Cryoablation in RUMC

Applications and challenges in the clinic

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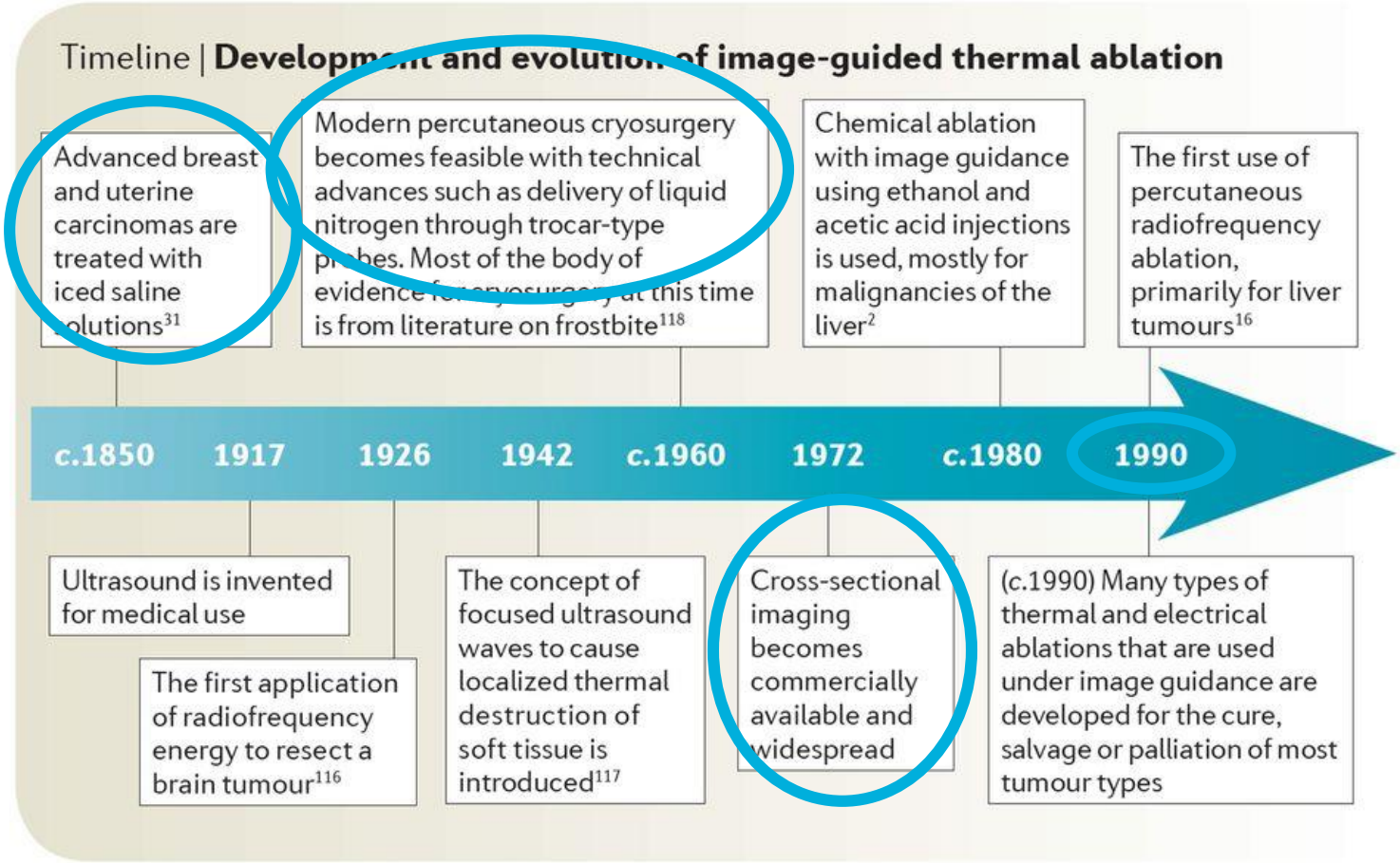
Radboudumc

