



XXI

CONGRESSO
DA SOCIEDADE
BRASILEIRA DE
RADIOTERAPIA

Redução de margens em RDT: mesa robótica (6D) e gating – qual o limite?

VILA NOVA STAR
REDE D'OR



GABRIELA REIS S DE JESUS

GRUPO ONCOLOGIA D'OR –
HOSPITAL VILA NOVA STAR

REALIZAÇÃO



SBRT
SOCIEDADE BRASILEIRA
DE RADIOTERAPIA

GERENCIAMENTO



AGÊNCIA OFICIAL



Declaração de conflito de interesse

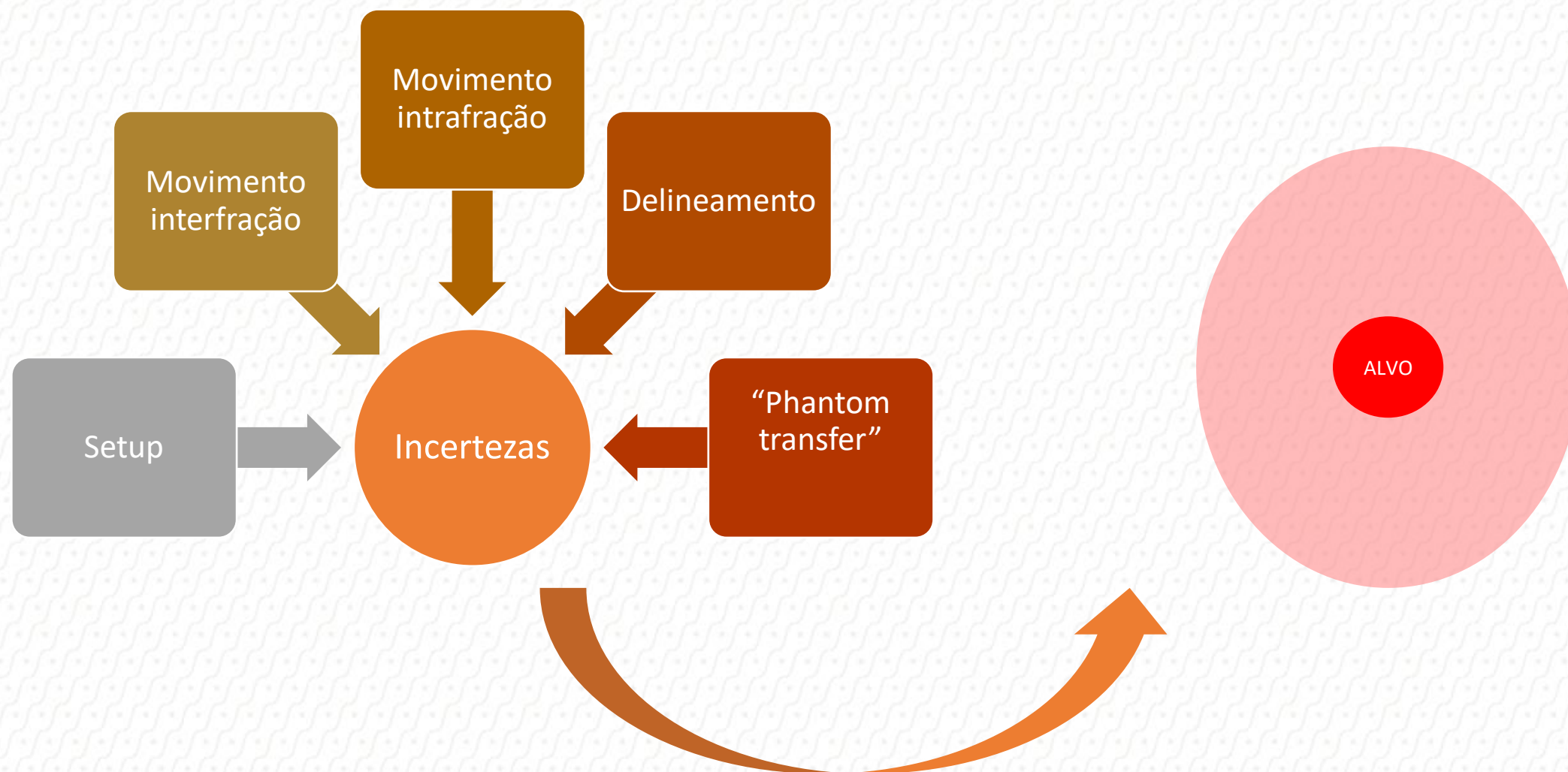
- Afirmo NÃO haver conflito de interesse a declarar.

Agradecimento

- Equipe de física – Hospital Vila Nova Star



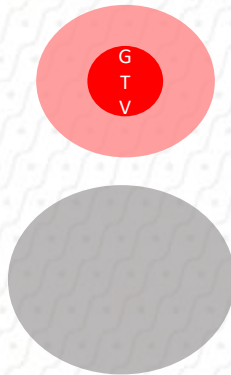
Acurácia e margens



Acurácia e margens



Gating

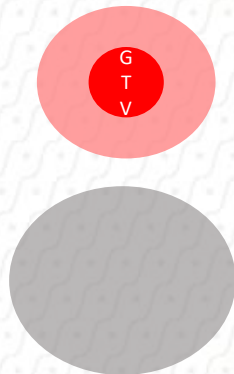


Mesa robótica



Gating

- Sincronizar o feixe de radiação a uma determinada fase / janela do ciclo respiratório, reduzindo a margem (ITV)



Correlação entre o sinal externo vs posição (interna) do alvo



Varian RGSC

Medida do fluxo de entrada/saída de ar – breath hold



Elekta ABC

Gating – redução do PTV

Radiation Oncology



Open Access

Research

A dosimetric analysis of respiration-gated radiotherapy in patients with stage III lung cancer

René WM Underberg¹, John R van Sörnsen de Koste^{*1}, Frank J Lagerwaard¹, Andrew Vincent², Ben J Slotman¹ and Suresh Senan¹

Address: ¹Department of Radiation Oncology, VU University medical center, de Boelelaan 1117, 1007 MB, Amsterdam, The Netherlands and ²Department of Bioinformatics, Antoni van Leeuwenhoek hospital, Plesmanlaan 121, 1066 CX, Amsterdam, The Netherlands

Email: René WM Underberg - rwm.underberg@vumc.nl; John R van Sörnsen de Koste^{*} - j.vansornsendekoste@vumc.nl; Frank J Lagerwaard - FJ.Lagerwaard@vumc.nl; Andrew Vincent - a.vincent@nki.nl; Ben J Slotman - bj.slotman@vumc.nl; Suresh Senan - s.senan@vumc.nl

