

乳腺癌根治术后放疗中腋窝危及器官的勾画与限量研究

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摘要: [目的] 探讨在乳腺癌根治术后放疗中勾画腋窝危及器官(OAR_{axilla})并对其进行剂量限制的可行性, 以期降低放疗所致上肢淋巴水肿风险提供剂量学证据。[方法] 回顾性选择26例乳腺癌根治术后患者, 针对每例患者采用标准及改进方法分别勾画腋窝OAR(OAR_s、OAR_M), 每例患者分别设计4套治疗计划: OAR_{axilla}限量与不限量的3D-CRT计划(CRT_{limit}、CRT)、OAR_{axilla}限量与不限量的IMRT计划(IMRT_{limit}、IMRT)。评估两种勾画方法所得到的OAR_s与OAR_M之间解剖位置关系和剂量学差异性, 以及腋窝OAR限量后OAR_{axilla}的剂量获益以及对靶区和其他OAR的剂量学影响。[结果] 基于两种方法所勾画的腋窝OAR(OAR_s、OAR_M)体积分别为20.9 cm³和23.6 cm³($P=0.000$), CI和DSC分别为0.79、0.88。除了CRT计划中的D_{min}以外, 两者无剂量学差异($P>0.05$)。在CRT和IMRT计划中, OAR_{axilla}限量显著性降低了其剂量, 其中D_{min}分别降低了13.9%和27.2%, 分别为34.0 Gy、30.3 Gy。OAR_{axilla}限量后靶区和其他OAR无本质上的剂量学差异。[结论] 在乳腺癌根治术后放疗中针对腋窝OAR的勾画以及剂量限制是可行的, D_{min}<36.8 Gy可作为腋窝危及器官的限量标准, 推荐采用改进方法勾画。

关键词: 乳腺癌; 放射治疗; 腋窝; 危及器官; 勾画

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Delineation and Dose Limitation of Axillary Organ at Risk During Breast Cancer Postoperative Radiotherapy

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Abstract: [Objective] To explore the feasibility of delineating the axillary organ at risk(OAR_{axilla}) and limiting its dose during breast cancer postoperative radiotherapy in order to provide dosimetric evidence for reducing the risk of breast cancer-related lymphedema caused by radiotherapy. [Methods] Twenty-six patients after modified radical mastectomy for breast cancer were selected retrospectively. For each patient, delineate the axillary OAR (OAR_s, OAR_M) using standard and modified methods. Four treatment plans were designed for each patient: OAR_{axilla} limited and unlimited 3D-CRT plans(CRT_{limit}, CRT), OAR_{axilla} limited and unlimited IMRT plans(IMRT_{limit}, IMRT). To evaluate the anatomical position relationship and dosimetric difference between OAR_s and OAR_M obtained by the two methods, as well as the dose benefit of OAR_{axilla} after axillary OAR limited and the dosimetric effect on the target area and other OARs. [Result] The volume of the axillary OAR(OAR_s, OAR_M) based on the two methods were 20.9 cm³ and 23.6 cm³($P=0.000$), and CI and DSC were 0.79, 0.88. Except for D_{min} in the CRT plan, there were no dosimetric differences between the two ($P>0.05$). In the CRT and IMRT plans, the OAR_{axilla} limit significantly reduced its dose, of which D_{min} was reduced by 13.9% and 27.2%, respectively, to 34.0 Gy and 30.3 Gy. There was no dosimetric difference between the target area and other OARs after the OAR_{axilla} limit. [Conclusion] It is feasible to delineate and limit the dose of the axillary OAR during breast cancer postoperative radiotherapy. D_{min}<36.8 Gy can be used as the limited standard of axillary OAR, and the modified delineation method is recommended.