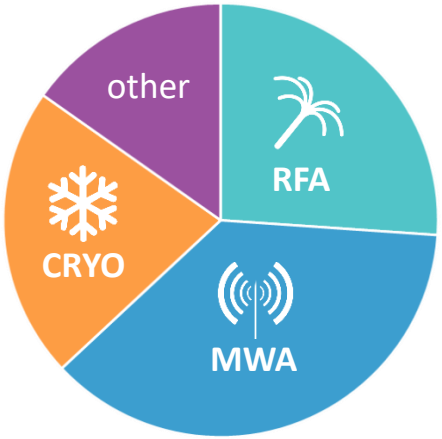
Tumor ablation



Chu et al. Nat. Rev. Cancer 2014

Tumor ablation

- Minimally invasive alternative to surgery
  - Fast, easy to learn
  - Well-tolerated, safe
  - Effective (< 5cm lesions)
- Growing indications, no. of procedures
- Different ablation types
  - Heat-based
  - Cold-based
  - Non-thermal

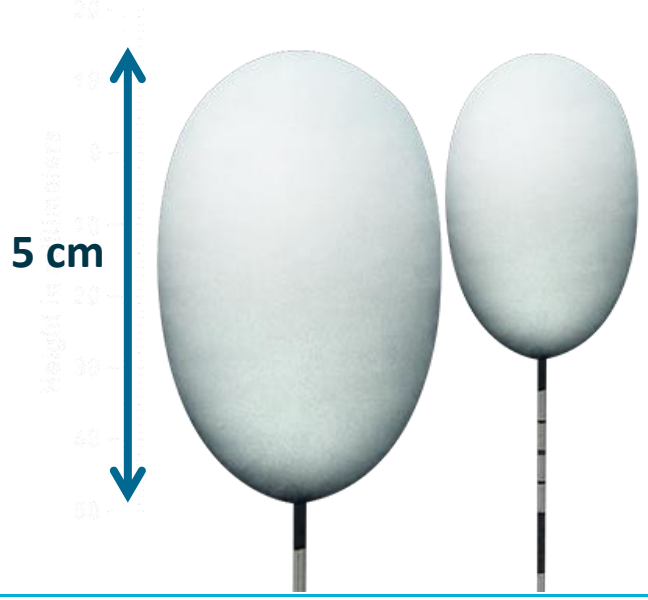


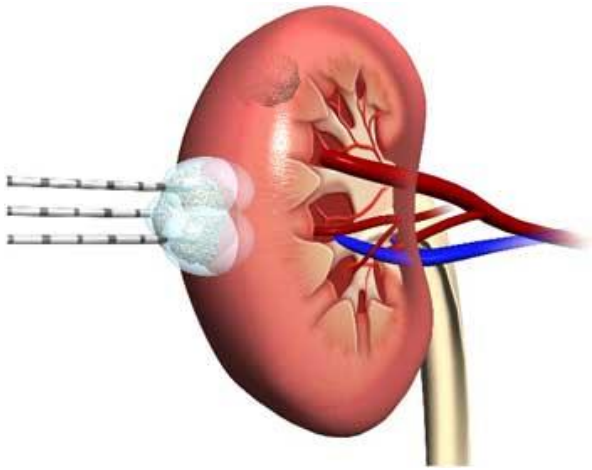
2018, US

https://www.mordorintelligence.com/industry-reports/tumor-ablation-market

Why cryo?

