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SBRT所面临的放射物理学问题

天津肿瘤医院射波刀中心

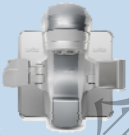
董洋



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- 如今诸多厂商宣称自己的设备为SBRT设备，或具备实现SBRT的性能
- 比如 γ 刀，X刀，射波刀，各种基于IGRT、4DCT甚至呼吸门控的加速器，TomoTherapy等等


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Table 1. Comparison of typical characteristics of 2D/3DRT radiotherapy and SBRT

Characteristic	2D/3DRT	SBRT
Dose/fraction	1.8-2 Gy	3-5 Gy
No. of fractions	10-20	1-5
Target definition	CT/PV (gross-tumor, planning target volume, clinical target volume, GTV=CTV)	CT/PV (gross-tumor, planning target volume, clinical target volume, GTV=CTV)
Margin	Yes	No
Physicochemical monitoring	Yes	No
Required setup accuracy	IGRT, IGRT	IGRT, IGRT
Primary imaging modalities used for treatment planning	CT, MRI, PET, CT/MRI/PET	CT, MRI, PET, CT/MRI/PET
Reliance on geometric accuracy	Yes	No
Management of the target	Yes	No
Physicochemical monitoring	Yes	No
Needs rigid registration	Yes	No
Soft tissue registration	Yes	No
Recovery of implementation	Yes	No
Biophysical understanding	Yes	No
Interaction with systemic therapies	Yes	No

有人说X刀， γ 刀，射波刀就是SBRT，这是一种误解，使用上述设备而进行8甚至10次以上分割的立体定向放疗，在TG101报告看来，已经超出了SBRT的范围

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- 根据TG101报告的描述，我们可以认为SBRT所代表的其实是一种信心，一种敢于在各种干扰因素纷繁复杂的体部实施1-5次大分割放疗的自信，而这种信心的来源建立在肿瘤放射物理学不断发展的基础之上
- AAPM TG101 Report
In SBRT, **confidence** in this accuracy is accomplished by the integration of modern imaging, simulation, treatment planning, and delivery technologies into all phases of the treatment process

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- 在RTOG0236号临床试验启动之初，当时的很多新技术尚不完善，不得不在协议里加以妥协。
- 一个经典的例子就是

6.2.2 Minimum Field Aperture (Field Size) Dimension

Due to uncertainties in beam commissioning resulting from **electronic disequilibrium** within small beam apertures, a **minimum field dimension of 3.5 cm** is required for any field used for treatment delivery. It is understood that this may exceed the technical requirements listed in Section 6.4 for small lesions (< 2.5 cm axial GTV dimension or < 1.5 cm cranio-caudal GTV dimension). In such cases, the prescription dose is still prescribed to the edge of the defined PTV.

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而现今，大量渐趋成熟的高新放疗技术都逐渐成为SBRT这种信心的强大保障，比如

各类在线或离线IGRT技术

4DCT及4D计划

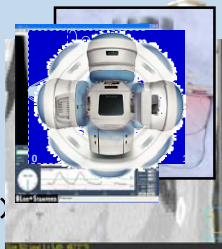
同步呼吸追踪

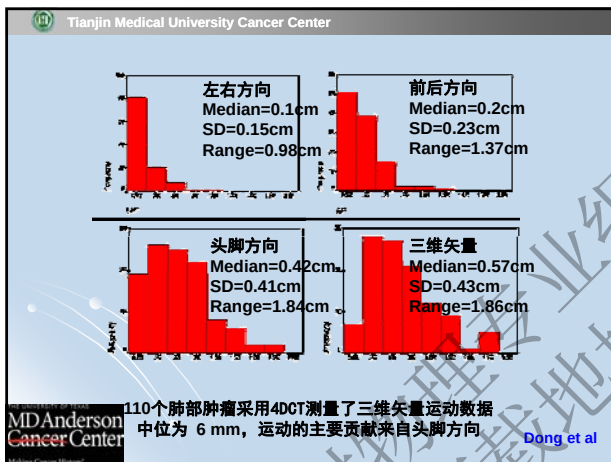
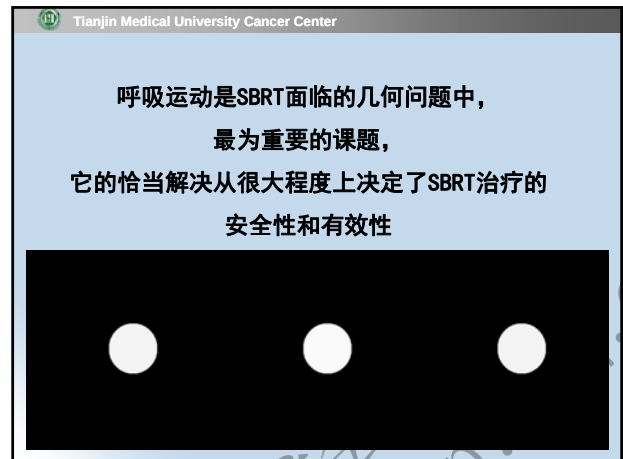
呼吸门控治疗

