Introduction of an EEBH workflow using AlignRT for Liver SBRT

Presented by Bec Giardina

Thank you to: **Megan McDonald,** Dr Vanessa Panettieri, Cherie Evans, Catherine Russell, A/Prof Sashendra Senthi, A/Prof Jeremy Ruben

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Disclosures

Alfred Health is an Australasian Reference Site for VisionRT. Travel relating to this event has been reimbursed by VisionRT.

Acknowledgement of Country

I would like to respectfully acknowledge the Traditional Owners of the land on which we meet today, the Wurundjeri Woi-Wurrung and Boon Wurrung people of the Kulin Nation, and pay my respects to Elders past and present.

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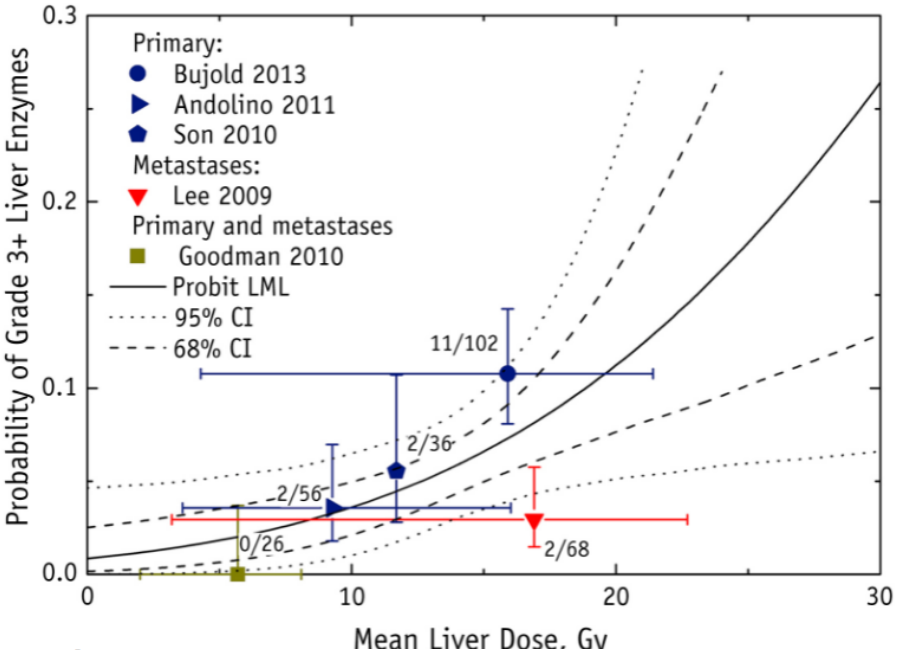
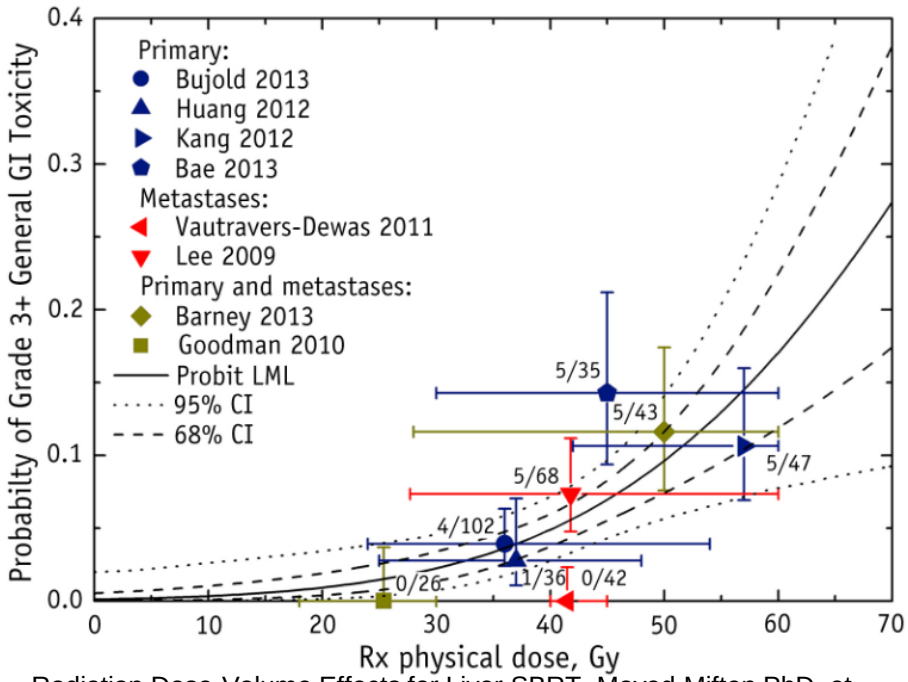
SBRT for liver

- SBRT is used widely for primary liver cancer and liver metastases as an effective treatment for local control
- Drawbacks- Limited by Liver and OAR toxicities and artifact





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Radiation Dose-Volume Effects for Liver SBRT Moyed Miften PhD, et al.International Journal of Radiation Oncology, Biology, Physics, 2021-05-01, Volume 110, Issue 1, Pages 196-205

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Background

- **Liver tumours are highly susceptible to respiratory-induced motion with reports of movement in the range of 5 to 50mm cranio-caudally during free breathing***

***Eccles C, et.al. Reproducibility of liver position using active breathing coordinator for liver cancer radiotherapy. *Int J Radiat Oncol Biol Phys.* 2006**

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Motion management for liver around the world

Elekta ABC system (spirometer device)
(Photo courtesy of Elekta Oncology, Crawley, UK website)

BodyFIX® system
(Photo courtesy of Elekta Oncology, Crawley, UK website)

Varian RPM System
(Photo courtesy of Varian website).

Other systems include;

- **Abdominal compression belts**
- **Calypso marker/beacons**
- **Phillips bellows system**
- **Gating and breath hold**
- **KIM (Kilovoltage intrafraction monitoring) using fiducials**
- **Use of ITVs with 4DCT (Experience at ARO)**

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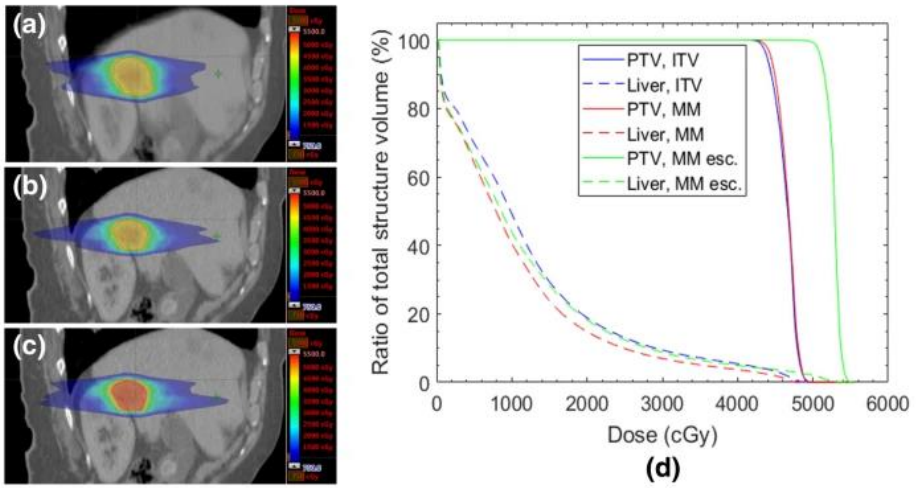
Alfred experience – previous liver SABR using 4DCT

Diagnosis	Fractionation	Range of liver dome sup/inf motion on 4DCT
Colon met	35/5 @ 80%	2cm
Melanoma met	45/3 @ 80%	1.6cm
Colon met	47.5/3 @ 80%	1.3cm
Pancreas met	45/5 @ 80%	2.3cm
Rectal met	50/5 @ 80%	2.3cm
Colon met	50/5 @ 80%	1.4cm
Cholangiocarcinoma	50/10 @ 80%	1.3cm
Haemangioendothelioma	60/8 @ 80%	0.7cm
Colorectal met	54/3 @ 80%	2.5cm
Melanoma met	60/8 @ 80%	2.2cm

Why Breath Hold?

Fig. 6



Part (**a**) shows the dose distribution to a lesion planned using the ITV method. Part (**b**) shows the re-plan using the motion managed PTV, at the same prescription level as in (**a**). Part (**c**) shows the escalation of dose, from 42.5 Gy to 50 Gy (78.6 Gy_{10} to 100 Gy_{10}), whilst adhering to OAR dose tolerances. Part (**d**) is a DVH demonstating PTV coverage (solid lines) for the three cases shown in (**a**) – (**c**), as well as liver dose (broken lines). ITV – ITV-based, MM – motion managed, MM esc – dose escalated motion management

- **Reduces size of PTV**
- **Reduces dose to OARs**
- **Enables dose escalation for SBRT**
- **Immobilises target anatomy**
- **Improves image quality for target delineation and CBCT**
- **Can treat patient's who would otherwise have been unsuitable for SBRT due to normal tissue toxicity**

***Gargett et al. (**5 - Gargett, M., Haddad, C., Kneebone, A. *et al.* Clinical impact of removing respiratory motion during liver SABR. *Radiat Oncol* 14, 93 (2019).