^{*} Corresponding author

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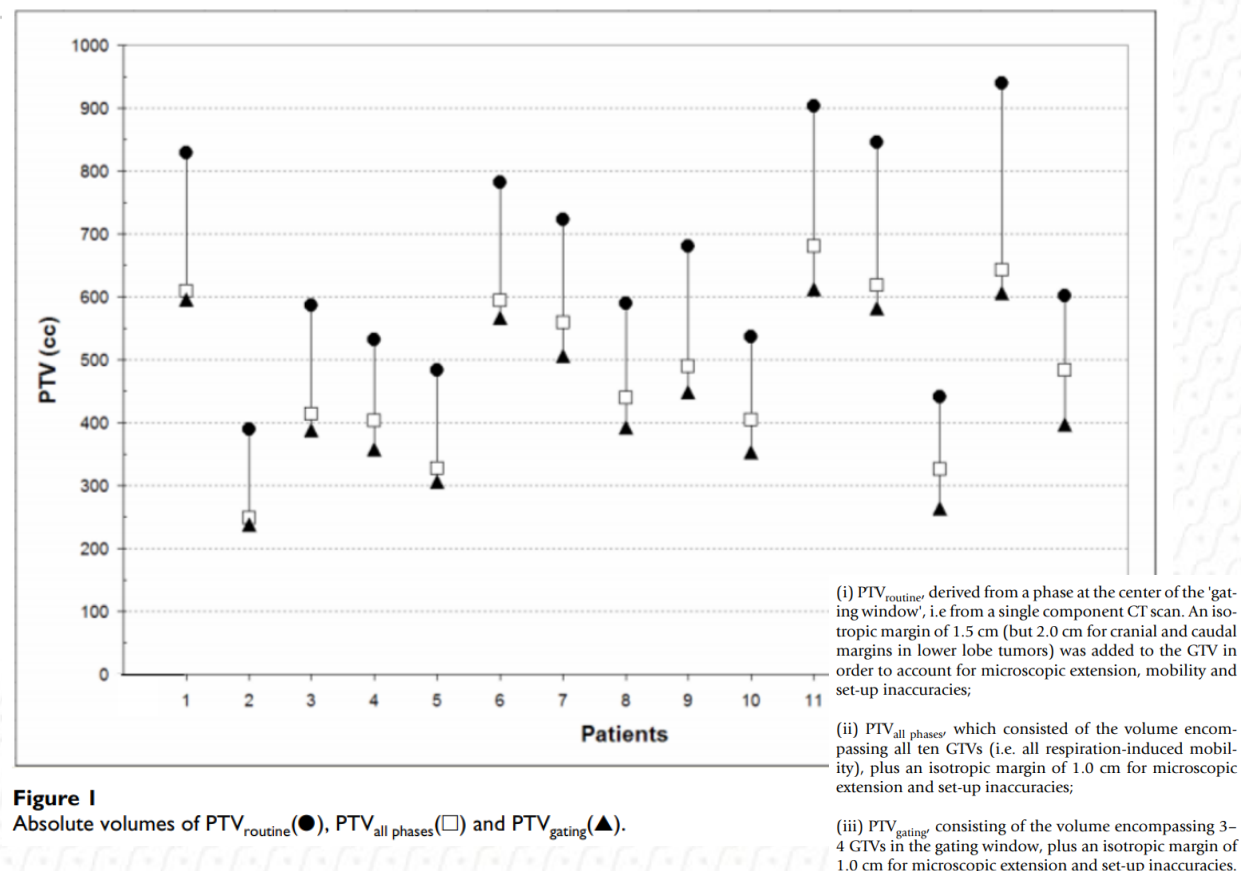


Figure 1

Absolute volumes of $PTV_{routine}$ (●), $PTV_{all\ phases}$ (□) and PTV_{gating} (▲).

Gating – impacto dosimétrico

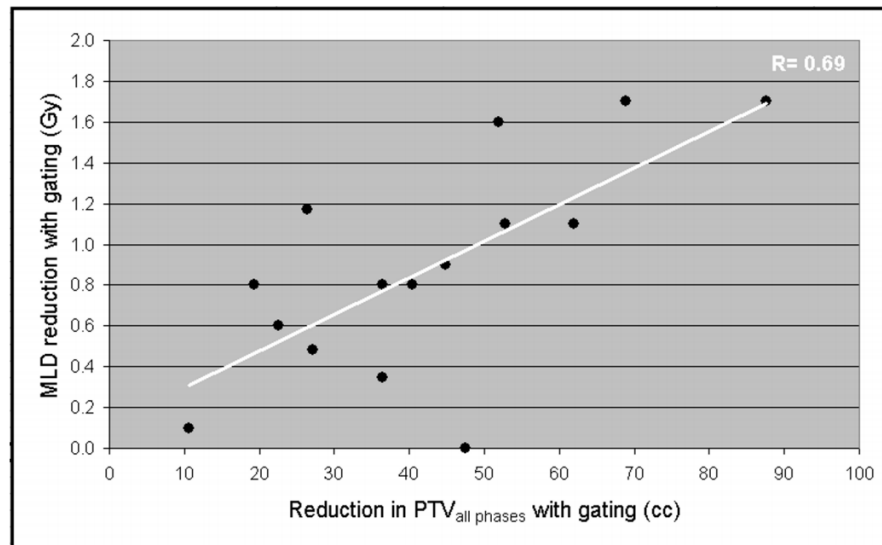


Figure 3
a-b Dosimetric correlation between (a) PTV reduction and V20 reduction, and (b) PTV reduction and MLD reduction.

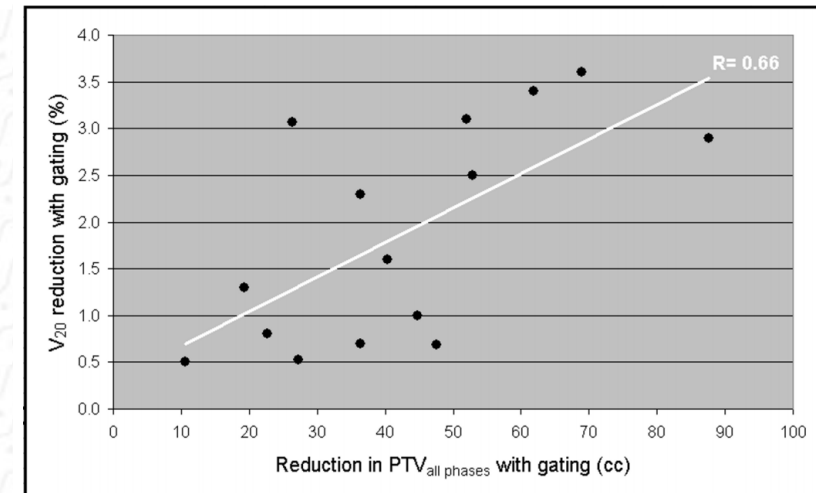


Figure 2
a-b Dosimetric correlation between (a) PTV reduction and V20 reduction, and (b) PTV reduction and MLD reduction.