Subject words: breast cancer; radiotherapy; axilla; organ at risk; delineate

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包括放疗在内的综合治疗疗效的提升使得乳腺癌患者能够长期生存,人们更加重视生活质量和晚期并发症^[1-2]。放疗中对心脏和肺等重要器官的保护已成为常规,并已积累了成熟经验^[3-4],但对如何降低放疗引起乳腺癌相关淋巴水肿(breast cancer related lymphedema, BCRL)的风险却缺乏深入的研究。BCRL是乳腺癌区域淋巴结照射(regional nodal irradiation, RNI)患者的重要并发症^[5],与腋外侧胸血管交界处(axillary-lateral thoracic vessel juncture, ALTJ)的照射剂量密切相关,其最小剂量(D_{min})小于36.8 Gy时BCRL发生率明显降低^[6]。本文在乳腺癌根治术后放疗中将ALTJ区域作为腋窝危及器官(organ at risk, OAR_{腋窝})进行勾画,在临床常见照射技术中对其进行限量研究,以期降低放疗所致BCRL风险提供剂量学证据。

1 资料与方法

1.1 一般临床资料

回顾性选择2019年1月至2019年12月在常熟市第一人民医院接受放疗的26例乳腺癌根治术后患者,入组标准:①女性,年龄<80岁;②卡氏评分(Karnofsky performance status, KPS)>80分;③改良根治术后;④病理确诊为浸润性乳腺癌;⑤肿瘤>5 cm或腋窝阳性淋巴结 ≥ 4 个,或 T_{1-2} 、腋窝阳性淋巴结1~3个,但伴有高危因素(腋窝淋巴结检出 <10 个、脉管癌栓、三阴性乳腺癌、年龄<35岁);⑥放疗前无上肢淋巴水肿(淋巴水肿指尺骨鹰嘴突上方15 cm或下方10 cm处测量,患侧的臂围与健侧的臂围差 ≥ 2.5 cm)。全组患者中位年龄54岁(40~74岁),中位腋窝淋巴结清扫数12个(6~24个)、中位阳性淋巴结数4.5个(0~14个),全组患者临床病理特征见表1。

1.2 模拟定位

患者仰卧于Med-Tech350乳腺托架进行固定,患侧上肢上举外展置于臂托,头偏向健侧。在通用电气CT(GE Light-Speed 64排)进行模拟定位,扫描前用铅丝标记胸壁手术疤痕。扫描范围为下颌骨至膈下缘,层厚为5 mm。CT图像通过数字图像存储及网络传输系统传输至三维治疗计划系统(Ray Station 4.9)。计划确认后在医科达Presice直线加速器照射。

1.3 靶区和OAR勾画

(1)CTV包括患侧胸壁,同侧锁骨上、腋窝淋巴结引流区。其中胸壁及腋窝淋巴结引流区以RTOG标准^[7]进行勾画,锁骨上淋巴结引流区以中国国家癌症中心标准^[8]进行勾画。胸壁PTV为CTV上下外扩7 mm,前后及左右外扩5 mm,上界为锁骨头下缘,并与锁骨上、下淋巴结引流区PTV(CTV均匀外扩5 mm)融为一体。

Table 1 Clinical characteristics of the patients

Characteristics		N(%)
Age(years old)	<60	19(73.1)
	≥ 60	7(26.9)
BMI(kg/m ²)	<24.99	15(57.7)
	≥ 24.99	11(42.3)
Side of tumor	Left side	11(42.3)
	Right side	15(57.7)
Immunohistochemistry	ER positive	18(69.2)
	PR positive	13(50.0)
	Her-2 strong positive or Fish showed amplification	1(3.8)
T stage	T ₁	8(30.8)
	T ₂	17(65.4)
	T ₃	1(3.8)
N stage	N ₀	1(3.8)
	N ₁	11(42.4)
	N ₂	9(34.6)
	N ₃	5(19.2)
Stage	II A	5(19.2)
	II B	6(23.2)
	III A	9(34.6)
	III B	1(3.8)
	III C	5(19.2)