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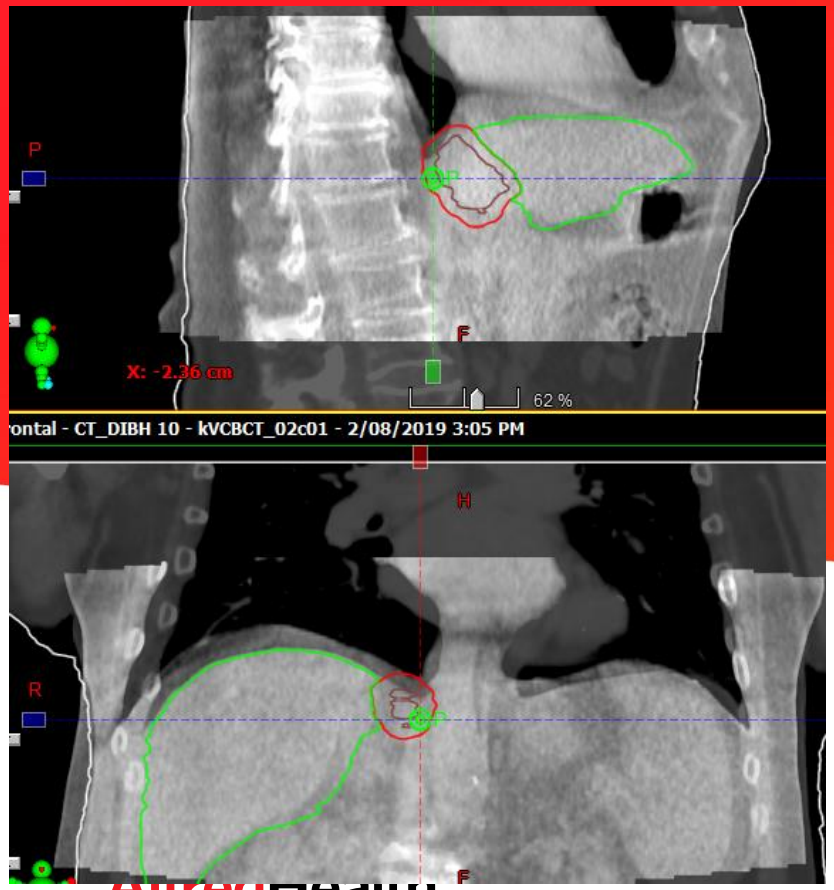
Why not DIBH?

Liver treatment needs to have different considerations than lung, due to the range of motions generally found and the position of the tumour. 3

3 Keall PJ, et al. The management of respiratory motion in radiation oncology report of AAPM Task Group 76. *Med Phys* (2006)



- **Inconsistent liver dome position**
- **Worldwide EEBH for liver more common experience than DIBH**
- **EEBH widely accepted as more reproducible & representative of liver motion in free breathe (more time spent in exhalation)***

***Mihai, Al. et. al. "SBRT for Oligometastatic Disease." Stereotactic Radiosurgery and Stereotactic Body Radiation Therapy (SBRT) (2018)**

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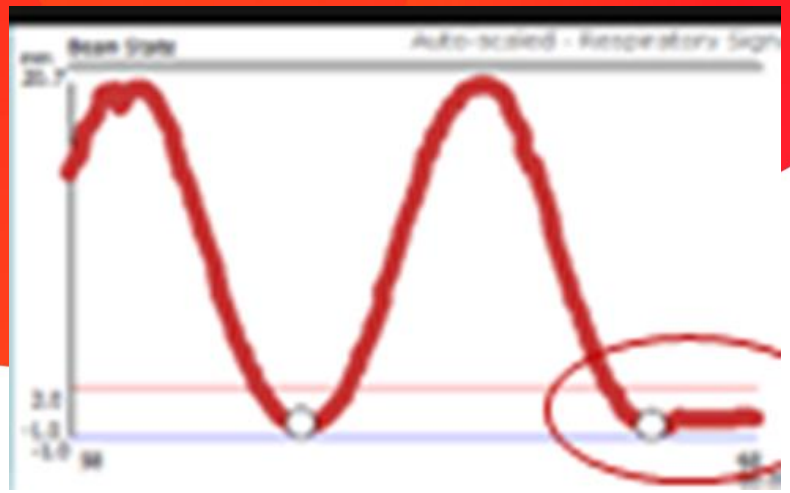
What is EEBH?

- End Expiration Breath Hold
- People in relaxed, free breathing spend more time in expiration than inspiration
- Reproducible and representative of the liver's most common position during free breathing
- Not a deep breath out, just a natural end point



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EEBH alternatives

- Literature review
- Site visit to PeterMac
- Could we develop an EEBH workflow using A/RT rather than Varian RPM?

Adapting an EEBH workflow to our department

OBJECTIVES

- **To develop an EEBH workflow using AlignRT.**
- **To determine whether liver motion can be reduced during EEBH.**
- **To determine whether radiographic liver dome position in EEBH correlates with surface anatomy.**

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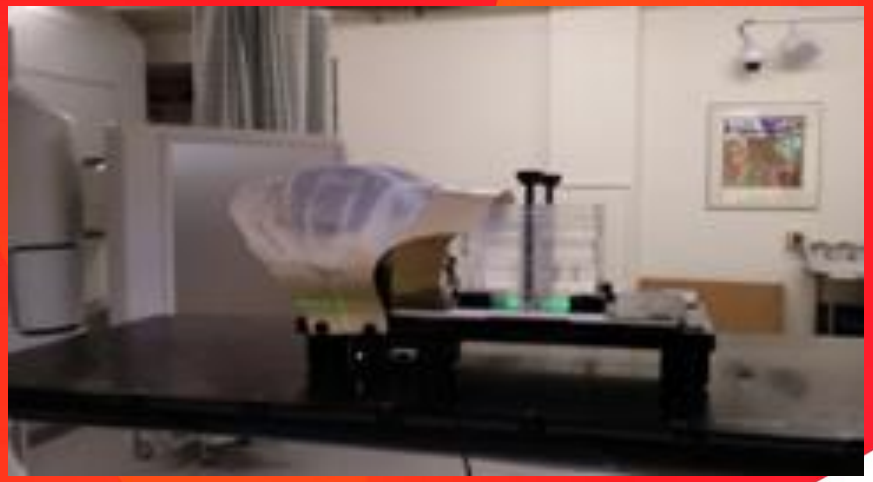
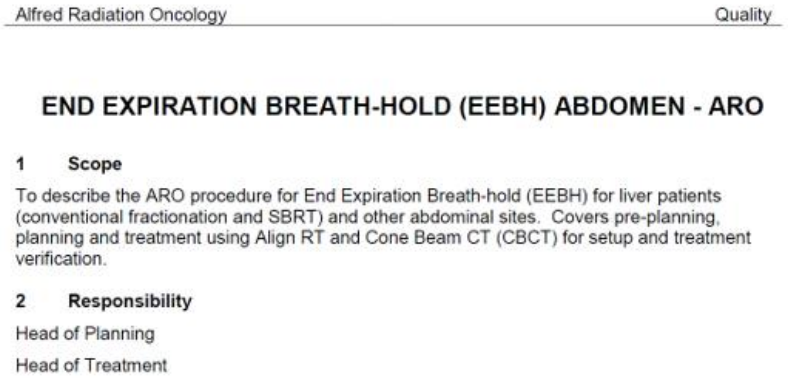
Adapting an EEBH workflow to our department

METHODS

- Implementation of new technique signoff from multidisciplinary team
- Testing and development of technique using A/RT and breathing phantom in CT and on Linacs
- Physics sign off on use of fluoroscopy.
- End to end tests
- Procedural documentation written





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END EXPIRATION BREATH-HOLD (EEBH) ABDOMEN - ARO

1 Scope

To describe the ARO procedure for End Expiration Breath-hold (EEBH) for liver patients (conventional fractionation and SBRT) and other abdominal sites. Covers pre-planning, planning and treatment using Align RT and Cone Beam CT (CBCT) for setup and treatment verification.