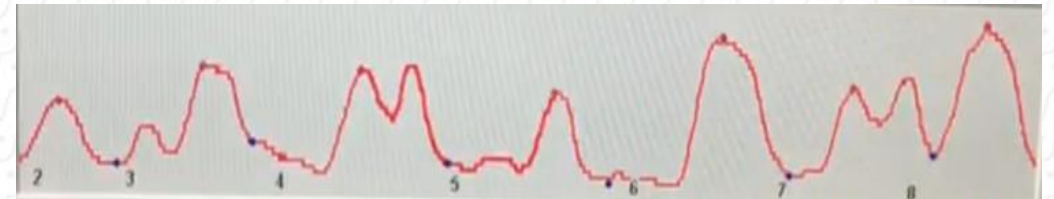
Underberg et al. A dosimetric analysis of respiration-gated RT in pTts stage III lung cancer. Rad Oncology, 2006

Gating – fatores de influência



Gating – fatores de influência

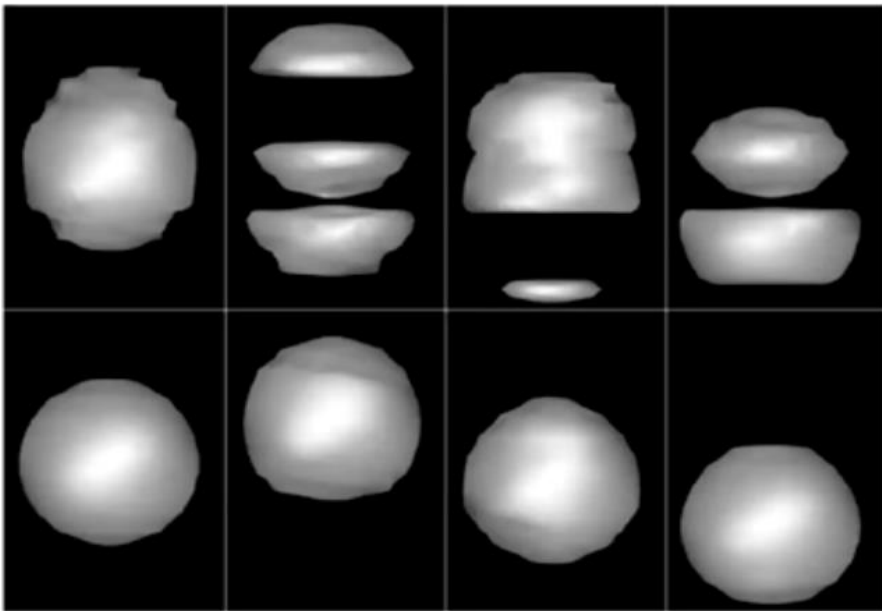
1. Correlação do movimento interno vs externo: cria-se uma associação da posição do marcador externo em relação à fase do ciclo respiratório



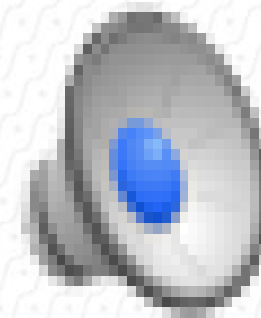
- Ciclos irregulares, por exemplo, podem criar um modelo de correlação “pobre” – para a mesma fase, diferentes amplitudes são associadas:
 - distorção na imagem;
- Avaliar candidatura do paciente ao gating/ estudo 4DCT;
 - Treinamento.

Gating – fatores de influência

2. Predição do movimento da lesão: definido no momento da simulação (4D-CT ou breath hold scan)



Rietzel et al., Med Phys 2005;32(4):874-889.



- Scans em respiração livre ou com protocolo inadequado de 4DCT introduzem erros geométricos que não serão corrigidos com o gating

Gating – fatores de influência

3. Variação significativa da amplitude da lesão

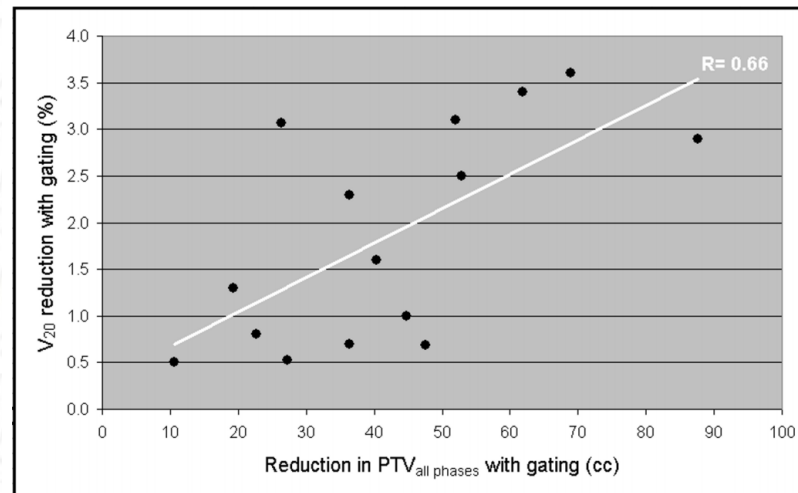
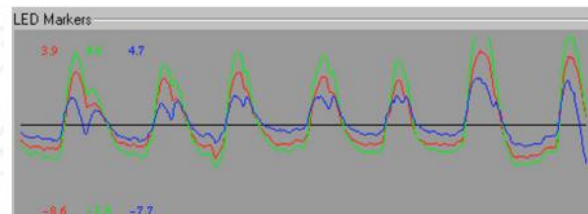


Figure 2
a-b Dosimetric correlation between (a) PTV reduction and V20 reduction, and (b) PTV reduction and MLD reduction.

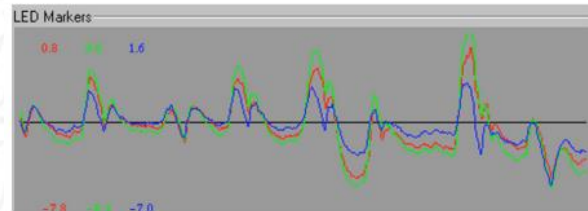
- Lesões que se movimentam pouco, podem não ter benefício no emprego do gating
- Avaliar custo (emprego de recursos, dificuldades operacionais)

Gating – fatores de influência

4. Correlação reprodutível entre CT-sim e AL

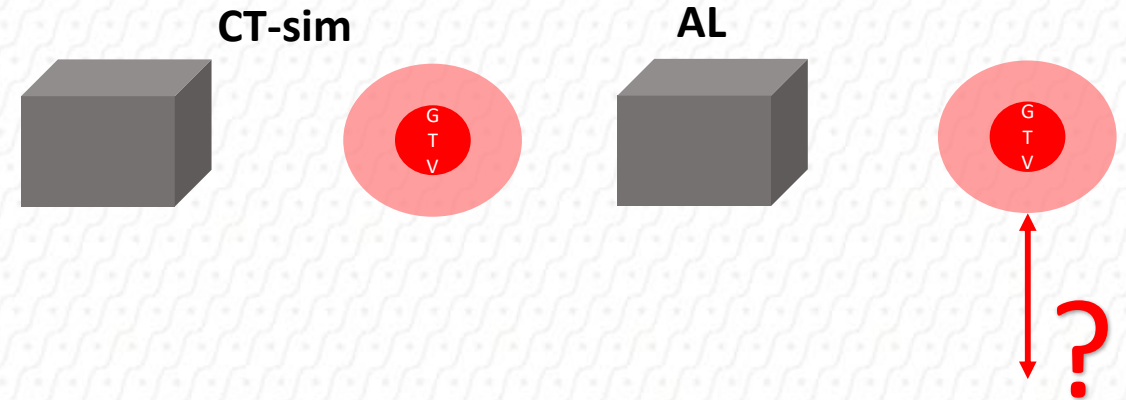


(a)



(b)

Figure 4. Variations in respiratory patterns from the same patient taken a few minutes apart. The three curves in each plot correspond to infrared reflector measured patient surface motion in the SI, AP, and ML directions, with each component arbitrarily normalized. In (a), the motion pattern is relatively reproducible in shape, displacement magnitude, and pattern. In (b), the trace is so irregular that it is difficult to distinguish any respiratory pattern. [Figure courtesy of Dr. Sonja Dieterich.]