(2)OAR_{腋窝}勾画:①标准勾画方法:根据Gross提供的方法^[6],将腋窝分为内、外、远外侧三个区域,其中内侧区域为RTOG标准腋窝II组和III组,外侧区为腋胸外侧血管连接处(ALTJ),定义为OAR_s,并在治疗计划中进行限量,远外侧区域为ALTJ区外侧区,解剖边界见表2及图1(Table 2, Figure 1)。②改进勾画方法:按照RTOG标准勾画腋窝I组,将腋血管消失层面的轮廓向上复制,直至肱骨头下一层,并适当调整位置及范围,定义为OAR_M(Figure 1)。

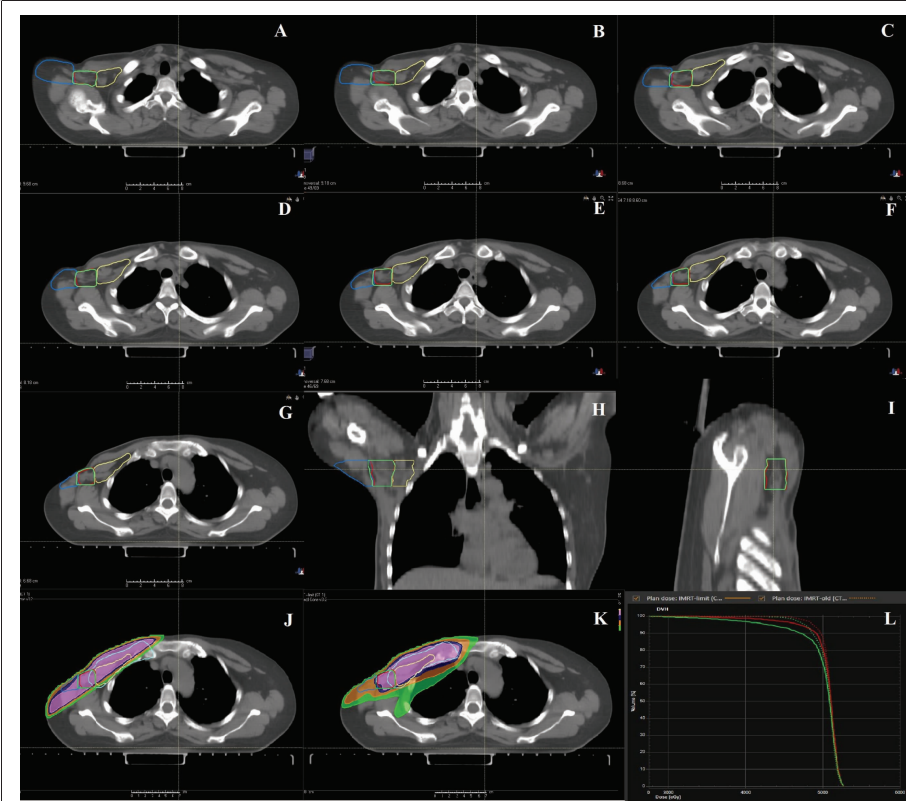
(3)其他OAR包括肺、心脏、肱骨头、脊髓、甲状腺等。

1.4 计划设计

针对每例患者分别设计4套治疗计划:(1)OAR_{腋窝}

Table 2 Anatomical boundaries of axillary region
(refer to the method provided by Gross^[6])

Structure	Anatomic definition
Level II and III region	Cranial: One axial slice below lowest contour of humeral head Caudal: Inferior-most contour of axillary vessels Anterior: Posterior surface of pectoralis major muscle Posterior: Anterior surface of the subscapularis muscle and ribs/intercostal muscles Lateral: Lateral border of pectoralis minor muscle Medial: Thoracic inlet
ALTJ region(OAR _s)	Cranial: One axial slice below lowest contour of humeral head Caudal: Inferior-most contour of axillary vessels Anterior: Plane defined by latissimus dorsi and pectoralis musculature Posterior: Anterior surface of the subscapularis muscle Lateral: Including the axillary vessels Medial: Lateral border of the pectoralis minor muscle
Lateral to ALTJ region	Cranial: One axial slice below lowest contour of humeral head Caudal: Inferior-most contour of axillary vessels Anterior: Skin surface Posterior: Anterior surface of the subscapularis muscle Lateral: Skin surface Medial: Lateral to and excluding axillary vessels