2 Responsibility

Head of Planning

Head of Treatment

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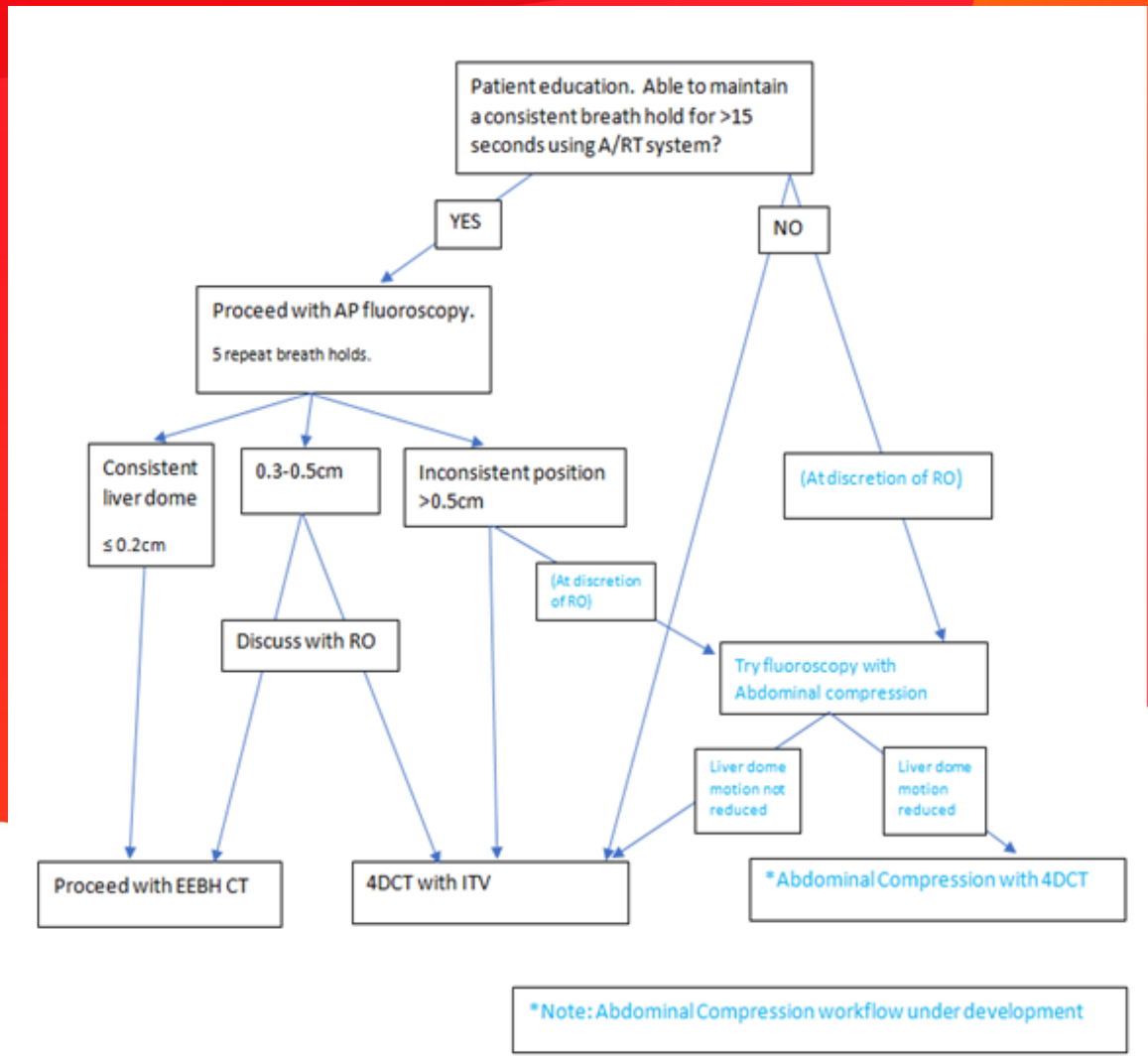
Workflow

Abdominal compression belt for shallow breathing



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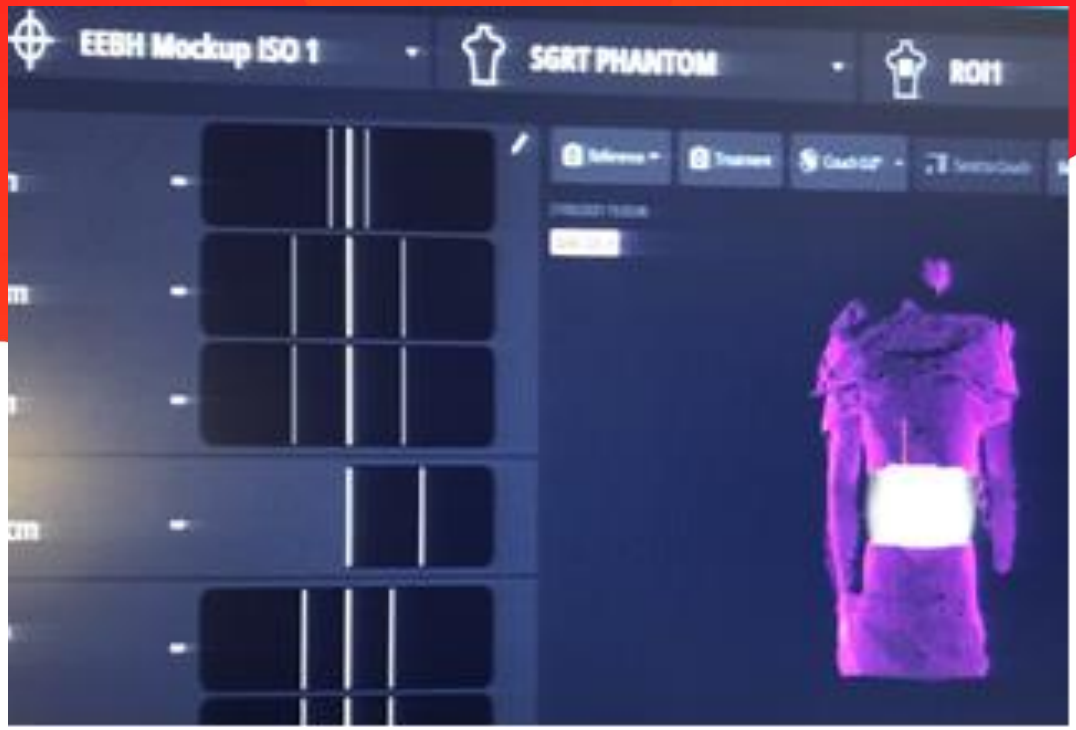
Mockup session

- Evaluate the movement of the liver dome/fiducial marker.
- Assess whether the patient can maintain repeated expiration breath holds.
- Assess whether the external SGRT surface correlates to reproducible internal anatomy, i.e. the liver dome.
- Assess whether the AlignRT signal is maintained as the gantry moves around the patient.



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Mockup Session Preparation

- Patient exclusion criteria
  - Difficulty understanding instructions & retaining informa
    dementia, poor grasp of English
- Inconsistent or difficult breathing: emphysema
- Mobility issues: inability to lie flat or need hovermatt transfer

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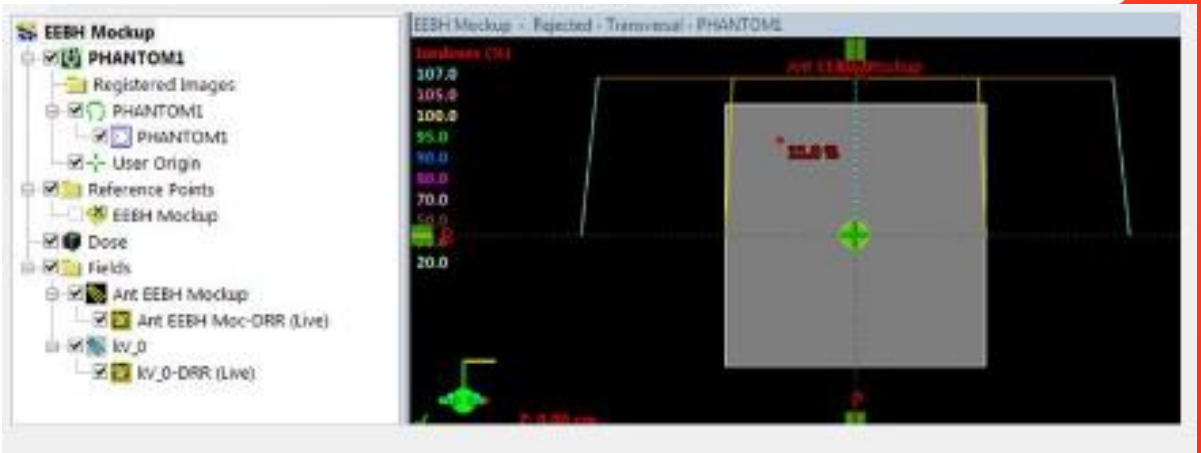
Mockup Session Preparation

- AlignRT requires a basic plan setup with imaging fields. This is created before the patient attends for the mockup session
- Requires a phantom plan to allow staff to mode up the patient on the treatment unit and capture the reference image



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Mockup Session – on the day

- Educate the patient about maintaining breath at end expiration
- Make the vacbag; arms down
- Document setup details for CT
- Mockup setup ISO

- ½ AP, TOX level & 3cm R of ML

Patient Setup	Vacfix on Reversed wingboard with A sponge @ c sponge HE sup @ H3 Arms by side A@F2, WKF FF A20
Setup Iso @ mockup	RL – 1cm L of SN, MS-Mid umb Setup iso = 3cm R of RL @ TOX @ ½ AP