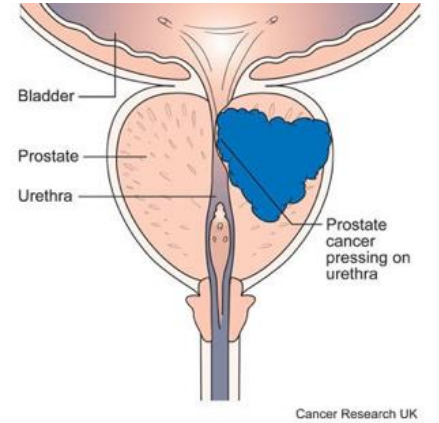
- Large ablation zones
- Simultaneous multiprobe ablations
- Controllable, well visualized
- Relatively ‘foregiving’ ablation modality

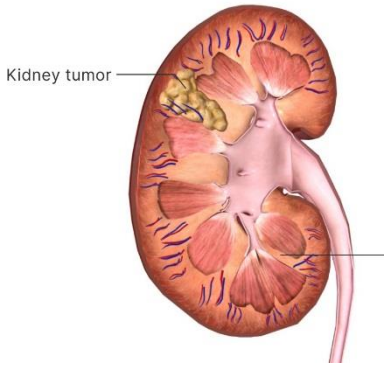


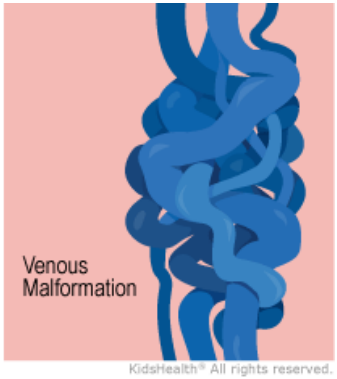


Clinical applications in RUMC

- Prostate
- Kidney
- Other (VM, bone, rectal)