A~G: Cross sectional diagram of OAR_{axilla} from top to bottom.
H and I: Coronal and sagittal diagram of OAR_{axilla}.
J and K: Dose distribution of CRT and IMRT plan(The innermost purple and outermost green filled areas are 50 Gy and 20 Gy).
L: The DVH of the OAR_{axilla} in the IMRT plan (The red and green solid lines are the doses of OAR_s and OAR_M after the OAR_{axilla} limit, respectively, and the dashed lines are the doses before the two limits). The red and green contours indicate OAR_s and OAR_M respectively. The yellow and blue contours indicate Level II and III region of axilla and lateral to ALTJ region respectively.

Figure 1 Delineation and dose diagram of OAR_{axilla}

不限量的 3D-CRT 计划(CRT);
(2)OAR_{腋窝}限量($D_{min}<36.8$ Gy)的 3D-CRT 计划(CRT_{limit});
(3)OAR_{腋窝}不限量的 IMRT 计划(IMRT);(4)OAR_{腋窝}限量($D_{min}<36.8$ Gy)的 IMRT 计划(IMRT_{limit})。

CRT 计划的设计:以常规切线野作为主野入射方向,以切肺体积最小为设野原则,在内外切方向设置 2 个主野,并利用多叶光栅屏蔽高剂量区及给予低剂量区补量(共 8~10 个子野),锁骨上区设置前后野,并调整机头角度,正向调整剂量权重、跳数及射野形状,得到剂量分布。CRT_{limit} 计划的设计是在 CRT 计划的基础上限定 OAR_{腋窝} $D_{min}<36.8$ Gy。

IMRT 计划的设计:以常规切线野作为主野入射方向,以切肺体积最小为设野原则,胸壁采取 4 野调强方式,锁骨上区采取前 4 后 1 共 5 野调强方式,并和胸壁共用 2 野,调节最大剂量、最小剂量参数,整体计划采用 7 野调强方式进行逆向优化,根据优化结果转换成所需子野及相应剂量权重和 MU,得到剂量分布。IMRT_{limit} 是在 IMRT 计划的基础上限定 OAR_{腋窝} $D_{min}<36.8$ Gy。

靶区剂量及 OAR 限值:胸壁及锁骨上、腋窝淋巴结引流区的处方剂量为 50 Gy 分 25 次照射。患侧肺 $V_{20}<30\%$ 、健侧肺 $V_5=0$;左侧乳腺癌心脏 $D_{mean}<5\sim7$ Gy、右侧乳腺癌心脏 $D_{mean}<1\sim2$ Gy,OAR_{腋窝} $D_{min}<36.8$ Gy,肱骨头 $D_{mean}<25$ Gy,

脊髓 $D_{\max} < 40\text{Gy}$ 。

1.5 评价指标

(1) 基于两种勾画方法的 OAR_{腋窝} 解剖轮廓相似性比较^[9-10]: (a) 体积值 (cm^3); (b) 一致性指数 (concordance index, CI), $CI = (A \cap B) / (A \cup B)$; (c) 形似性指数 (Dice's similarity coefficient, DSC), $DSC = 2(A \cap B) / (A + B)$, 其中 A 和 B 是相比较的两个轮廓。