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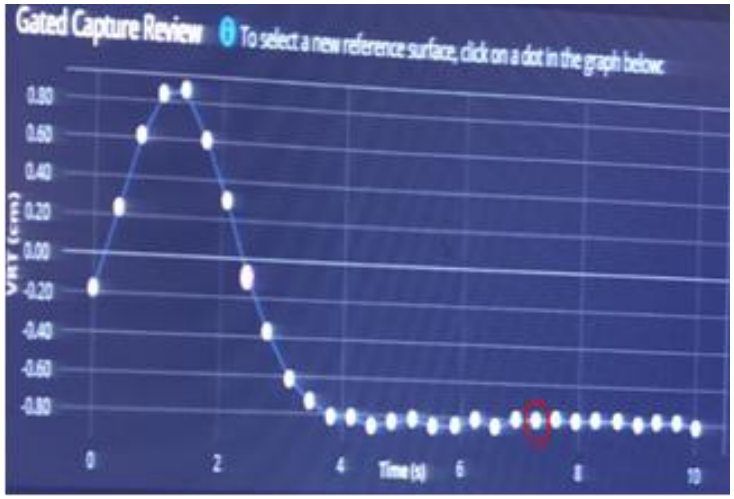
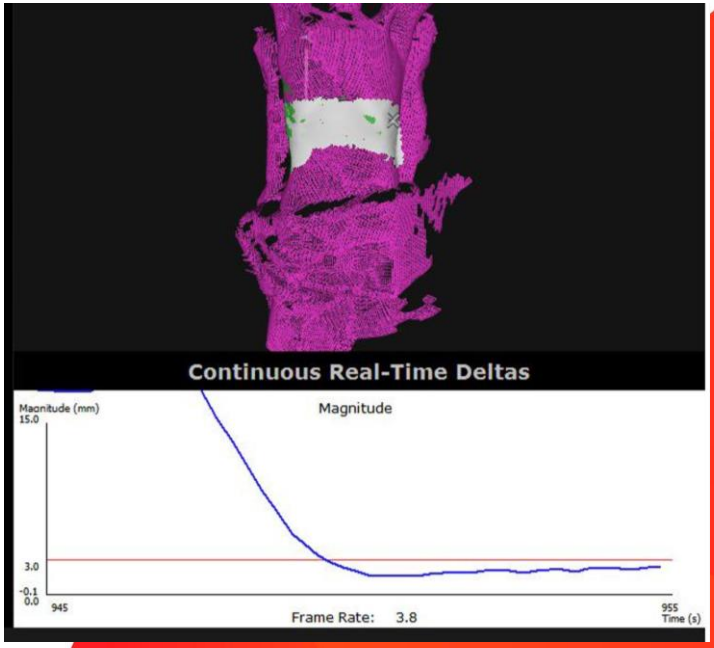
Mockup session

- Gated image taken and expiration point chosen
- Ensure patient is comfortable – breathe in/breathe out and hold
- Abdominal muscles relaxed
- Magnitude window used to assess the curve
- Visual coaching device used for the patients





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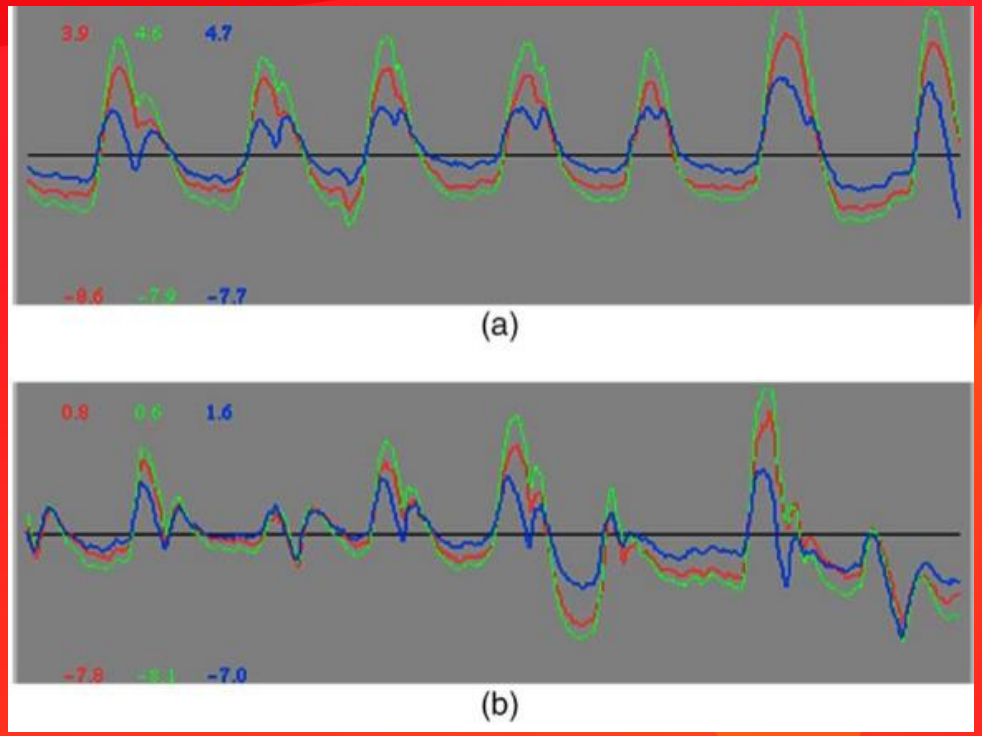
Importance of coaching and relaxing



Variations in respiratory patterns from the same patient taken a few minutes apart. The three curves in each plot correspond to infra-red 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*

*** Keall PJ, et al. The management of respiratory motion in radiation oncology report of AAPM Task Group 76. *Med Phys* (2006)**

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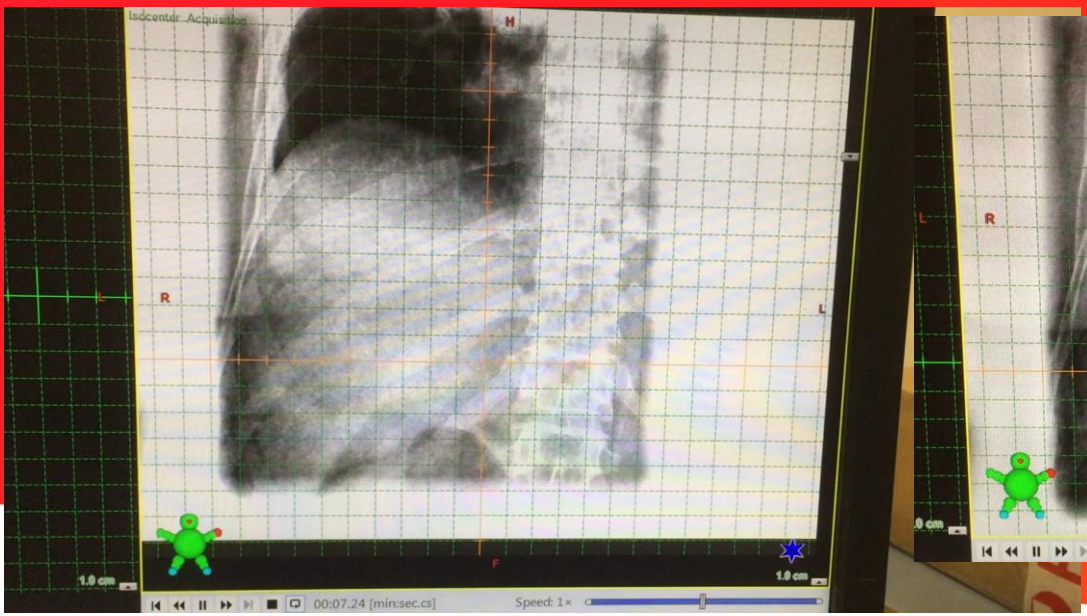
Fluoroscopy session

