2.1 靶区剂量学

比较两组全乳靶区D_{max}、D_{min}、D_{mean}、V_{95}、V_{105}、V_{110}差异均无统计学意义（P>0.05）（表1）。

表1 靶区剂量学评估（$\bar{x}\pm s$，n=15）

Tab.1 Dosimetric evaluation of target volume (*Mean±SD*, *n*=15)

Group	D_{max}/cGy	D_{min}/cGy	D_{mean}/cGy	V_{95}/%	V_{105}/%	V_{110}/%
SIB-IMRT	5 984.70±350.36	4 210.70±218.84	5 305.60±58.73	99.75±0.19	47.15±11.38	20.63±9.29
IMRT+E	5 894.20±197.15	4 176.00±267.06	5 301.10±58.24	99.75±0.22	44.46±14.91	21.95±8.30
t value	0.872	0.389	0.211	0.053	0.554	0.411
P value	0.391	0.700	0.835	0.985	0.584	0.684

SIB-IMRT: synchronons X-ray integrated boost intensity modulated radiotherapy; IMRT+E: Late course electron boost intensity modulated radiotherapy

2.2 全乳靶区和瘤床靶区的CI与HI

全乳靶区和瘤床靶区CI与HI，两组比较差异均无统计学意义（P>0.05）（表2）。

2.3 危及器官肺的剂量学

两组比较右肺V_{20}差异有统计学意义（P<0.05），右肺V_5、V_{10}、D_{mean}、左肺D_{mean}、全肺V_{20}差异均无统计学意义（P>0.05）（表3）。

2.4 其他危及器官的剂量学

两组比较心脏V_5、V_{15}、D_{mean}，左乳腺D_{mean}和skin（瘤床前缘皮下0.5 cm厚的皮肤组织）D_{mean}差异均无统计学意义（P>0.05）；LTAT（瘤床后缘1 cm厚的肺组织）D_{mean}差异有统计学意义（P<0.05）（表4）。

表2 靶区适形度与均匀性指数分析（$\bar{x}\pm s$，n=15）

Tab.2 Conformal index and heterogeneity index of target volume (*Mean±SD*, *n*=15)

Group	CI-R	HI-R	CI-C	HI-C
SIB-IMRT	1.13±0.02	0.83±0.04	1.04±0.01	0.68±0.15
IMRT+E	1.13±0.02	0.84±0.03	1.03±0.01	0.65±0.16
t value	0.724	0.483	1.565	0.614
P value	0.464	0.633	0.129	0.544

CI-R: Conformal index of the right breast; HI-R: Heterogeneity index of the right breast; CI-C: Conformal index of clinical target volume1; HI-C: Heterogeneity index of clinical target volume1

表3 肺的剂量学评估（$\bar{x}\pm s$，n=15）

Tab.3 Dosimetric evaluation of lung (*Mean±SD*, *n*=15)

Group	Right-lung				D_{mean} of left-lung/cGy	V_{20} of whole lung/%
	V_5/%	V_{10}/%	V_{20}/%	D_{mean}/cGy		
SIB-IMRT	85.33±9.09	52.40±5.04	24.53±1.88	1 560.70±81.86	309.93±103.57	13.27±0.76
IMRT+E	79.60±9.48	55.53±9.75	26.13±2.00	1 598.30±129.62	325.37±90.62	14.13±1.13
t value	1.691	1.106	2.258	0.951	0.435	2.458
P value	0.102	0.278	0.032	0.350	0.677	2.458

表4 心脏、左乳腺、LTAT和skin的剂量学评估（$\bar{x}\pm s$，n=15）

Tab.4 Dosimetric evaluation of heart, left breast, LTAT and skin (*Mean±SD*, *n*=15)

Group	Heart			D_{mean}/cGy		
	V_5/%	V_{15}/%	D_{mean}/cGy	Left-breast	LTAT	Skin
SIB-IMRT	58.00±16.98	4.93±9.95	687.24±246.68	317.95±108.21	4 823.70±235.20	4 518.90±260.12
IMRT+E	68.27±13.26	7.87±9.56	790.05±185.72	347.86±103.57	4 527.90±465.77	4 482.80±169.71
t value	1.846	0.962	1.290	0.773	2.196	0.450
P value	0.076	0.336	0.208	0.446	0.037	0.656