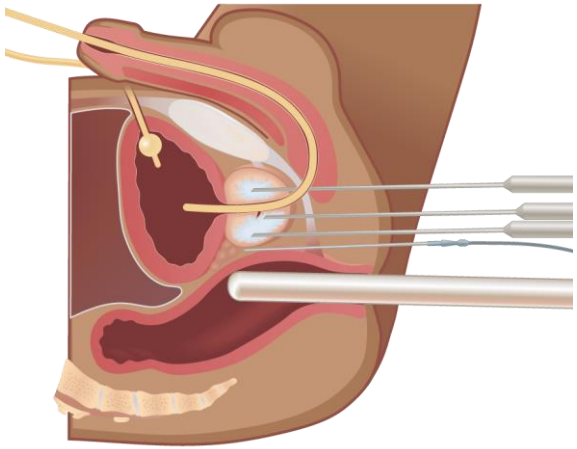






Prostate

- MR-guided cryoablation
  - Local recurrence after radiotherapy

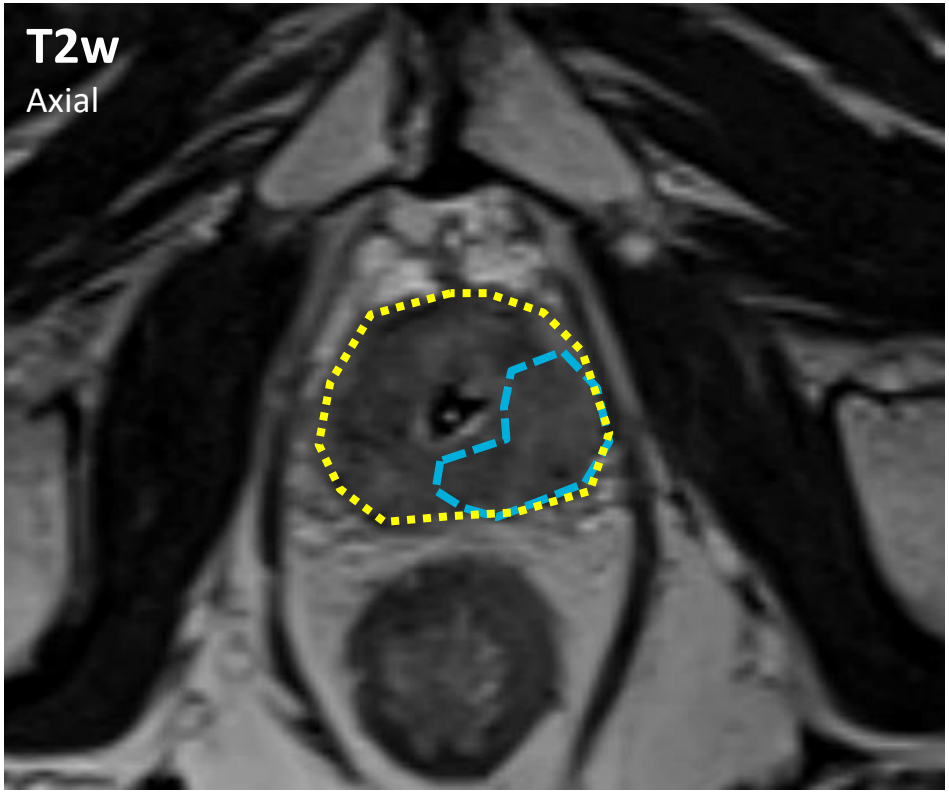


  - General anesthesia
  - 17G cryoneedles under real-time MR guidance
  - Two cycles 10:3 min freeze-thaw
  - Urethral and rectal warmer