- Mesmo com uma aquisição adequada, se o ciclo respiratório sofrer alteração no momento do tratamento, não se pode admitir que o alvo está sendo adequadamente rastreado durante a etapa de entrega da dose.

Gating – fatores de influência

- 5. Associar um método de imagem no momento do tratamento: permite visualizar a posição da lesão em tempo real e fazer as devidas adaptações



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journal homepage: www.thegreenjournal.com



Original Article

Both four-dimensional computed tomography and four-dimensional cone beam computed tomography under-predict lung target motion during radiotherapy

Elisabeth Steiner^{a,*}, Chun-Chien Shieh^a, Vincent Caillet^{a,b}, Jeremy Booth^{b,c}, Ricky O'Brien^a, Adam Briggs^b, Nicholas Hardcastle^{d,e}, Dasantha Jayamanne^b, Kathryn Szymura^b, Thomas Eade^{b,f}, Paul Keall^a

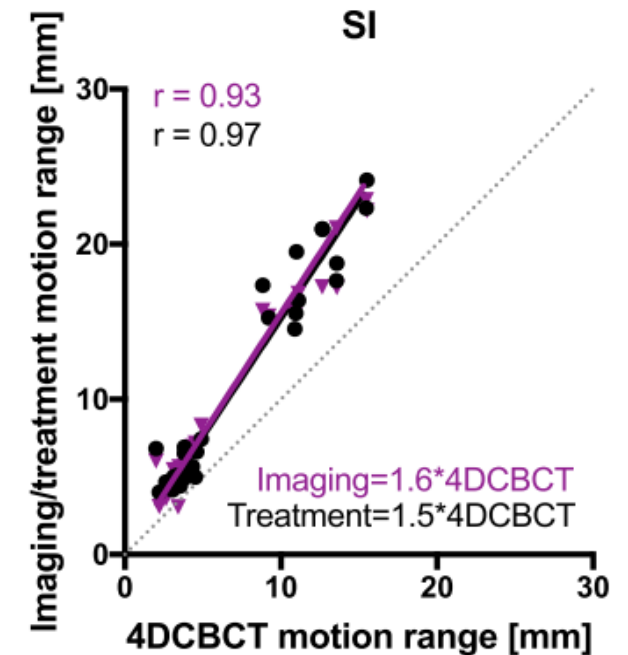
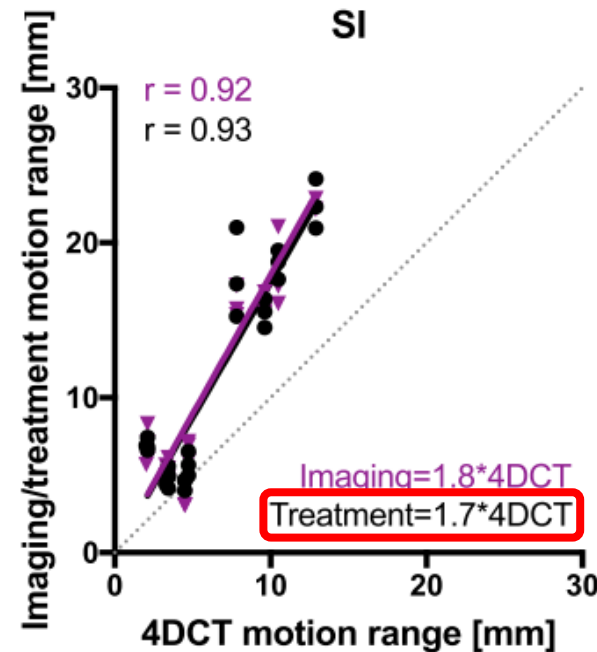
^aACRF Image X Institute, The University of Sydney Central Clinical School; ^bNorthern Sydney Cancer Centre, Royal North Shore Hospital, Sydney; ^cSchool of Physics, University of Sydney; ^dPhysical Sciences, Peter MacCallum Cancer Centre, Melbourne; ^eInstitute of Medical Physics, The University of Sydney; and ^fThe University of Sydney Northern Clinical School, Australia



Gating – fatores de influência

- Estimativa de movimentação interna com 4D é subestimada em relação à movimentação durante o tratamento (Calypso®)
- 4D-CBCT é um pouco mais representativo que 4D-CT
 - CT: apenas cerca de 1 ciclo respiratório por corte
 - CBCT: 15-20 ciclos por aquisição

Comparing pre-treatment and intra-treatment motion



4DCT and 4DCBCT under-predict RT motion

E. Steiner et al. / Radiotherapy and Oncology 135 (2019) 65–73

Gating – fatores de influência

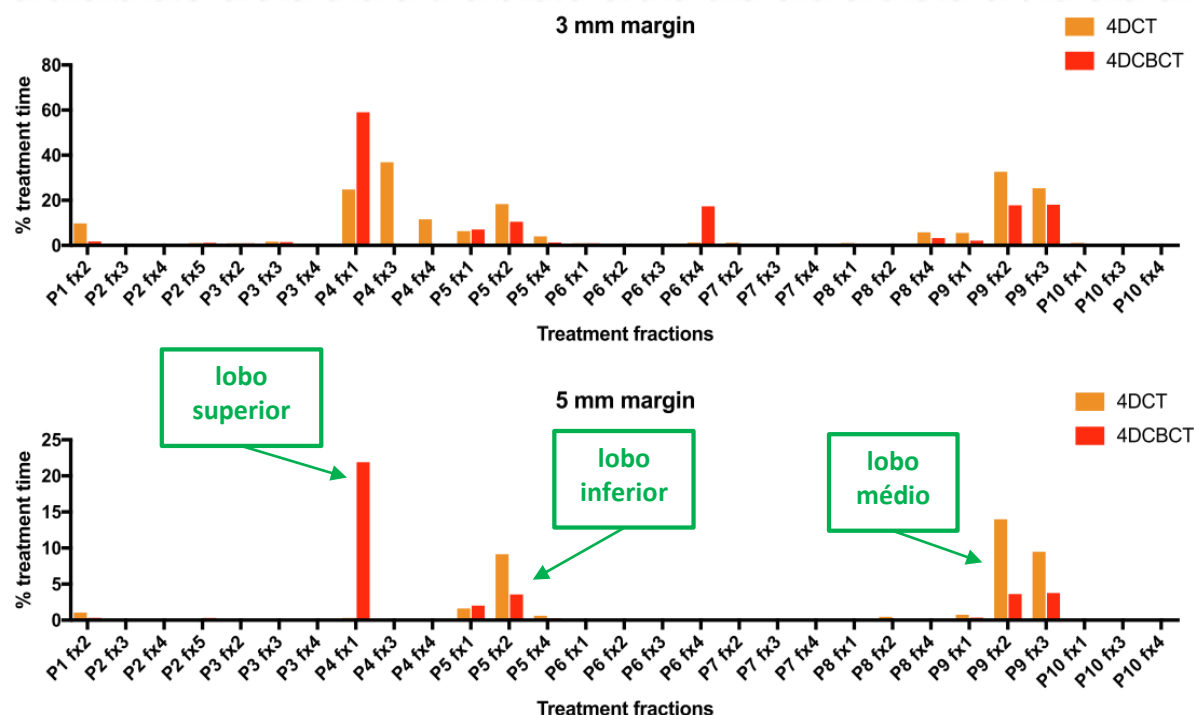


Fig. 4. Percentage of treatment time per fraction when the reconstructed motion ranges from 4DCT and 4DCBCT plus a 3 mm or 5 mm isotropic margin were exceeded in SI, LR or AP directions.