The *Z* test was used for V_{15} of heart. LTAT: Lung tissue of 1 cm thick after the tumor bed

3 讨 论

乳腺癌局部治疗失败主要原因是瘤床区及其邻近部位复发，所以术后全乳放疗是保乳术后放疗的标准放疗方式。全乳放疗加瘤床补量照射不仅可以提高局部控制率，而且还可以降低局部复发率[4-6]。常规全乳与瘤床序贯照射造成的部分乳腺照射野交界处或靶区内不必要的重叠和漏照射[7-9]。SIB-IMRT是在全乳照射的同时实现瘤床补量照射，既避免了常规全乳与瘤床序贯照射造成的部分乳腺照射野交界处或靶区内不必要的重叠和漏照射，而且缩短了总的治疗时间[10-12]。

李楠等[13]评价SIB-IMRT结果：全乳PTV V_{95}为

（99.10±1.00）%、D_{max}为（7 046.240±104.248）cGy、D_{min}为（4 081.180±246.940）cGy，心脏D_{mean}为（425.120±131.960）cGy，同侧肺D_{mean}为（1 125.770±230.930）cGy、V_{20}为（21.43±4.64）%，对侧乳腺D_{mean}为（21.200±7.900）cGy。李建彬等[14]报道保留乳房术后结果发现SIB-IMRT和IMRT+E计划中多数剂量学参数差异无统计学意义，但IMRT+E计划中受照射剂量大于等于CTV处方剂量的患侧肺脏容积明显高于SIB-IMRT。魏贤顶等[15]探讨保乳术后常规IMRT+E和SIB-IMRT两种计划的剂量学差异，结果发现瘤床偏内侧两种方法无明显差异，均可接受。瘤床偏外侧SIB比序贯电子线补量有更好的靶区剂量分布，不增加危及器官的受量，同时可缩短放疗疗程。上述报道证实SIB-IMRT和IMRT+E的剂量学优势在保证靶区覆盖率的前提下，降低危及器官的受照射剂量与容积，并减少总的治疗时间。

本研究结果显示：右乳癌保乳术后瘤床银夹标记IMRT的两种补量方式，大多数靶区和危及器官的剂量参数差异无统计学意义（$P>0.05$）。但SIB-IMRT组对肺、心脏和左乳腺等的保护整体上优于IMRT+E组，尤其是右肺V_{20}明显低于IMRT+E组，差异有统计学意义（$P<0.05$）。而IMRT+E技术则降低了LTAT和skin的剂量，并且SIB-IMRT计划的LTAT D_{mean}高于IMRT+E计划，差异有统计学意义（$P<0.05$），这可能与X射线和电子线剂量学特点密切相关，提示保乳术后SIB-IMRT和IMRT+E时要重视瘤床后缘局部小体积肺组织剂量的评估，防止该区域剂量偏高造成局部肺损伤的加重。在实际执行过程中，SIB-IMRT不必进行二次移位、能量的切换、限光筒的安装等，比IMRT+E更加简单方便，大大提高了工作效率，减少总的治疗时间，省时又省力，值得临床推广应用。

【参考文献】

[1] BECKHAM W A, POPESCU C C, PATENAUDE V V, et a1. Is mutibeam IMRT better than standard treatment for patients with left-sided breast cancer[J]. Int J Radiat Oncol Biol Phys, 2007, 69 (3): 918-927.

[2] POLGAR C, FODOR J, MAJOR T, et a1. The role of boost irradiation in the conservative treatment of stage I. II breast cancer [J]. Pathol Oncol Res, 200l, 7(4): 241-250.

[3] 李建彬, 徐敏, 于金明. 乳腺癌放射治疗研究现状[J]. 中华放射肿瘤学杂志, 2003, 12(5): 124-127.
LI J B, XU M, YU J M. Radiation therapy of breast cancer research [J]. Chinese Journal of Radiation Oncology, 2003, 12(5): 124-127.

[4] GUERRERO M, LI X A, EARL M A, et al. Simultaneous integrated boost for breast cancer using IMRT: a radiobiological and treatment planning study[J]. Int J Radiat Oncol Biol Phys, 2004, 59(5): 1513-1518.