Free-breathe



Breath hold

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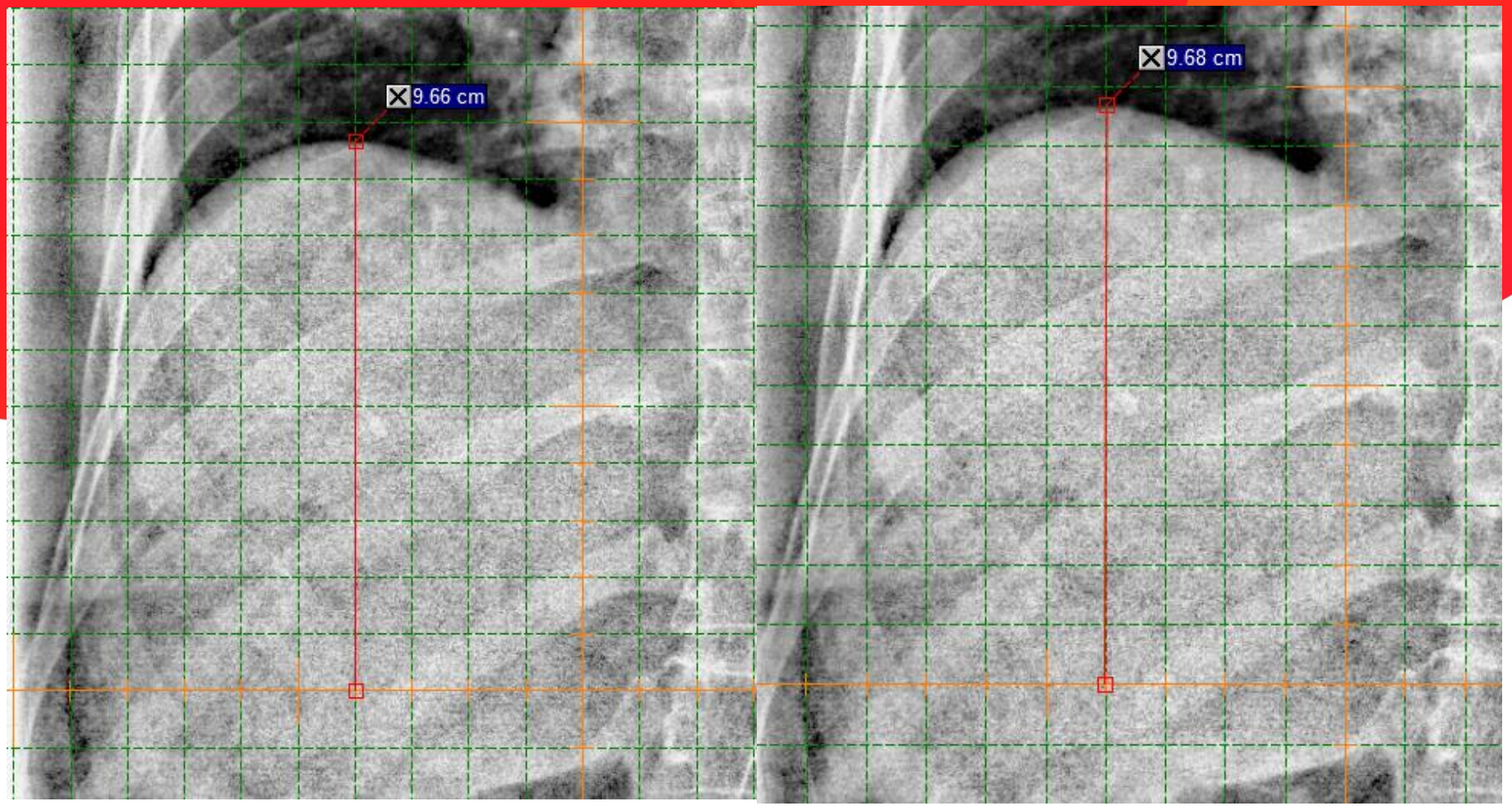
Fluoroscopy

5 x breath holds taken and reviewed for consistency



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Mockup session

Patient Setup	Vacfix on Reversed wingboard with A sponge @ c sponge HE sup @ H3 Arms by side A@F2, WKF FF A20
Setup Iso @ mockup	RL – 1cm L of SN, MS-Mid umb Setup iso = 3cm R of RL @ TOX @ ½ AP
Free Breathing Liver motion range (sup/inf) <0.5cm not a candidate for EEBH => 4DCT	5cm across 2.1cm
Visual Aid?	no
Variation to Align RT threshold?	
Breathing Instructions:	Breath out and hold
Flouroscopy Assessment – Sup/Inf Variation	
Distance from superior extent of liver to graticule (straight measurement sup/inf - cm)	
Distance from Clip to superior extent of liver – if applicable (straight measurement sup/inf - cm)	

Double click on table to access and enter Fluoroscopy values

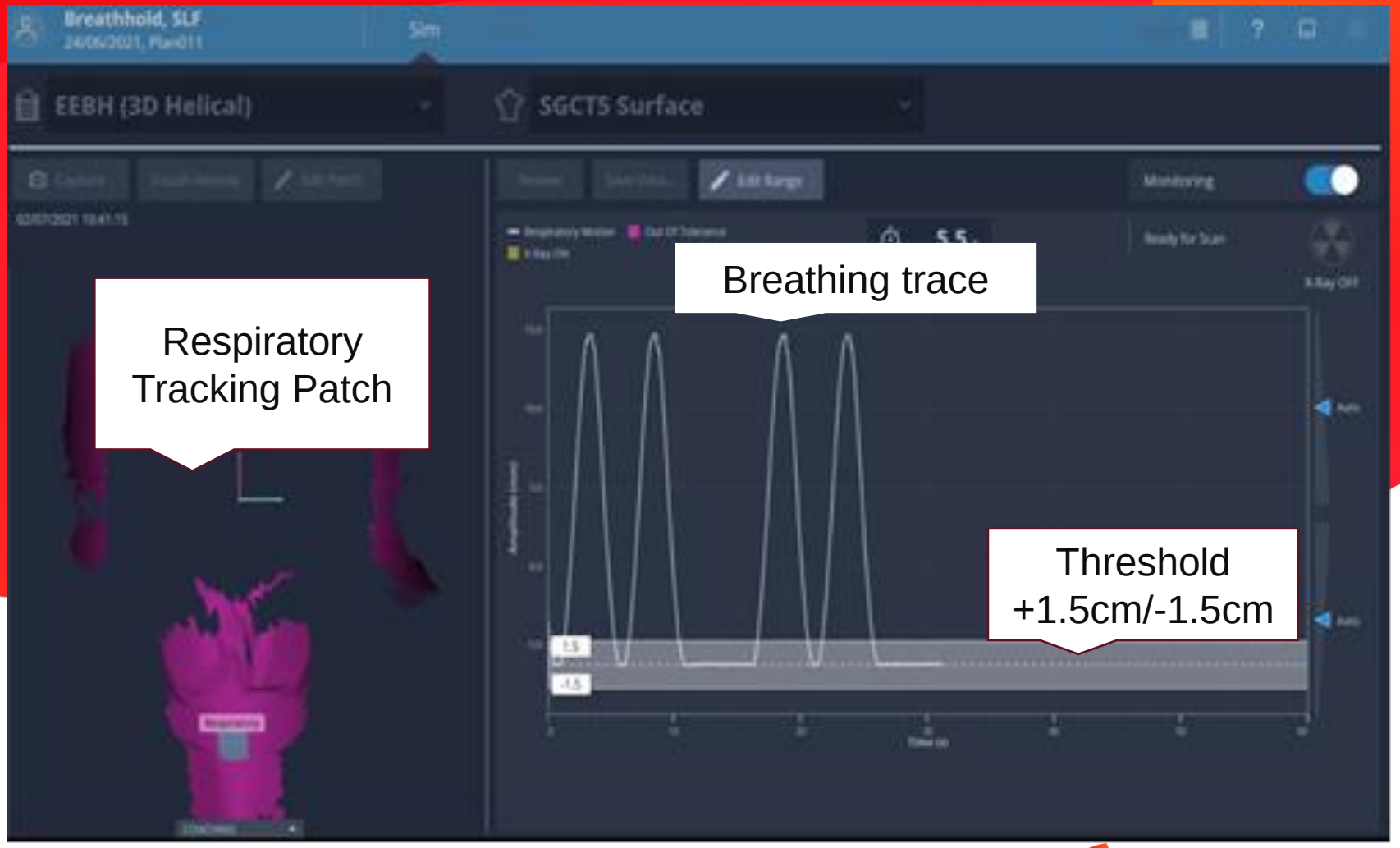
	sup/inf(cm)	Clip/Dome(cm)	Setup Session Decision	Setup Session Decision
Fluoro 1	7.2			
Fluoro 2	7.2			Proceed to EEBH CT
Fluoro 3	7.2			
Fluoro 4	7.5			
Fluoro 5	7.2			
Range	**0.3**	**0.0**		

EEBH candidate?	yes.
PTV Margin?	Consideration for sup/inf?

If sup/inf. variation of the liver position during breath holds is:

≤ 0.2cm	Patient is suitable for EEBH
0.3-0.5cm	Discuss the value of EEBH, the impact on PTV margin and patient suitability with RO ➢ proceed with either EEBH CT protocol or free breath 4DCT.
>0.5cm	Proceed with 4DCT in free breathing and no EEBH.
	(Possibility to trial abdominal compression belt for free breath 4DCT ➢ for discussion with RO and HOP/HOT).