Bomers et al. Radiology 2013; Bomers et al. JVIR 2019

Prostate

- 1. Lesion identification

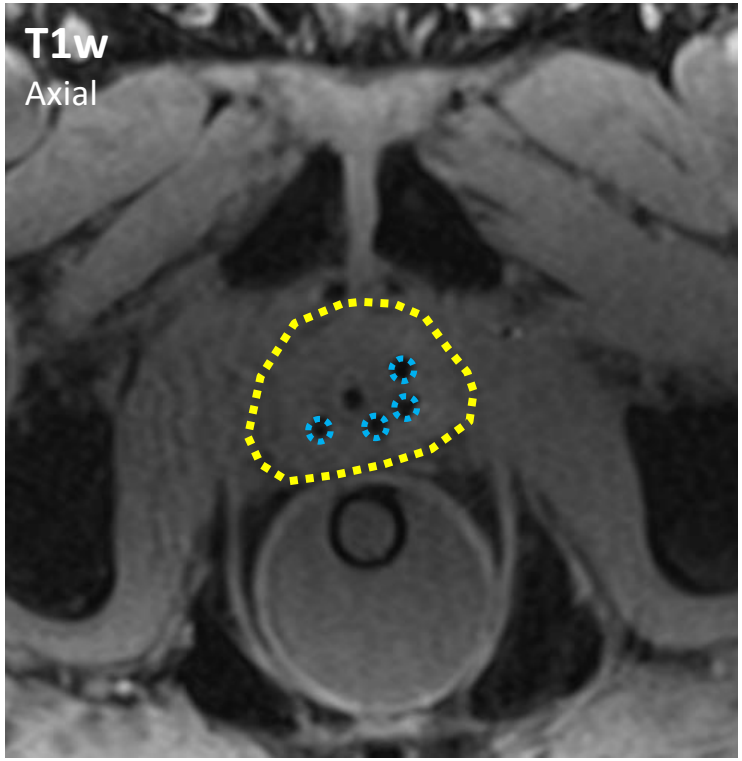


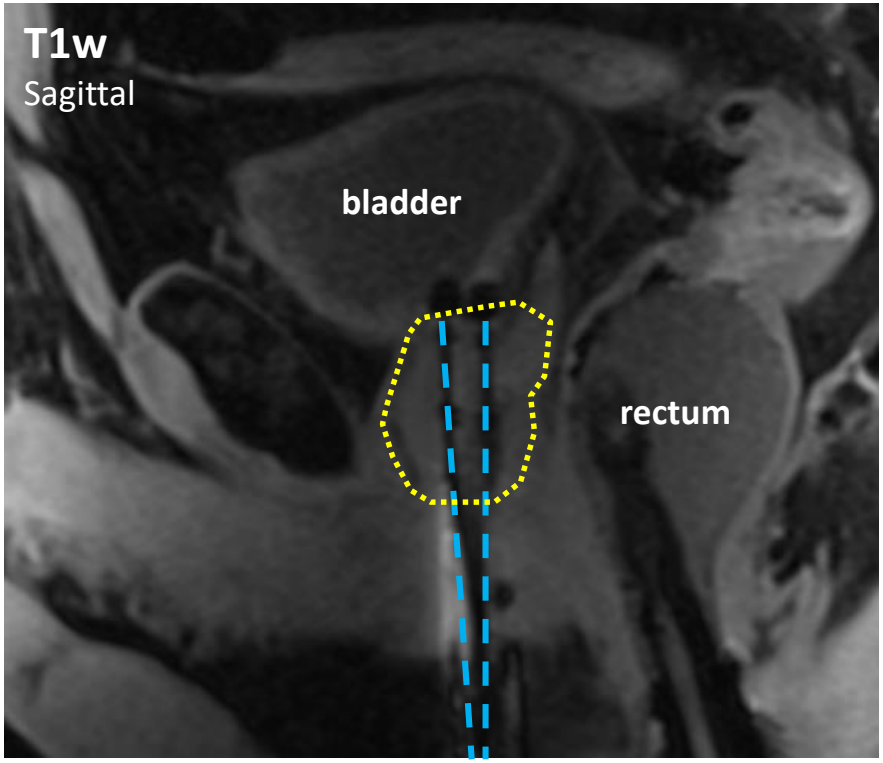
Prostate

- 2. Needle insertion

Prostate

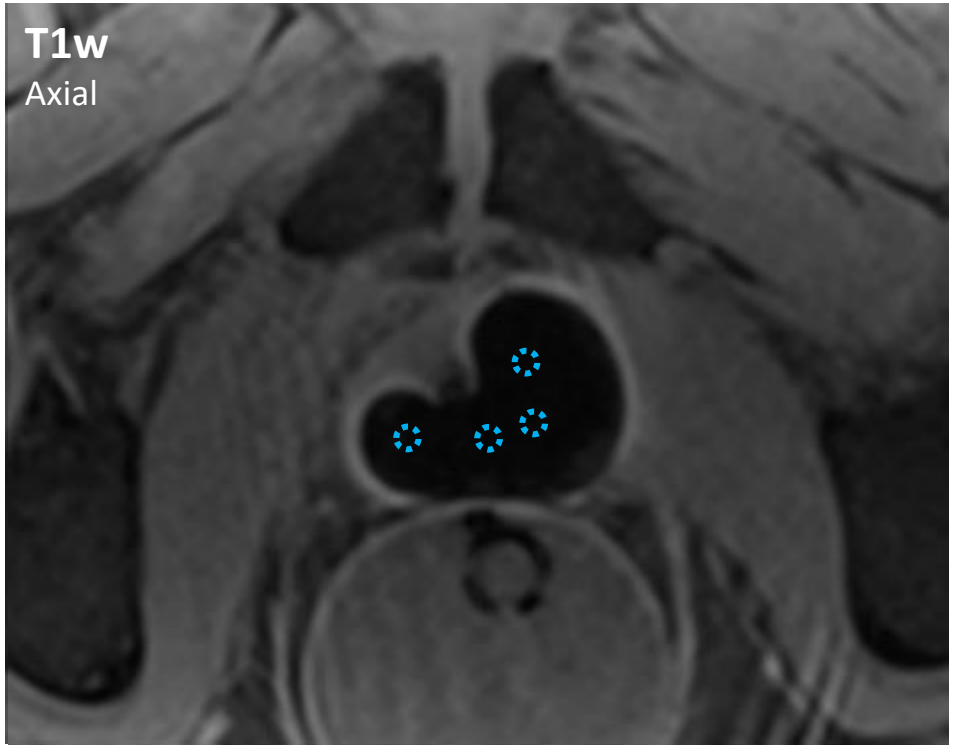