MC算法

容积调强

..... (此处略去100字)





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PHYSICS CONTRIBUTION

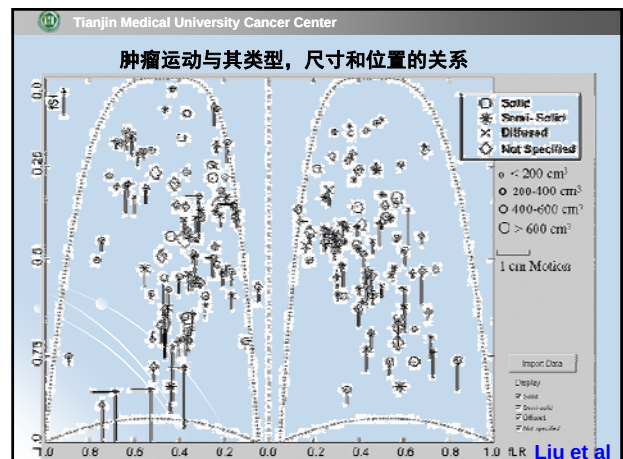
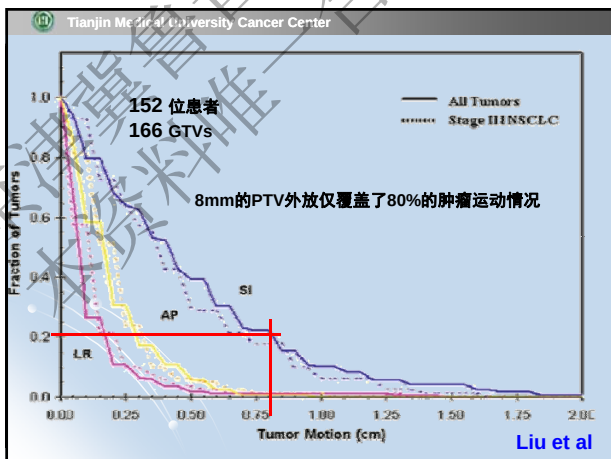
ASSESSING RESPIRATION-INDUCED TUMOR MOTION AND INTERNAL TARGET VOLUME USING FOUR-DIMENSIONAL COMPUTED TOMOGRAPHY FOR RADIOTHERAPY OF LUNG CANCER