Baseline drifts larger than 5 mm were observed in at least one direction in 27% of the treatment fractions. The resulting uncertainties could be reduced by more frequent intrafraction imaging. Ideally, real-time motion tracking is available during treatment to monitor baseline drifts and sudden breathing pattern changes as they occur [23–25].

Overall a typical margin of 5 mm combined with a 4DCT- or 4DCBCT-based motion measurement covered for exceeding treatment motion in 76% and 83% of the treatment fractions, respectively, and the times of exceeding motion were short (1–20%, Fig. 4). This is in agreement with the data of Shi et al. [26] reporting that the tumour motion exceeded the motion estimation from 4DCT plus a 5 mm margin in up to 13% of the treatment time.

Treatment target motion amplitude variability had less effect on the motion under-prediction than the observed baseline drifts. In order to correct for amplitude variations in real-time, various options are available: multileaf collimator (MLC) tracking [23], motion tracking with CyberKnife [27], Vero [24], couch tracking [25] or gating the beam for larger amplitudes [11].



4DCT and 4DCBCT under-predict RT motion

Gating – fatores de influência

Treatment motion range variations from fraction to fraction due to baseline drifts and amplitude variability were observed. This is consistent with the data published by Shah et al. [9] and Dhont et al. [10]. Our data show that the imaging and treatment target motion range was significantly larger than predicted in 4DCT and 4DCBCT and can be used to understand the limitations of 4DCT and 4DCBCT. Ge et al. [21] found that 4DCT did not represent abdominal tumour motion and concluded “It may not be appropriate to use 4DCT without monitoring of patient motion on a regular basis for patients with abdominal tumours, especially SBRT patients.” Based on our current study, we can apply their conclusion to include both 4DCT and 4DCBCT for lung cancer SABR patients: It may not be appropriate to use 4DCT or 4DCBCT for lung cancer SABR patients without intra-treatment motion monitoring.

4DCT and 4DCBCT under-predict RT motion

E. Steiner et al./Radiotherapy and Oncology 135 (2019) 65–73

- Ressalva: resultados clínicos atuais de SBRT são excelentes. O impacto clínico destas possíveis descobertas precisa de maior avaliação, mas exemplifica os riscos em se reduzir margens além das práticas atuais.

Gating – estabeleça um protocolo

Critério de seleção de pacientes

- Amplitude
- Localização da lesão
- Treinamento?

Protocolo de aquisição de imagem

- Pitch vs rotação do gantry vs frequência respiratória

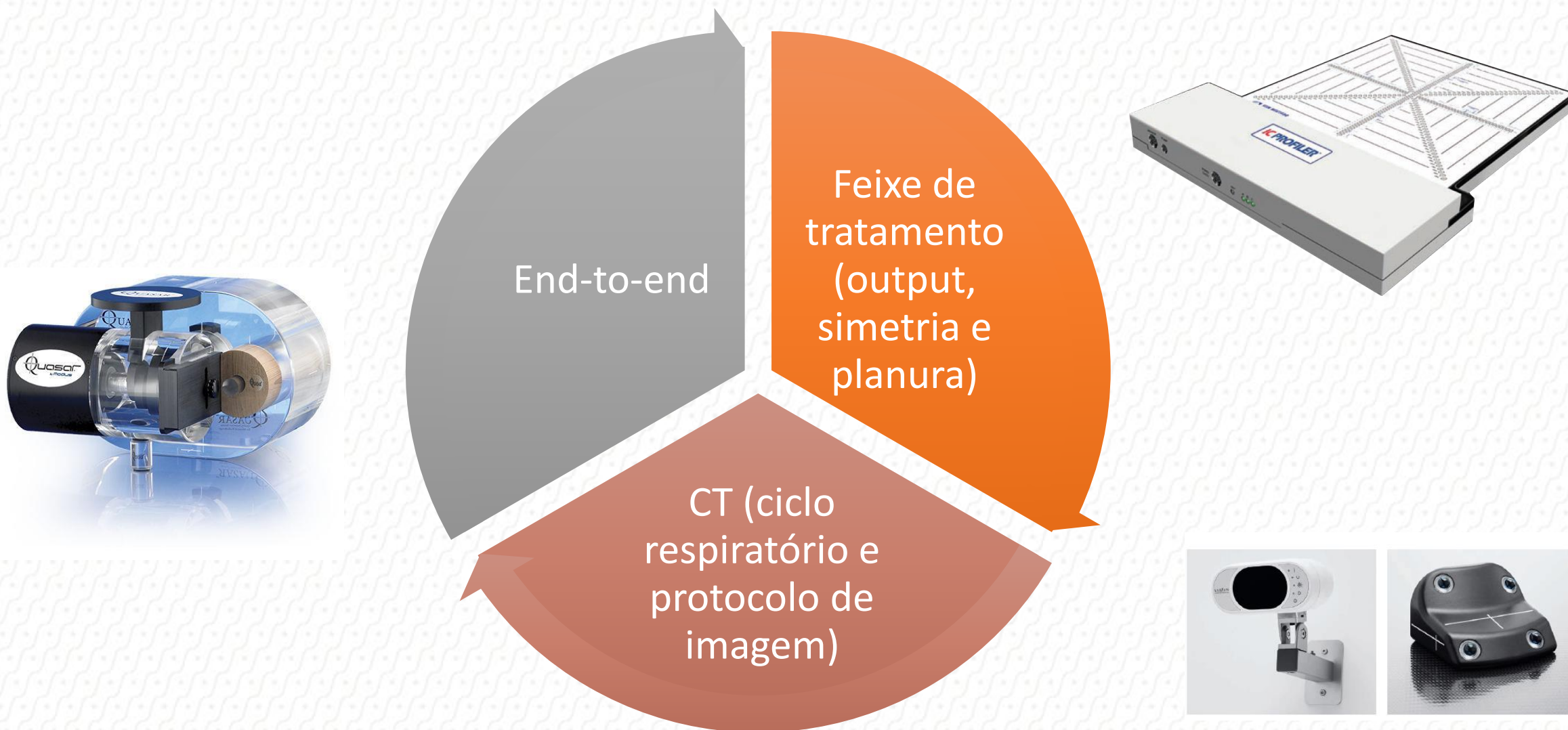
IGRT

- Diafragma ou fiduciais como marcador
- 4D CBCT
- Imagens trigadas

Estratégias para mitigar falta de reprodutibilidade no AL

- Treinamento
- Dispositivo visual para o paciente
- Planejamento “estepe” com margens maiores

Gating – QA



AAPM TG-76 (2006)

It is important to note that respiratory motion is just one potential source of error in radiotherapy. Other important errors, particularly for lung tumors, are gross tumor volume (GTV) and clinical target volume (CTV) definition variations and setup errors. Large inter-physician GTV variations for lung cancer²⁰⁻²³ and CTV variations for breast cancer^{24,25} have been published. The dosimetric consequences of these variations are almost an order of magnitude larger than those caused by respiration-induced motion (see section IV). Also, setup errors for lung^{22,26-32} and breast³³⁻⁴⁰ cancer are of the same or of a higher order than those of respiratory motion. Respiratory motion varies from day to day, and tumor and normal tissues can shrink, grow, and shift in response to radiation therapy and potentially other concomitant therapies.