- 2. Targeting

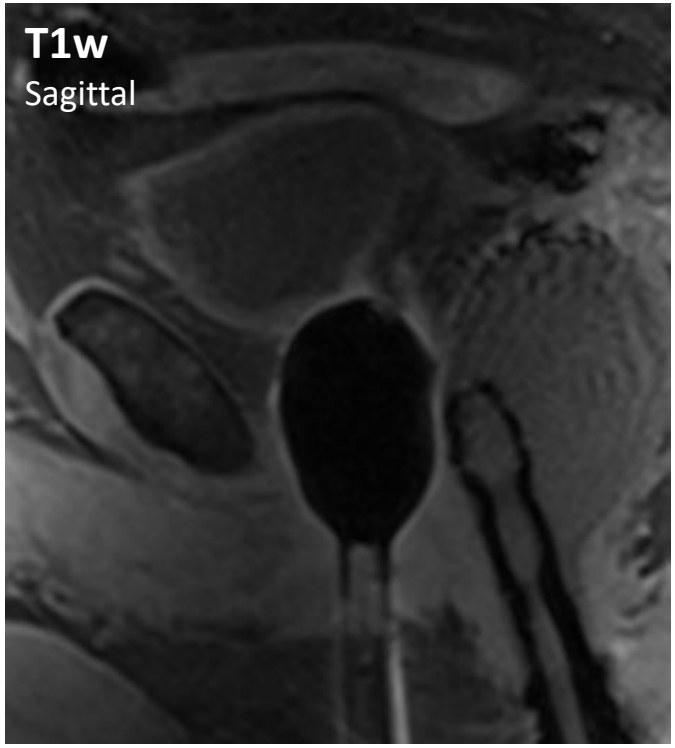




Prostate

- 3. Treatment monitoring



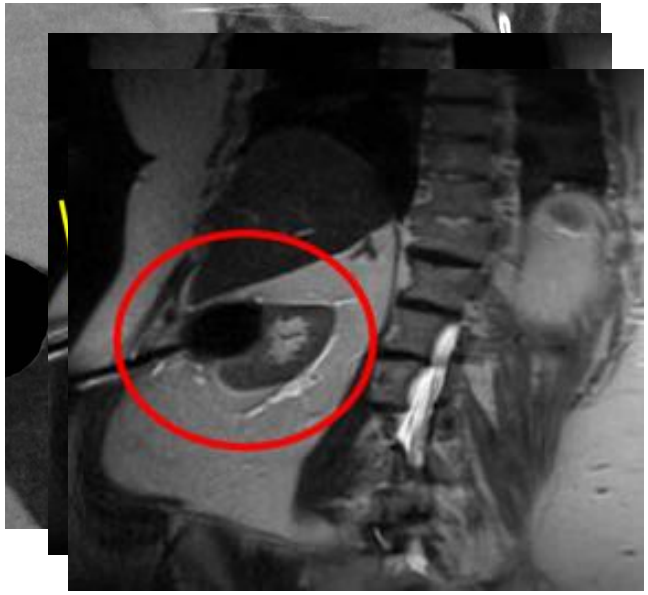


Kidney

- CT or MR-guided cryoablation
  - Non-surgical candidates (poor renal #, single kidney, previous Tx)