(2) 靶区剂量适形性 (conformal index, ci) 与剂量均匀性指数 (homogeneity index, hi)。

ci 计算公式为 $ci = V_{T, \text{ref}} / V_T \times V_{T, \text{ref}} / V_{\text{ref}}$ ^[11], 其中 $V_{T, \text{ref}}$ 为接受剂量等于或大于处方剂量的靶区体积 (cm^3), V_T 为靶区体积 (cm^3); V_{ref} 为接受等于或大于处方剂量的总体积 (cm^3)。ci 值的范围是 0~1, 值越大说明靶区适形度越好。

hi 计算公式为 $hi = D_{5\%} / D_{95\%}$ ^[12], 其中 $D_{5\%}$ 、 $D_{95\%}$ 分别为受照射剂量最高的 5% 和 95% 的 PTV 中的最小剂量 (Gy), hi 理想值为 1, 且随计划的不均匀而增大。

(3) 其他剂量学参数。心脏平均剂量 D_{mean} 、 V_{10} 、 V_{20} , 患侧肺 V_5 、 V_{10} 、 V_{20} , OAR_{腋窝} 最大剂量 $D_{\max}$ 、平均剂量 D_{mean} 、最小剂量 $D_{\min}$ 。

1.6 统计学处理

采用 SPSS 23.0 软件进行分析, 计量资料以均值 $\pm$ 标准差 ($\bar{x} \pm s$) 表示, 采用配对 t 检验比较两组计划之间的差异。 $P < 0.05$ 为差异有统计学意义。

2 结 果

2.1 基于两种勾画方法的 OAR_{腋窝} 解剖轮廓比较

OAR_S 和 OAR_M 体积分别为 $(20.85 \pm 5.09) \text{ cm}^3$ 、 $(23.60 \pm 5.60) \text{ cm}^3$, 改进方法勾画的 OAR 略大于标准方法 ($P = 0.000$)。两者比较的 CI 和 DSC 分别为 0.79 ± 0.03 、 0.88 ± 0.02 。

2.2 基于两种勾画方法的 OAR_{腋窝} 剂量学比较

除了 CRT 计划中的 $D_{\min}$ 以外, 基于两种勾画方法得到的 OAR_{腋窝} 在其他参数方面 ($D_{\max}$ 、 D_{mean} 和 $D_{\min}$) 均无统计学差异 ($P > 0.05$) (Table 3)。

2.3 OAR_{腋窝} 限量前后的剂量学比较

2.3.1 靶区剂量学比较

OAR_{腋窝} 限量前后, 靶区无本质上的剂量学差异 (Table 4)。其中 CRT 计划中 PTV_{all} 的 V_{DT} 为 90.8% vs 90.1%, $P = 0.155$ 。在 IMRT 计划中 OAR_{腋窝} 限量后

Table 3 Dosimetric comparison of OAR_{axilla} based on two delineation methods (Gy)

Plan	Index	OAR _S	OAR _M	t	P
CRT	$D_{\max}$	55.7 ± 1.6	55.7 ± 1.5	0.121	0.905
	D_{mean}	51.4 ± 0.8	51.3 ± 1.1	-1.305	0.204
	$D_{\min}$	39.5 ± 3.4	36.7 ± 3.5	-1.771	0.001
IMRT	$D_{\max}$	53.4 ± 0.6	53.3 ± 0.9	-0.887	0.383
	D_{mean}	51.3 ± 0.3	51.1 ± 0.6	-1.880	0.072
	$D_{\min}$	41.6 ± 2.8	40.5 ± 2.9	-1.692	0.103
CRT _{limit}	$D_{\max}$	55.3 ± 1.4	54.9 ± 1.7	-1.094	0.284
	D_{mean}	50.4 ± 1.9	50.5 ± 1.0	0.220	0.828
	$D_{\min}$	34.0 ± 2.8	32.8 ± 2.8	-1.009	0.055
IMRT _{limit}	$D_{\max}$	53.7 ± 0.6	53.8 ± 0.6	1.931	0.065
	D_{mean}	50.7 ± 0.6	50.7 ± 0.8	-0.722	0.477
	$D_{\min}$	30.3 ± 2.9	31.4 ± 2.6	1.604	0.121