CT using SimRT



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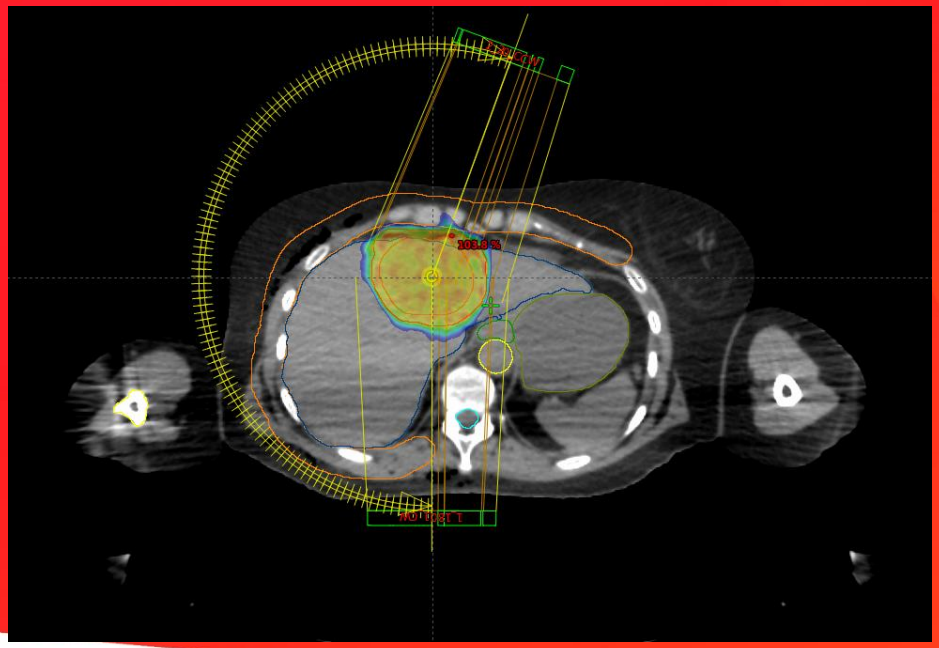
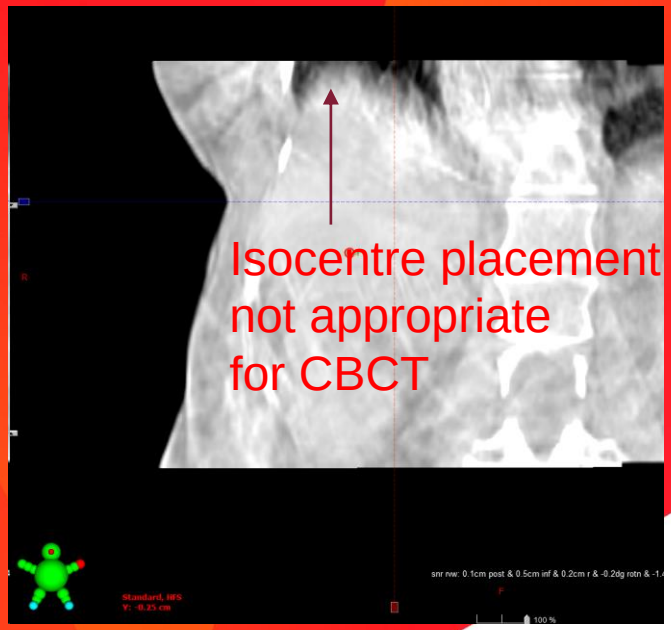
Planning considerations





- VMAT FFF
- SABR
- 80% px
- COMET OAR guidelines

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Treatment – Align RT

IMAGE 5: FB Setup ROI

IMAGE 6: EEBH ROI

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Treatment workflow

- Setup to the FB reference image
- Flick to the BH reference image
- Ask patient to breathe in, breathe out and hold

- Pre-treatment verification imaging performed in BH. AlignRT is not interlocked with imaging

- Shifts applied whilst patient in BH and a new capture is taken

- Imaging repeated to confirm new capture

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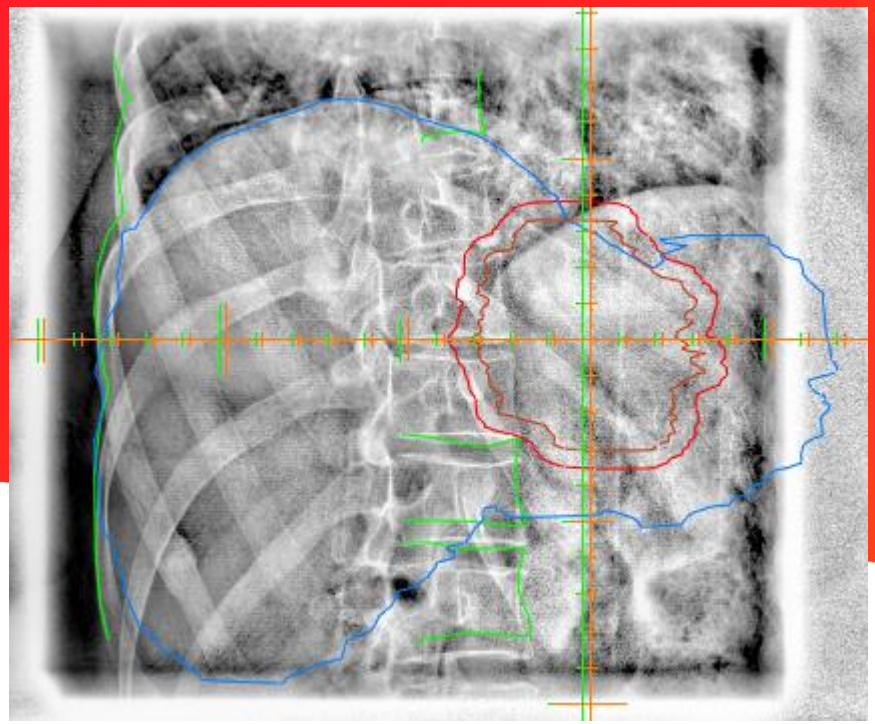
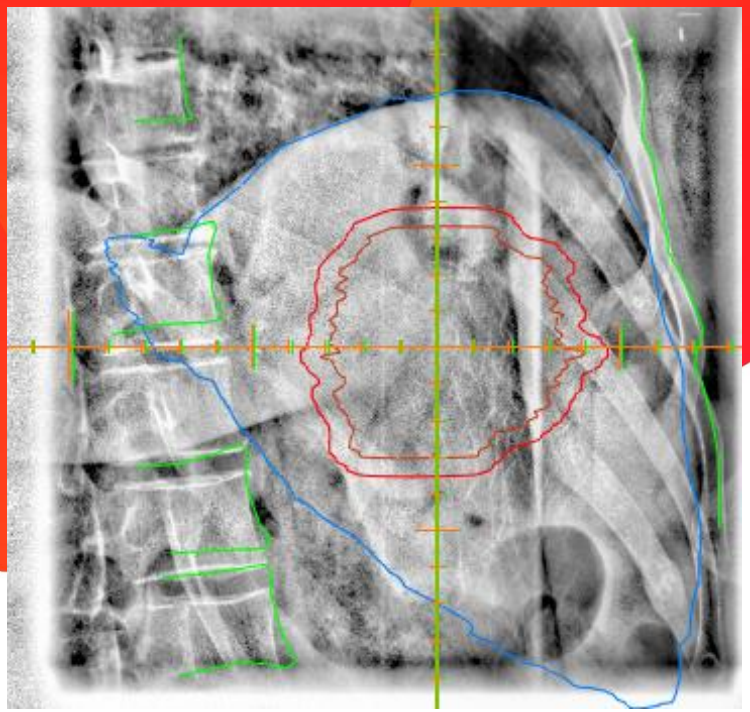
Treatment





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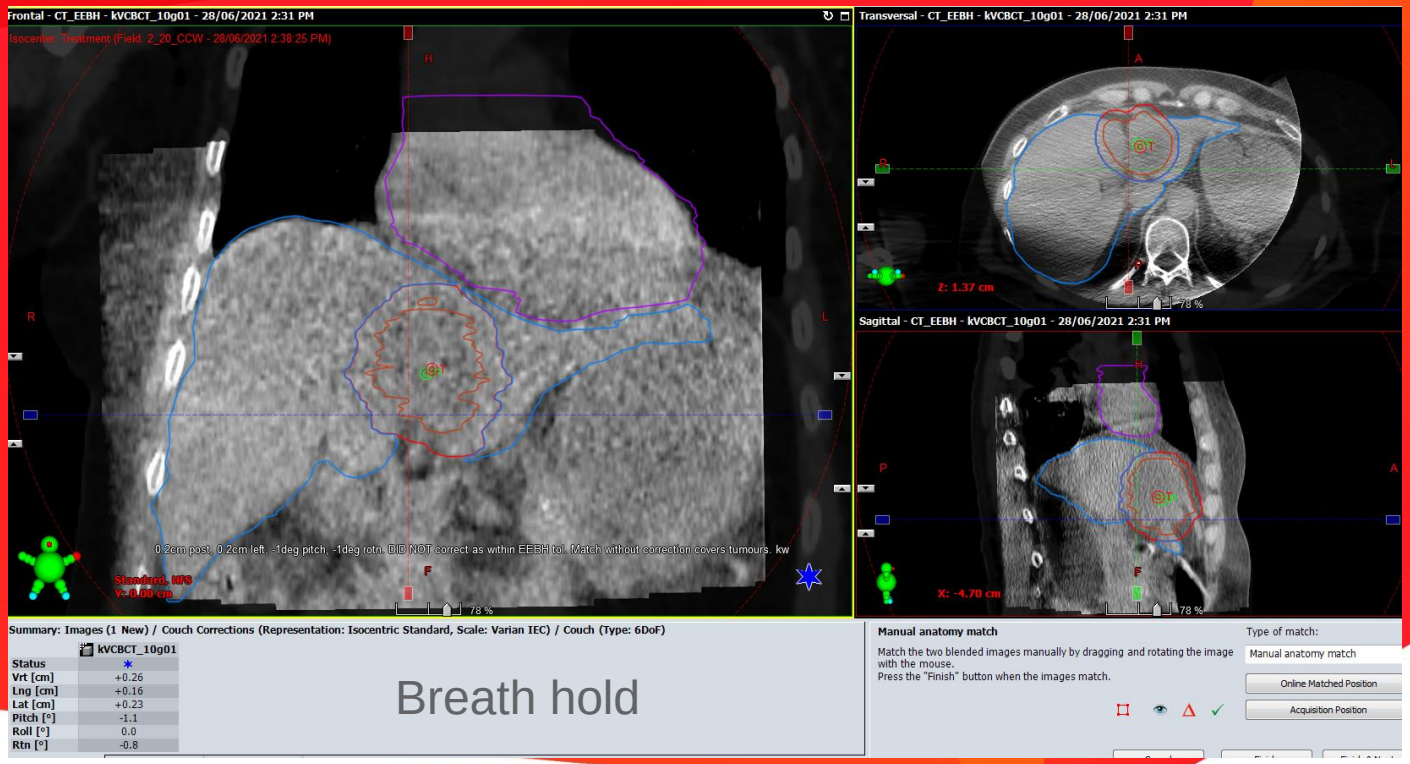
Treatment