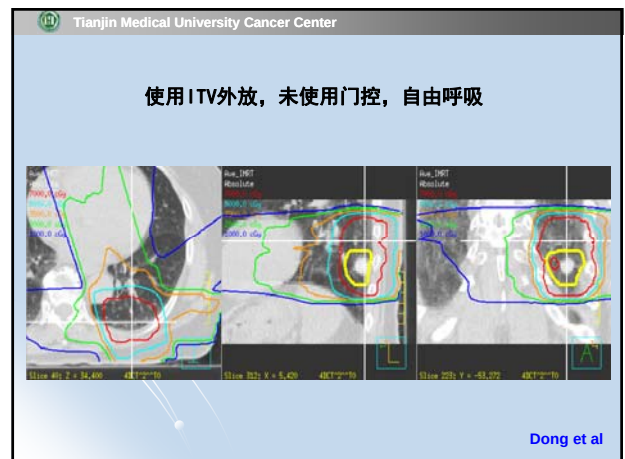
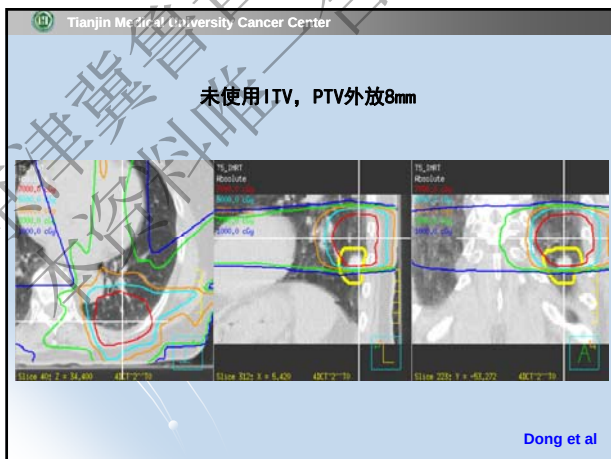
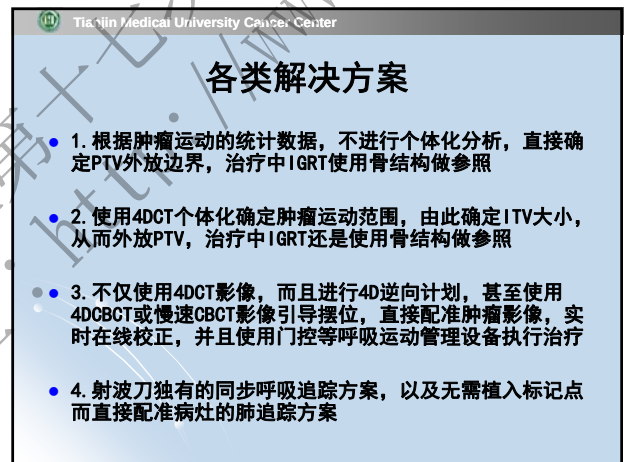
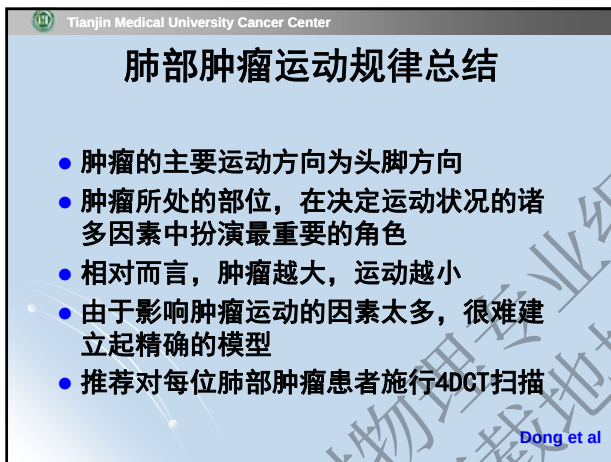
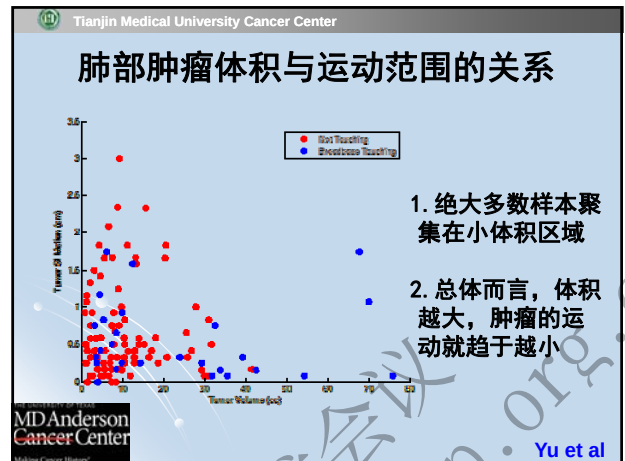
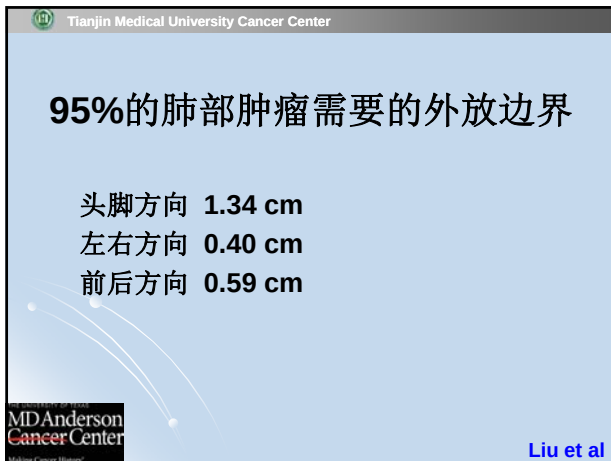
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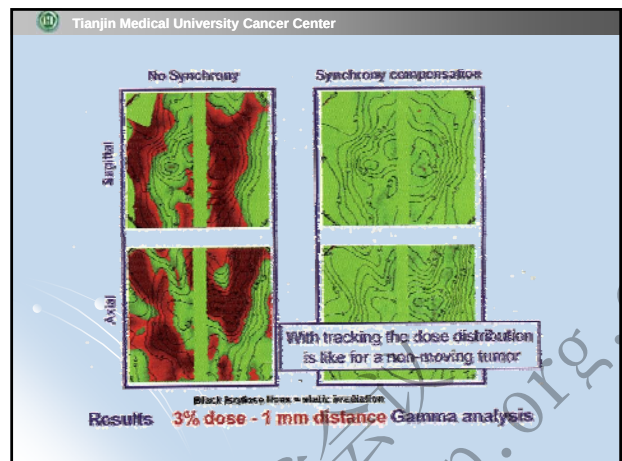
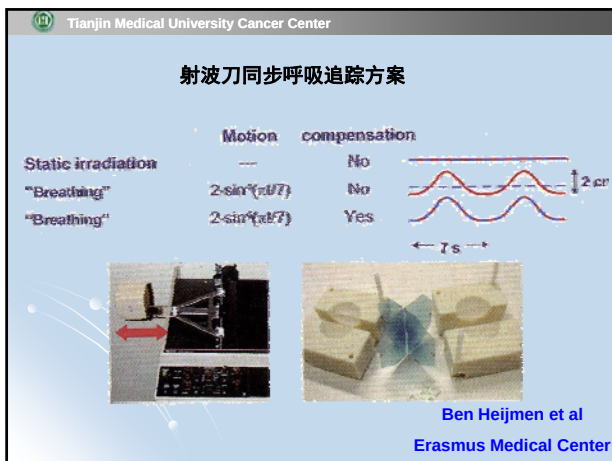
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- 评估了152位患者的肺部肿瘤运动
- 使用4D CT影像
- 并分析了肿瘤的位置, 大小, 类型
- 其中10% 的患者运动超过1cm
- 治疗时患者采用自由呼吸