[5] MATTIA F, OSTI A, CARNEVALE S, et al. Exclusive electron intra operative radiotherapy in early-stage breast cancer: amonoinsti tutional experience[J]. Anti Res, 2013, 33(3): 1229-1235.

[6] 欧阳淑玉, 贺礼理, 谢小雪, 等. 左侧乳腺癌两种调强放射治疗计划剂量学比较[J]. 中南大学学报(医学版), 2013, 5(10): 1003-1008.
OUYANG S Y, HE L L, XIE X X, et al. Dosimetric comparison of left-side whole breast irradiation with IMRT and hybrid IMRT [J]. Journal of Central South University(Medical Science), 2013, 5 (10): 1003-1008.

[7] MIRJAM E, MAST L. Left-sided breast cancer radiotherapy with and without breath-hold: does IMRT reduce the cardiac dose even further[J]. Radiol Oncol, 2012, 108(2): 248-253.

[8] 白雪, 杜向慧, 王升晔, 等. 乳腺癌保乳术后调强计划的剂量学研究[J]. 中国辐射卫生, 2013, 22(2): 242-245.
BAI X, DU X H, WANG S Y, et al. Dosimetric study of intensity modulated radiotherapy of breast cancer after conservative surgery [J]. Chinese Journal of Radiation Health, 2013, 22(2): 242-245.

[9] GAUER T, ENGE lK, KIESE A, et al. Comparison of electron IMRT to helical photon IMRT and conventional photon irradiation for treatment of breast and chest wall tumours[J]. Radiol Oncol, 2010, 94(3): 313-318.

[10] GUANG H, JIN L X, CHEN X W, et al. A comparative dosimetric study for treating left-sided breast cancer for small breast size using five different radiotherapy techniques: convention nal tangential filed-in-filed, tangential-IMRT, multi-beam IMRT and VMAT[J]. Radiol Oncol, 2013, 4(8): 89-99.

[11] 包虹. 33例I期乳腺癌保乳术后不同放射治疗方式的剂量学研究[J]. 中国医学物理学杂志, 2011, 28(4): 2725-2728.
BAO H. Dosimetric study of different radio therapy techniques in thirty three patients with stage I breast cancer after breast-conserving surgery[J]. Chinese Journal of Medical Physics, 2011, 28(4): 2725-2728.

[12] SMITH W, MENON G, WOLFE N, et al. IMRT for the breast: a comparison of tangential planning techniques [J]. Phys Med Biol, 2010, 55(4): 1231-1241.

[13] 李楠, 李光, 赵欣宇, 等. 乳腺癌保乳术后切线野照射与瘤床同步整合补量调强放射治疗的剂量学区别[J]. 中国医科大学学报, 2011, 40(7): 635-638.
LI N, LI G, ZHAO X Y, et al. Breast cancer postoperative tangent field irradiation with confirmed breast tumor bed synchronous integrated filling quantity of intensity-modulated radiotherapy dosimetry difference [J]. Journal of China Medical University, 2011, 40(7): 635-638.

[14] 李建彬, 马志芳, 卢洁, 等. 乳腺癌保留乳房术后瘤床同步X射线和电子线整合补量调强放疗剂量研究[J]. 中华放射医学与防护杂志, 2006, 26(5): 479-482.
LI J B, MA Z F, LU J, et al. Breast cancer postoperative breast tumor bed sync X-ray and electron line filling quantity of intensity-modulated radiotherapy dose study [J]. Chinese Journal of Radiological Medicine and Protection, 2006, 26(5): 479-482.

[15] 魏贤顶, 赵于天, 金建荣, 等. 乳腺癌保乳术后外照射内侧和外侧瘤床两种加量方法的剂量学比较[J]. 中国医学物理学杂志, 2013, 30(3): 4100-4103.
WEI X D, ZHAO Y T, JIN J R, et al. Confirmed breast breast cancer postoperative external exposure tumor bed medial and lateral two methods of added amount of dosimetry comparison [J]. Chinese Journal of Medical Physics, 2013, 30(3): 4100-4103.

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