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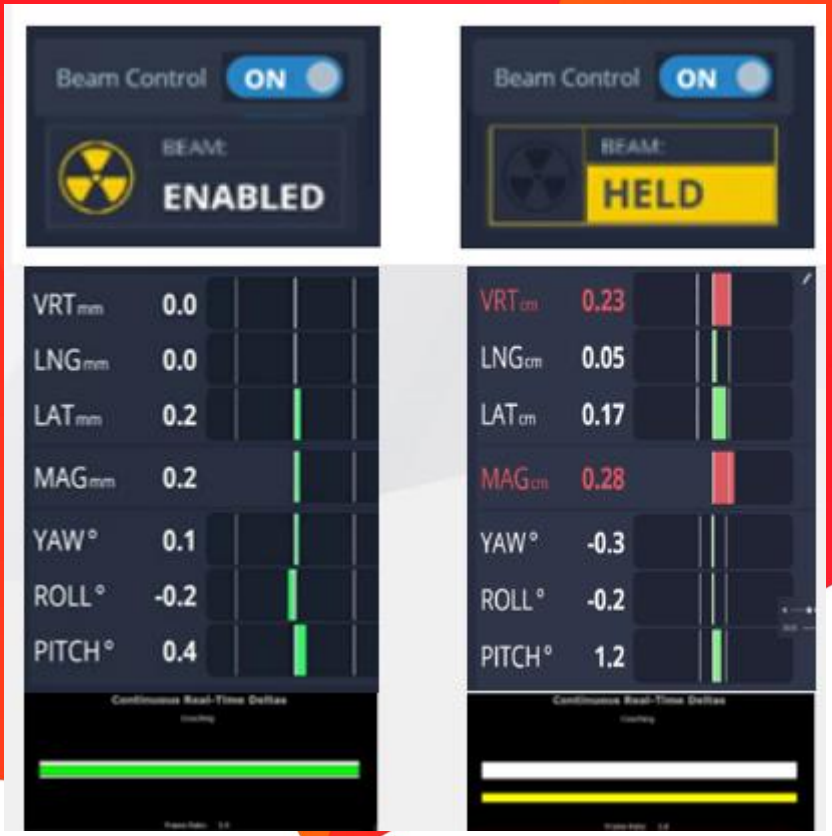
Treatment

- Treatment beam is interlocked
- Repeat any imaging if drifting out of tolerance
- Depending on length of arc or MU multiple breaths maybe needed
- Can set beam hold delay 1 or 2 sec out of tolerance



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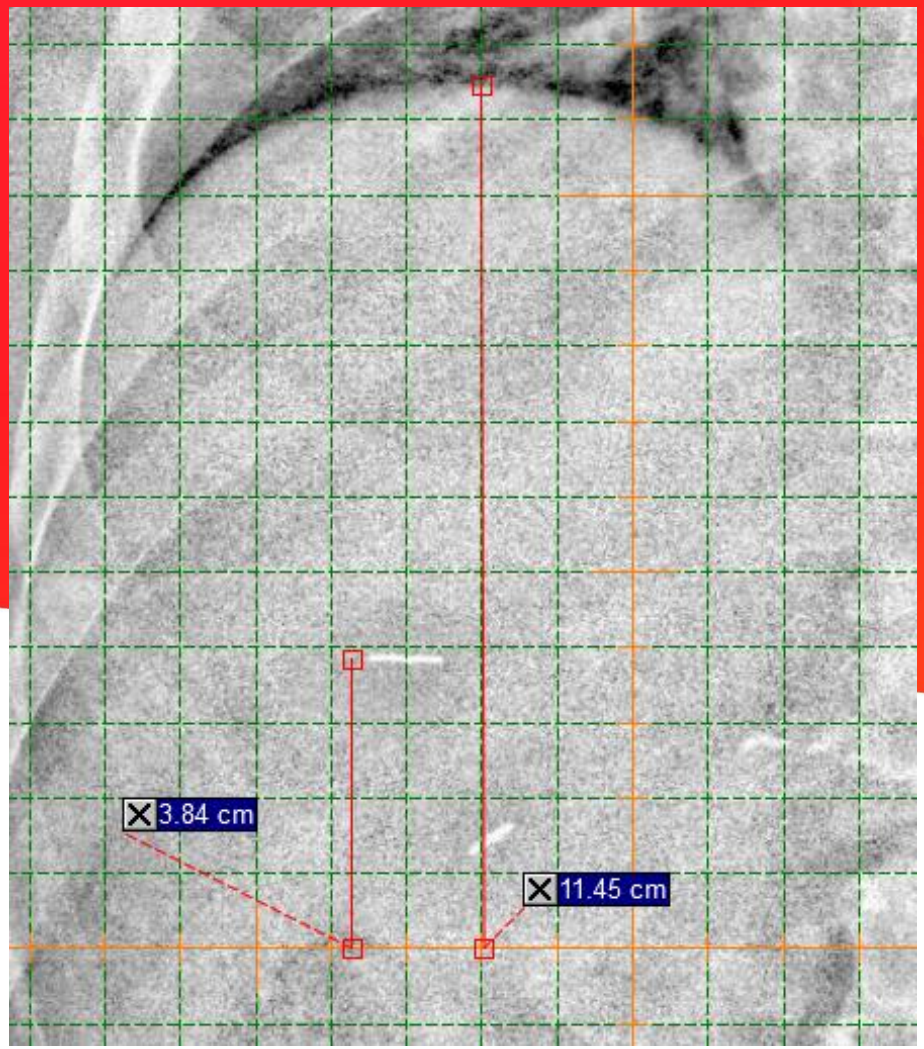
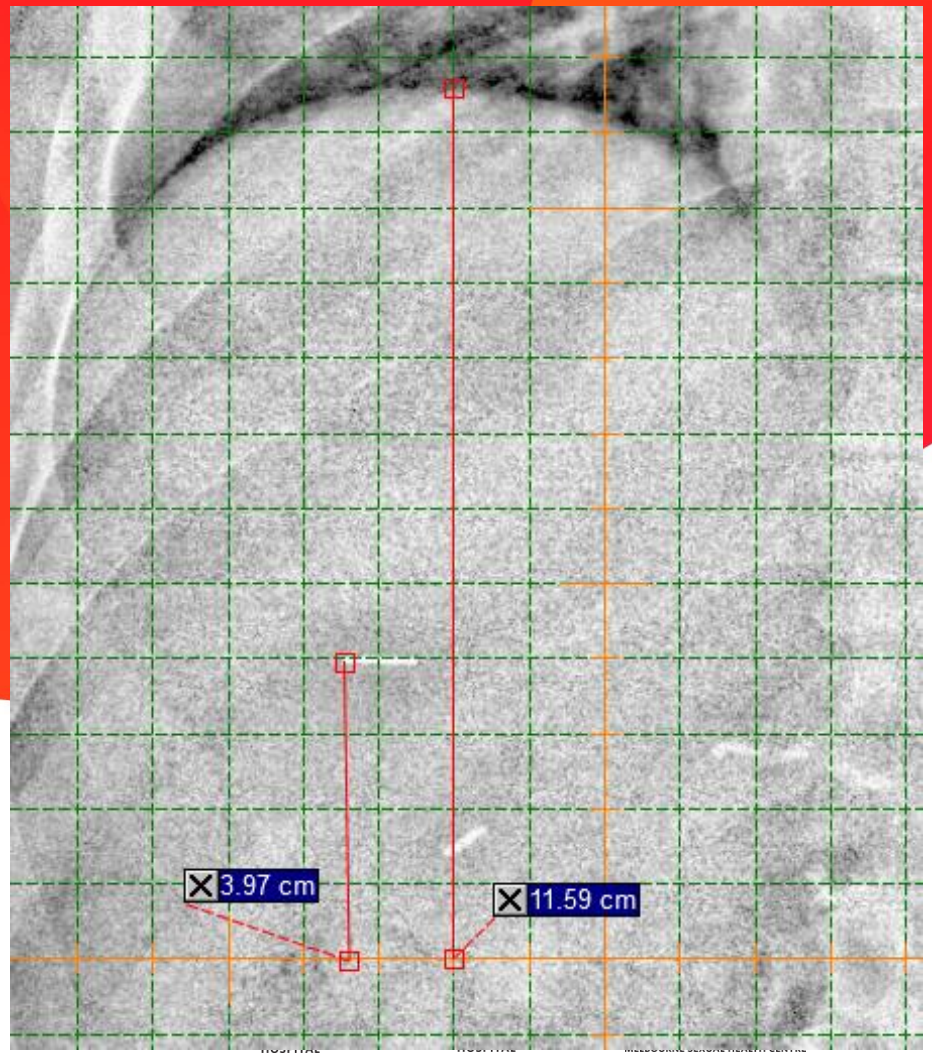
Patient 1