计划的 $D_{\max}$ 略高 (54.0 Gy vs 53.8 Gy , $P = 0.001$), MU 略高 (976 vs 958 , $P = 0.023$); 在 CRT 计划中 OAR_{腋窝} 限量后计划的 D_{mean} 略低 (51.9 Gy vs 52.0 Gy , $P = 0.001$), ci 略优 (0.55 vs 0.54 , $P = 0.00$)。OAR_{腋窝} 限量前后腋窝淋巴结 I~III 组剂量学差异无统计学意义。

2.3.2 OAR 剂量学比较

在 CRT 和 IMRT 计划中, OAR_{腋窝} 限量显著性降低了其剂量, 其中 $D_{\min}$ 分别降低了 13.9% 和 27.2%, 分别为 34.0 Gy vs 39.5 Gy 、 30.3 Gy vs 41.6 Gy 。在 CRT 和 IMRT 计划中, OAR_{腋窝} 限量前后患者的心脏和患侧肺的剂量无统计学差异 ($P > 0.05$) (Table 4)。

3 讨 论

乳腺癌放疗后上肢淋巴水肿的发病因素较为复杂, 研究显示, 腋窝淋巴结清扫和 RNI 后上肢淋巴水肿发生率从 9% 到 65% 不等。本课题组已发表的研究显示, 基于 Norman 问卷和周径测量两种诊断方法的 BCRL 发病率分别为 31.7% 和 27.0%, 在术后 2 年内发病率逐渐上升, 尤以第 1 年为甚。腋窝淋巴结清扫、放疗、改良根治术和腋窝淋巴结清扫数目为危险因素, 其中放疗是发生 BCRL 最重要的危险因素, 可使 BCRL 发病风险增加 3.54 倍^[13-16]。本文在上述临床研究的基础上进一步探讨如何降低放疗所致 BCRL 的风险。

放疗后淋巴管内皮细胞破坏、淋巴管新生抑制、淋巴液回流受阻是导致淋巴水肿的可能原因^[17]。研究显示, 所照射的腋窝组织的体积和分布是发生淋巴水肿的独立危险因素。位于背阔肌与胸小肌外侧

Table 4 Dosimetric comparison of target volume and other OARs after OAR_{axilla} limit