Liu et al. IJROBP, vol 68, No.2, page 531, 2007







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Stanford总结 肺部SBRT的共同特征

- 肿瘤体积较小 → 小射野
- 外放范围较小（拥有呼吸管理设备时）
- 分次少（1-5次），但是单次剂量大
- PTV通常位于组织密度非常不均匀的位置，例如肺与胸壁，肺与肋骨，肺与肿瘤等 → 非均匀性校正
- → 小射野非均匀辐射剂量学

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- 小射野辐射场的主要特征是侧向电子不平衡、剂量梯度很陡
- 正是由于存在侧向电子不平衡，从而在相异介质中表现出剂量跃变，比如对肺等低密度介质来说，当存在电子不平衡时，此时产生的次级电子仍然具有较高的能量，以至于穿过肺等低密度组织时，向侧向散射，将能量沉积在射线束的集合范围以外，使射野内剂量降低，射野外剂量增加

修正或修正剂量学模型
估了肿瘤靶区内的剂量

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组织密度不均匀性校正算法上的差别

TPS在得到不同组织的相对电子密度后是通过剂量计算算法得到不同组织的在辐射场作用下的衰减特性，然后作出剂量计算。

但不同的算法对不同组织算出的结果有很大的差异造成不同的算法有不同的剂量计算结果，让使用者无所适从。

正确选取能够提供适当组织密度不均匀性校正的算法，对于SBRT剂量计算的准确性至关重要