AAPM REPORT NO. 91



The Management of Respiratory Motion
in Radiation Oncology

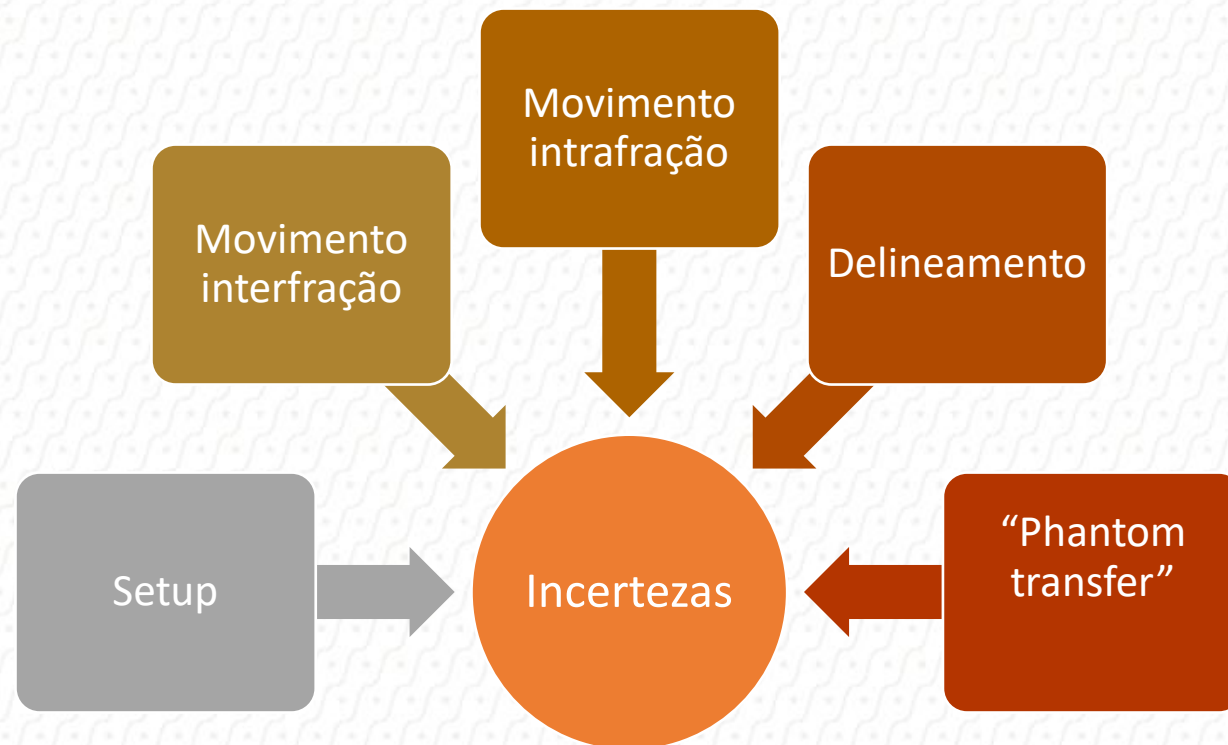
Report of AAPM Task Group 76

July 2006

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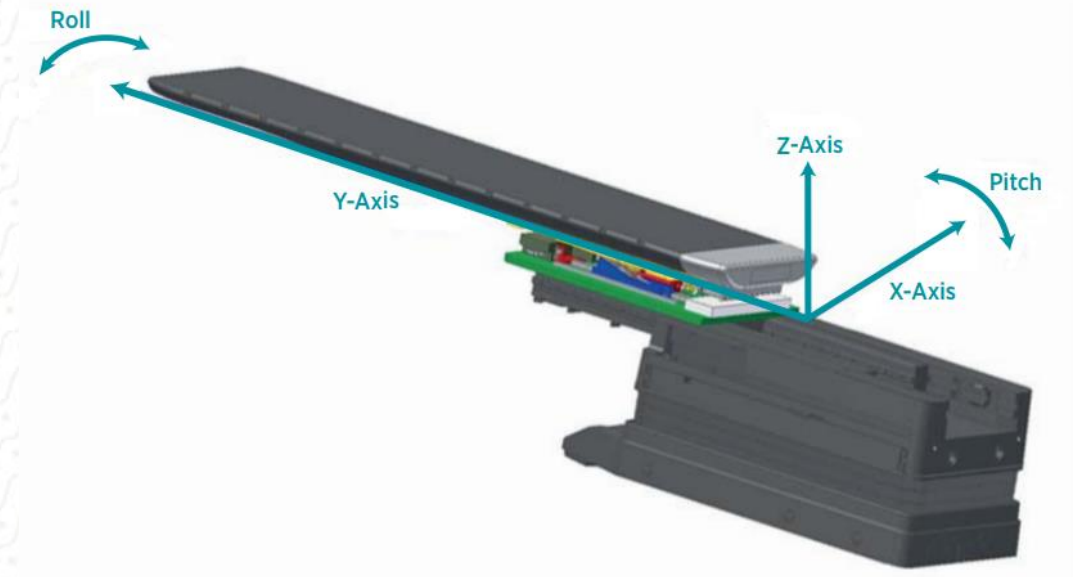
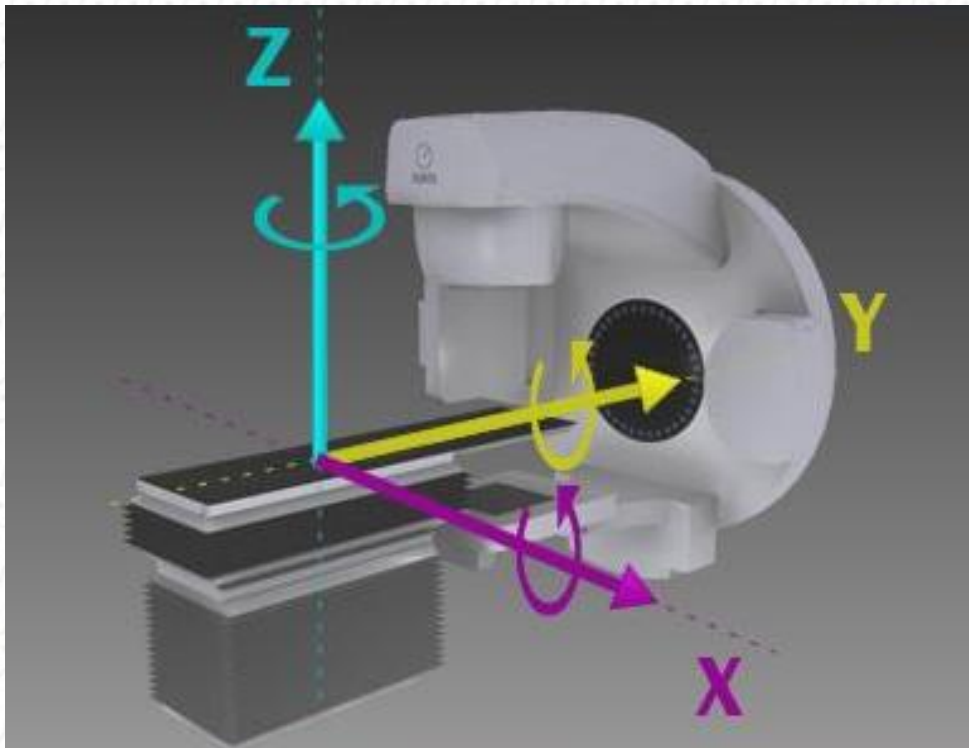
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Margens em RDT