Index	CRT	CRT _{limit}	<i>t</i>	<i>P</i>	IMRT	IMRT _{limit}	<i>t</i>	<i>P</i>
PTV _{all}								
V _{DT} (%)	90.8±1.9	90.1±1.6	4.147	0.155	95.0±1.9	95.0±1.4	0.000	0.941
D _{max} (Gy)	57.7±1.2	57.7±1.0	-0.104	0.918	53.8±0.6	54.0±0.7	-3.831	0.001
D _{mean} (Gy)	52.0±0.3	51.9±0.3	3.833	0.001	51.3±0.3	51.2±0.2	1.622	0.117
<i>hi</i>	1.12±0.02	1.12±0.03	0.195	0.847	1.05±0.01	1.05±0.01	1.453	0.159
<i>ci</i>	0.54±0.07	0.55±0.06	-5.771	0.000	0.67±0.04	0.67±0.05	-0.571	0.573
MU	591±63	592±63	0.250	0.805	958±176	976±174	-2.416	0.023
ALN-I								
D ₉₅ (Gy)	12.3±13.5	13.0±14.4	-0.772	0.447	15.2±12.3	14.0±11.2	1.182	0.248
D ₉₀ (Gy)	14.8±13.7	15.9±16.2	-0.965	0.344	16.2±11.7	16.1±11.7	2.217	0.056
V ₄₅ (%)	58.1±14.5	57.1±14.8	2.407	0.024	56.7±14.0	56.4±13.9	1.451	0.159
ALN-II								
D ₉₅ (Gy)	45.2±4.8	44.3±5.4	1.652	0.111	49.4±1.8	49.2±1.7	1.132	0.269
D ₉₀ (Gy)	47.3±2.9	47.1±2.8	2.217	0.036	50.0±1.0	50.0±1.0	0.536	0.597
V ₄₅ (%)	94.7±5.3	94.4±2.7	-0.999	0.327	99.2±1.6	99.2±1.6	-0.895	0.379
ALN-III								
D ₉₅ (Gy)	49.6±2.6	49.4±2.6	0.628	0.536	50.1±1.0	50.0±0.9	2.781	0.070
D ₉₀ (Gy)	50.5±1.6	50.5±1.5	-0.369	0.715	50.5±0.6	50.3±0.6	1.886	0.071
V ₄₅ (%)	99.0±2.0	99.1±2.0	-0.548	0.589	99.9±0.3	99.9±0.3	1.273	0.215
OAR _{axilla}								
D _{max} (Gy)	55.7±1.6	55.3±1.4	2.362	0.026	53.4±0.6	53.7±0.6	-3.363	0.002
D _{mean} (Gy)	51.4±0.8	50.4±1.9	2.655	0.014	51.2±0.3	50.7±0.6	5.303	0.000
D _{min} (Gy)	39.5±3.4	34.0±2.8	8.353	0.000	41.6±2.8	30.3±2.9	7.657	0.000
Heart, all patient(n=26)								
D _{mean} (Gy)	3.2±2.9	3.2±2.9	1.364	0.185	3.8±2.5	3.8±2.5	-0.433	0.668
V ₁₀ (%)	6.2±8.0	6.2±8.0	2.132	0.053	7.4±8.2	7.3±8.2	1.369	0.183
V ₂₀ (%)	4.6±6.2	4.6±6.2	1.000	0.327	4.2±5.2	4.2±5.2	0.413	0.683
Heart, left side patient(n=11)								
D _{mean} (Gy)	6.2±2.1	6.2±2.1	1.000	0.341	6.4±1.3	6.4±1.3	3.300	0.508
V ₁₀ (%)	14.4±5.6	16.2±3.8	-1.669	0.126	14.4±5.6	16.2±3.9	-1.683	0.123
V ₂₀ (%)	10.7±4.8	9.7±3.0	1.339	0.210	10.7±4.8	9.7±3.0	1.370	0.201
Ipsilateral lung								
V ₅ (%)	43.8±3.1	43.7±3.1	1.498	0.147	49.5±3.7	49.5±3.7	1.476	0.152
V ₁₀ (%)	34.3±2.6	34.2±2.6	3.149	0.104	39.5±2.9	39.5±2.9	-1.078	0.291
V ₂₀ (%)	27.3±2.5	27.2±2.5	1.863	0.074	27.7±1.0	27.7±1.0	-2.390	0.065

之间的 I 组腋窝淋巴结和位于胸小肌后方的 II 组腋窝淋巴结的照射增加了淋巴水肿的风险,因其含有较高数量的淋巴结。如果靶区避开腋窝 I / II 组,范围即使超过腋头的 1/3 以上,5 年内淋巴水肿的发病率从 37%降低到 7%,且不增加复发风险^[18]。因此,降低腋窝的受量是降低放疗所致 BCRL 风险的唯一手段。

腋窝逆向淋巴显影(axillary reverse mapping, ARM)技术的出现使得可靠地区分乳腺和上臂的淋巴路径成为可能^[19]。ARM 的研究表明,乳房和手臂淋巴途径之间可能存在交叉引流,会增加淋巴水肿

发生率,而 ALTJ 区可能是手臂引流的前哨区域或对于邻近淋巴结区域旁支再生的关键区域^[20]。Beek 等^[21]将 107 例前哨淋巴结阳性的 cN₀ 乳腺癌患者随机分为标准腋窝淋巴结清扫术(axillary lymph node dissection, ALND)组及 ARM-ALND 组,结果显示,标准 ALND 组 12 个月及 24 个月时淋巴水肿发生率分别为 19.5%及 26.7%,而 ARM-ALND 组仅为 5.0%及 6.1%。Clough 等^[22]对乳腺前哨淋巴结相对于腋窝解剖标志点定位进行的一项研究发现,98.2%的乳腺引流淋巴管位于胸外静脉内侧,这可能是 ALND 术后 RNI 范围不包括腋窝 I 区上部和 II 区会降低