- 57 yo Female
- Metastatic ca. Breast
- Previous RT to R Breast (2006) & SBRT R Lung 50.4Gy/12fxs (2018) and subsequent pneumonitis
- Solitary metastases in liver
- RO requested breath-hold due to high toxicity and risk of exceeding OAR tolerance of duodenum (50.4Gy/12fxs)

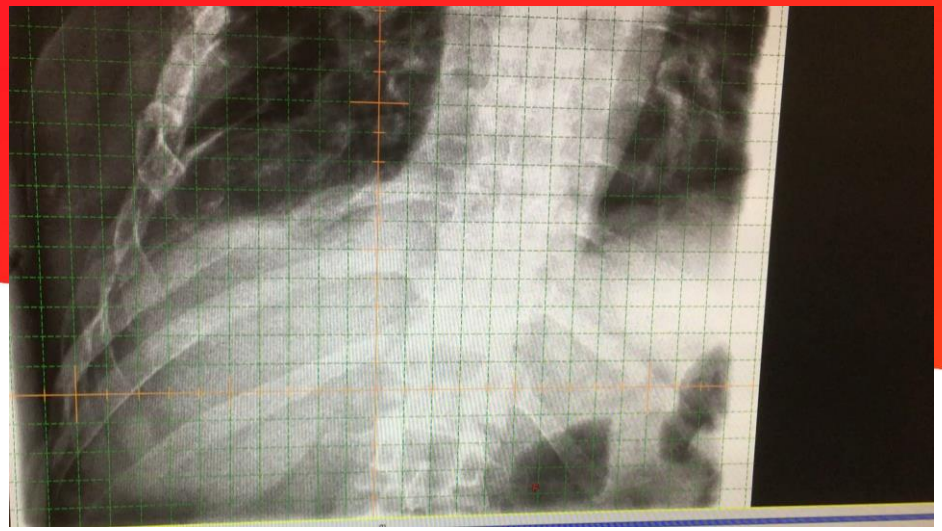
Patient 2





Patient 3

- 71yo Male
- Mesothelioma patient
- Lungs damaged and R lung not functional
- Good lesson in patient selection



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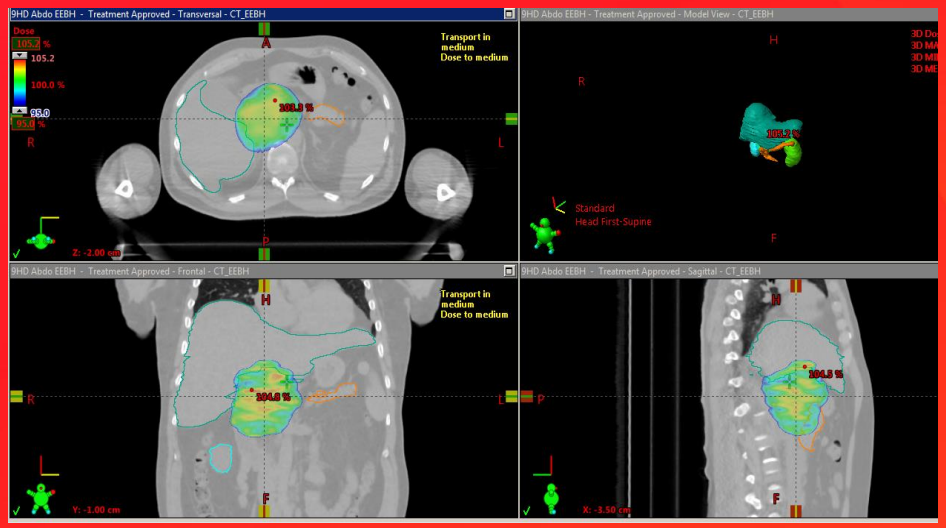
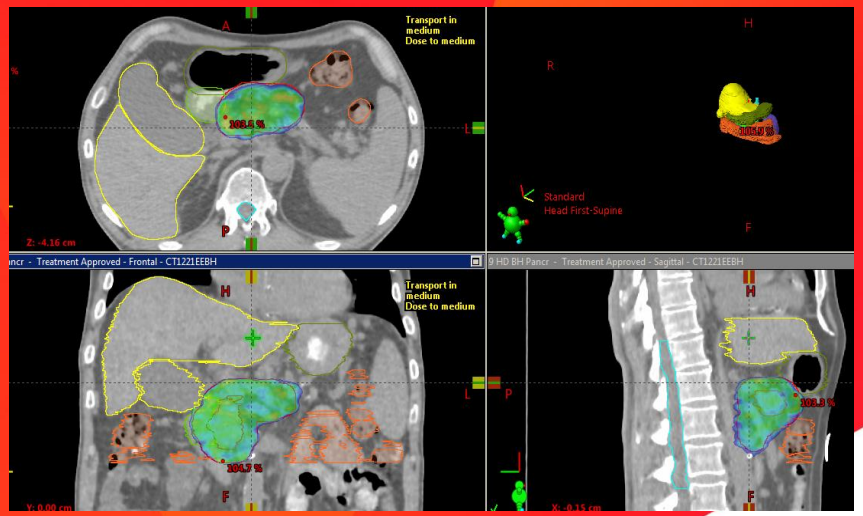
Other Abdominal Sites



Porto-caval lymph node



Pancreas

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Summary

- **The first patient completed their EEBH treatment at the Alfred in July 2021. PTV volume was reduced by 22.1% using EEBH**
- **In suitable patients, Align RT can be used to deliver SBRT in EEBH.**
- **Reduced liver motion allows a smaller PTV size to be treated with less toxicity to the liver.**

Summary

- Since our implantation a few years ago, we have successfully used EEBH for other abdominal sites, Kidney, pancreas
- There are limitations of the Fluoroscopy to assess motion for sites such as Left kidney and its unpredictability with its motion to the diaphragm
- We have tightened up our eligibility criteria, i.e. to do a better assessment prior to the session and exclude them if they have any contra-indications. i.e. mobility issues, difficulty breathing, difficulty understanding instructions, etc
- A high number of patients treated and the rate of success of BH vs 4DCT for our patient cohort

Future Directions

- As technology advances, potential to do breath-hold in conjunction with gating software or real time tracking
- Prospective data collection
- Continue to collaborate with local centers
- Develop free-breathing gating protocol with SGRT for patients that can't achieve breath-hold and for patient's where consistency isn't certain. i.e. L kidney.

Thankyou

- **Alfred colleagues – A/Prof Sasha Senthi, A/Prof Jeremy Ruben, Cherie Evans, Catherine Russell, Megan McDonald**
- **Dr Vanessa Panietteri, Department of physics, PMCC**
- **Sue McKenna – Clinical Applications Regional Manager, VisionRT**
- **The VisionRT and SGRT Community**

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References

1 - Eccles C, Brock KK, Bissonnette J-P, Hawkins M, Dawson LA. Reproducibility of liver position using active breathing coordinator for liver cancer radiotherapy. *Int J Radiat Oncol Biol Phys.* 2006; 64: 751–9.

2 - Case RB, Sonke J-J, Moseley DJ, Kim J, Brock KK, Dawson LA. Inter- and Intrafraction Variability in Liver Position in Non–Breath-Hold Stereotactic Body Radiotherapy. *Int J Radiat Oncol Biol Phys.* 2009; 75: 302– 8.

3 - Keall PJ, Mageras GS, Balter JM, Emery RS, Forster KM, Jiang SB, et al. The management of respiratory motion in radiation oncology report of AAPM Task Group 76. *Med Phys* (2006) 33:3874–90010.1118/1.2349696

4 - Radiation Dose-Volume Effects for Liver SBRT Moyed Miften PhD, et al.International Journal of Radiation Oncology, Biology, Physics, 2021-05-01, Volume 110, Issue 1, Pages 196-205

5 - Gargett, M., Haddad, C., Kneebone, A. *et al.* Clinical impact of removing respiratory motion during liver SABR. *Radiat Oncol* 14, 93 (2019). https://doi.org/10.1186/s13014-019-1300-6

6 - Mihai, Alina, and Michael T. Milano. "SBRT for Oligometastatic Disease." Stereotactic Radiosurgery and Stereotactic Body Radiation Therapy (SBRT) (2018): 293.

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