Mesa robótica

- Dispositivo que auxilia no posicionamento do paciente durante a entrega da dose;



- Adiciona os graus de liberdade rotacionais, comparado às mesas padrões

Mesa robótica – é necessária?

BJR

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FULL PAPER

Are pitch and roll compensations required in all pathologies? A data analysis of 2945 fractions

¹PIETRO MANCOSU, PhD, ¹GIACOMO REGGIORI, PhD, ¹ANNA GAUDINO, PhD, ¹FRANCESCA LOBEFALO, PhD,
¹LUCIA PAGANINI, MSc, ¹VALENTINA PALUMBO, MSc, ¹ANTONELLA STRAVATO, PhD, ¹STEFANO TOMATIS, PhD
and ²MARTA SCORSETTI, MD

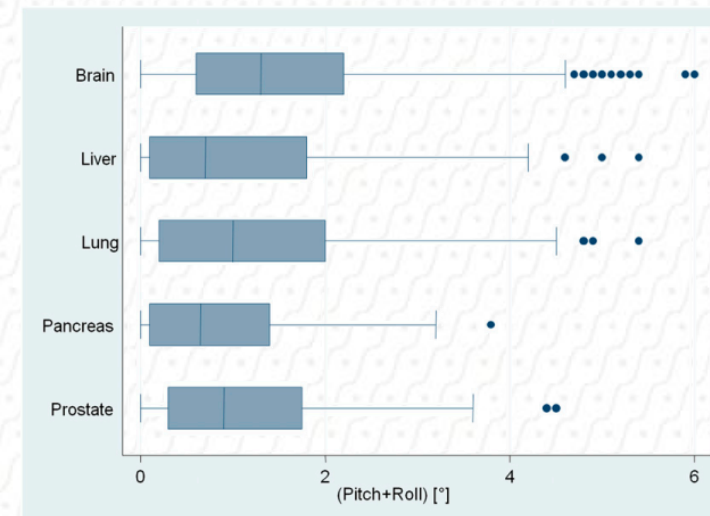
¹Physics Service of Radiation Oncology Department, Clinical and Research Center, Rozzano, Milan, Italy

²Radiation Oncology Department, Humanitas Clinical and Research Center, Rozzano, Milan, Italy

Address correspondence to: Dr Giacomo Reggiori

E-mail: giacomo.reggiori@humanitas.it

Figure 2. Box plot representation. The five organs are reported on the y-axis, whereas on the x-axis, the sum of the absolute values of pitch and roll rotations are shown. For each organ, the 75th and 25th percentiles are represented by the right and left edges of the “rectangular” box, while the central line is the median value. The data range and the outliers are reported, too.



Mesa robótica – impacto dosimétrico

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FULL PAPER

Dosimetric effects of roll rotational setup errors on lung stereotactic ablative radiotherapy using volumetric modulated arc therapy

^{1,2}JAEGI LEE, BS, ^{2,3,4,5}JUNG-IN KIM, PhD, ^{1,3}SUNG-JOON YE, PhD, ^{3,4,6}HAK JAE KIM, MD, ^{1,2}JOEL CARLSON, BS and ^{2,3,4,5}JONG MIN PARK, PhD

¹Program in Biomedical Radiation Sciences, Department of Transdisciplinary Studies, Seoul National University Graduate School of Convergence Science and Technology, Seoul, Korea

²Biomedical Research Institute, Seoul National University College of Medicine, Seoul, Korea

³Department of Radiation Oncology, Seoul National University Hospital, Seoul, Korea

⁴Institute of Radiation Medicine, Seoul National University Medical Research Center, Seoul, Korea

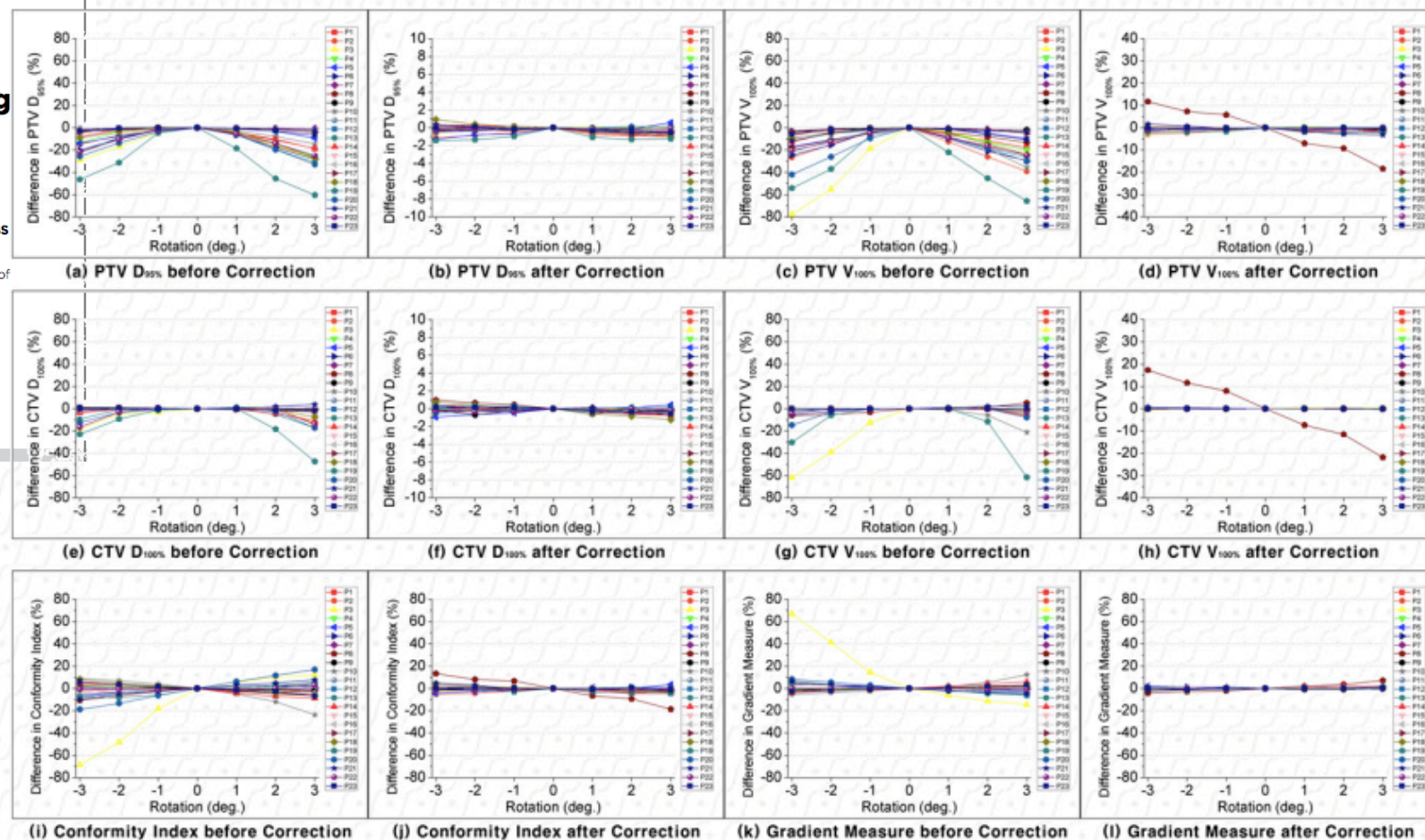
⁵Center for Convergence Research on Robotics, Advanced Institutes of Convergence Technology, Suwon, Korea