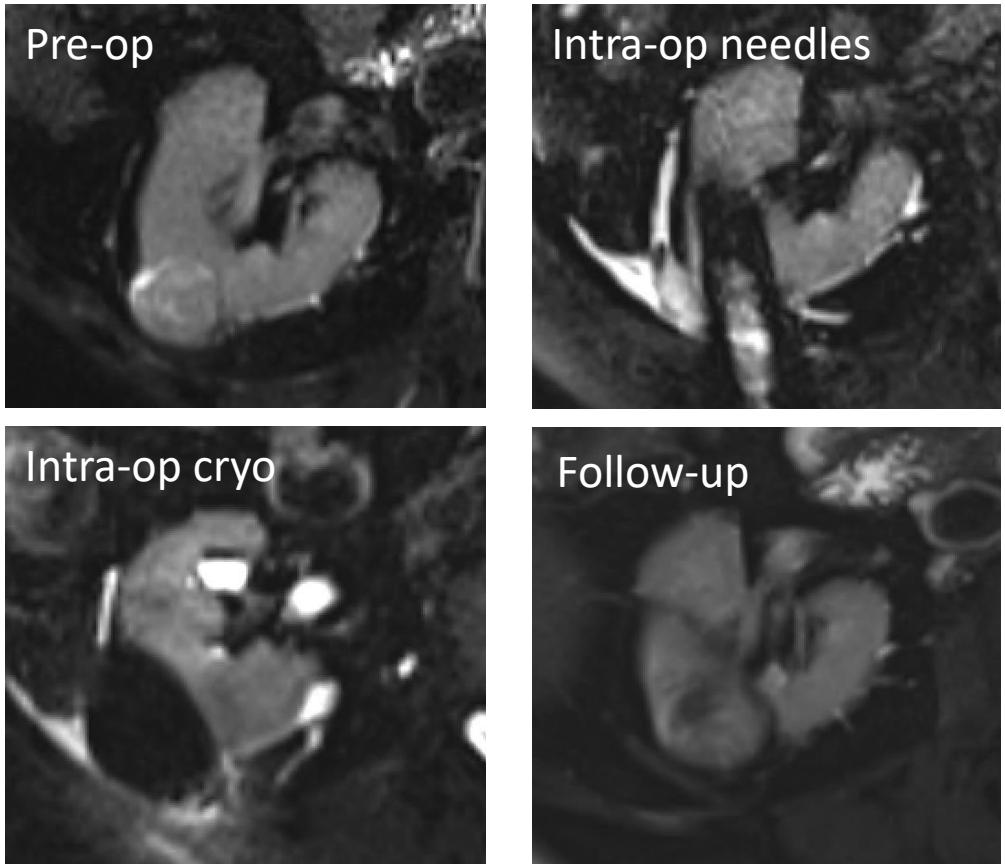
  - General anesthesia
  - Percutaneous needle placement
  - Similar protocol as prostate