淋巴水肿发生率的原因。Byun 等^[23]的研究发现 RNI 范围不包括 I、II 区腋窝时会明显降低 3 年淋巴水肿发生率(16.8% vs 24.1%)。Gross 等^[18]的研究发现,腋窝 I 区上部和 II 区是腋窝清扫后淋巴水肿风险的重要区域,而 ALTJ 区域位于腋窝 I 区淋巴结上部,因此被确定为淋巴水肿预后的 OAR,进一步研究发现,其 D_{min} 限制在 36.8 Gy 以下时患者 3 年淋巴水肿发生率明显降低(5.7% vs 37.4%)。

本文将 ALTJ 区域作为腋窝 OAR($OAR_{腋窝}$)进行勾画,并评估在临床常见 CRT(野中野技术)和 IMRT 技术中 $OAR_{腋窝}$ 限量的可行性,结果发现,在 CRT 和 IMRT 计划中, $OAR_{腋窝}$ 限量可以在不降低靶区剂量和不增加其他 OAR 剂量的情况下显著性降低其剂量,两者的 D_{min} 分别降低了 13.9%和 27.2%,剂量均 <36.8 Gy,分别为 34.0 Gy 和 30.3 Gy,可见,IMRT_{lim} 计划更易降低 $OAR_{腋窝}$ 的 D_{min} 。

区别于心脏、肺等容易被勾画的 OAR,解剖结构复杂可能会限制 $OAR_{腋窝}$ 在临床上的常规勾画。由于 ALTJ 区域位于腋窝 I 区淋巴结上部,因此本文提出了一种改进勾画方法,即只要按照 RTOG 指南勾画腋窝 I 组,将腋血管消失层面的轮廓向上复制至肱骨头下一层为止,并适当调整位置及范围。结果显示,改进方法所勾画的 $OAR_{腋窝}$ 轮廓与 Gross 提供的标准方法相差甚小,改进方法勾画的 OAR 略大于标准方法,但两者无实质上的剂量学差异。因此,改进方法有利于 $OAR_{腋窝}$ 在乳腺癌根治术后放疗计划中被常规、简易、快速地勾画。

有研究分析了阳性前哨淋巴结的解剖分布后发现,前哨淋巴结基本没有位于 ALTJ 区^[22,24]。国际乳腺癌研究小组发现腋窝清扫术后治疗失败的情况非常少见,从低风险患者的 1.3%到高风险患者(3 个以上阳性淋巴结)的 5%不等^[25]。因此,针对切除 10 个以上淋巴结(且有 1~3 个阳性淋巴结)的淋巴结阴性患者,应尽量减少 ALTJ 区的 D_{min} ;然而在高危情况下,更全面的腋窝剂量覆盖可能是最安全的方法^[6]。

本研究初步证实了在乳腺癌根治术后放疗中腋窝 OAR 的勾画及其限量的可行性,为降低放疗所致上肢淋巴水肿的发生率提供了剂量学依据。本文限于乳腺癌根治术后放疗患者,而对于保乳术后,特别是前哨淋巴结 1~3 个阳性的高危患者,需要区域淋巴结照射,但由于仅行前哨淋巴结活检术而淋巴水

肿发生率较腋窝淋巴结清扫低^[26],其 ALTJ 区剂量与乳腺癌相关淋巴水肿发生率关系也有待进一步临床验证。

综上所述,在乳腺癌根治术后放疗中针对腋窝 OAR 的勾画以及剂量限制是可行的, $D_{min}<36.8$ Gy 可作为腋窝 OAR 的限量标准,可采用改进方法勾画,并能为临床降低放疗所致上肢淋巴水肿风险提供剂量学依据。

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