⁶Department of Radiation Oncology, Seoul National University College of Medicine, Seoul, Korea

Address correspondence to: Dr Jong Min Park

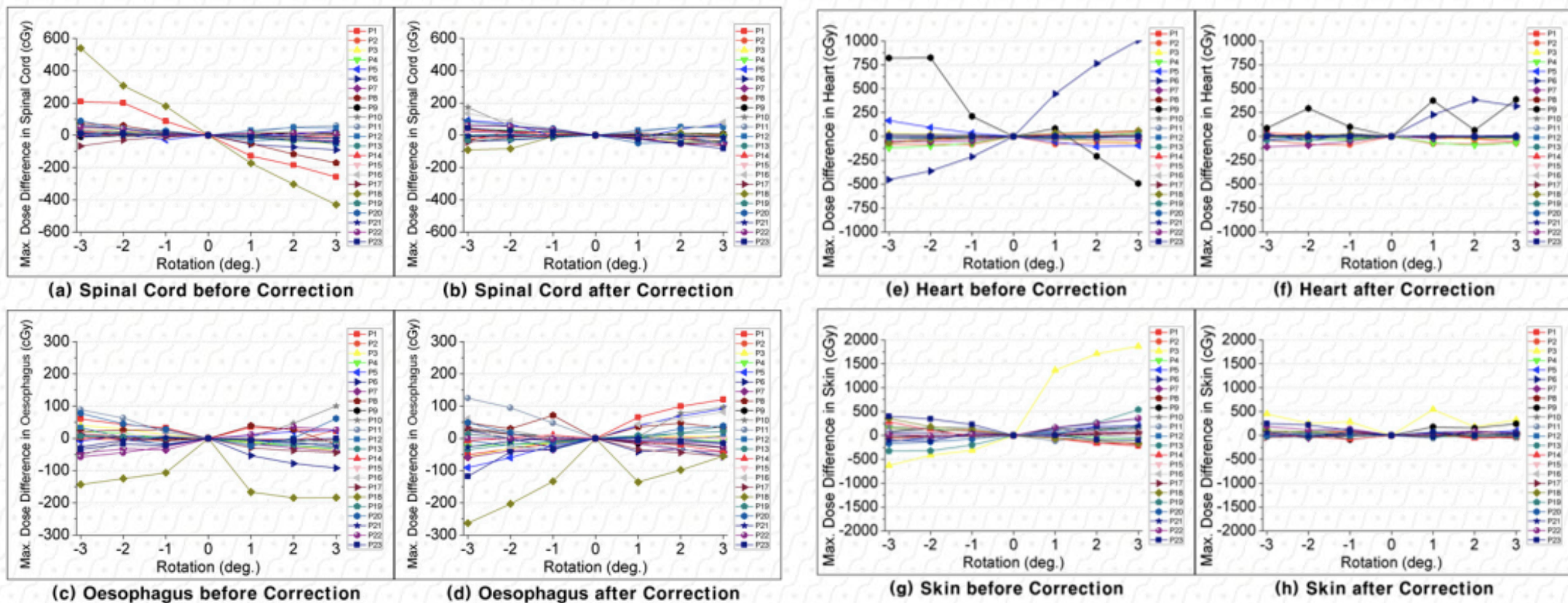
E-mail: leodavinci@naver.com

Figure 1. Changes in the dose received at least 95% volume ($D_{95\%}$) of planning target volume (PTV) (a), the volume received by 100% of prescription dose ($V_{100\%}$) of PTV (c), $D_{100\%}$ of clinical target volume (CTV) (e), CTV $V_{100\%}$ (g), conformity index (CI) (i) and gradient measure (GM) (k) by roll-rotational setup errors before translational corrections are shown. After translational corrections, changes in PTV $D_{95\%}$ (b), PTV $V_{100\%}$ (d), CTV $D_{100\%}$ (f), CTV $V_{100\%}$ (h), CI (j) and GM (l) are also shown.



Mesa robótica – impacto dosimétrico

Figure 2. Changes by roll-rotational setup errors in the maximum dose to the spinal cord (a), oesophagus (c), heart (e) and skin (g) before translational corrections are shown. After translational corrections, changes in the maximum dose to the spinal cord (b), oesophagus (d), heart (f) and skin (h) are also shown.



Mesa robótica – limitações

- Mesa robótica realiza transformações rígidas
 - Se necessário deformação, reposicionar.
 - Acessórios indexados, em geral, garantem boa reprodutibilidade na região torácica;
 - Cuidado com braços, mamas volumosas
- Grandes rotações aplicadas– probabilidade de deslize / possibilidade de compensação de movimento pelo paciente
 - Melhorar posicionamento para reduzir rotações
- Peso máximo permitido é, em geral, inferior ao da mesa padrão

Mesa robótica – QA



Rotação na
posição
“home”

Rotações
conhecidas

Translações
conhecidas

Teste com
carga

Considerações finais

- Gating e mesa robótica são tecnologias que agregam no aumento da acurácia, sendo especialmente importantes para casos hipofracionados, como os de SBRT de pulmão;
- É necessário discutir sobre as limitações;
 - Nem sempre falar sobre limitações é algo negativo – oportunidade de discutir a necessidade de margens e/ou possibilidade de redução
- O cálculo de margens (e sua redução) não pode ser definido arbitrariamente:
 - Considere a especificidade de sua instituição, dos recursos disponíveis e de cada paciente



Obrigada!

VILA NOVA $\star$ STAR
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