  - CT confirmation or
  - Real-time MRI monitored ablation



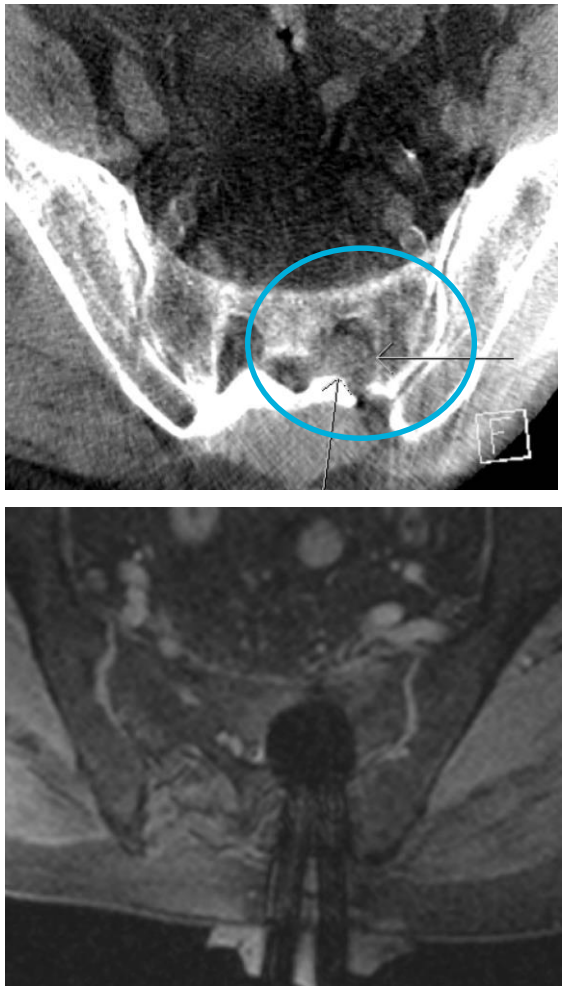
Kidney

MRI-guided procedure

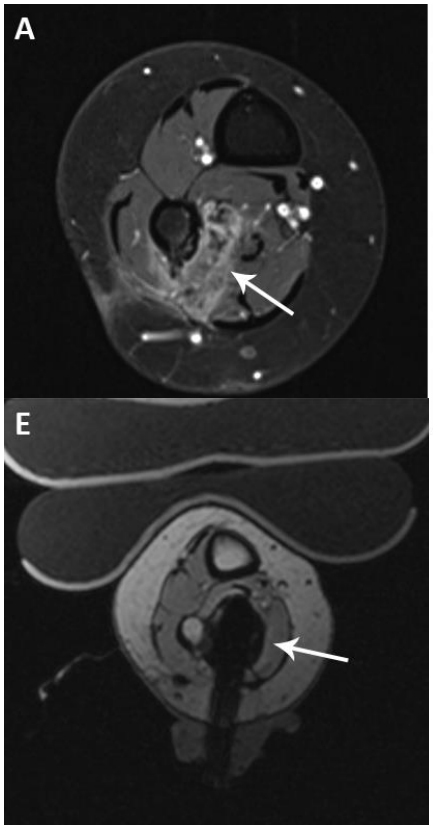


Van Oostenbrugge et al. JVIR 2017

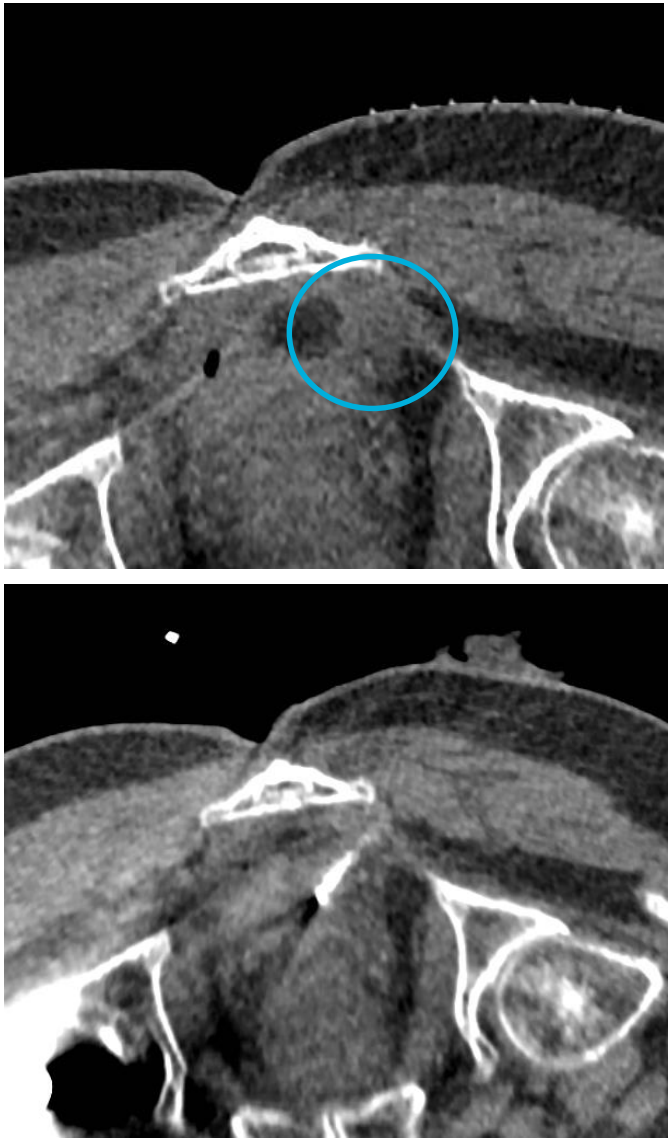
Other



Chordoma



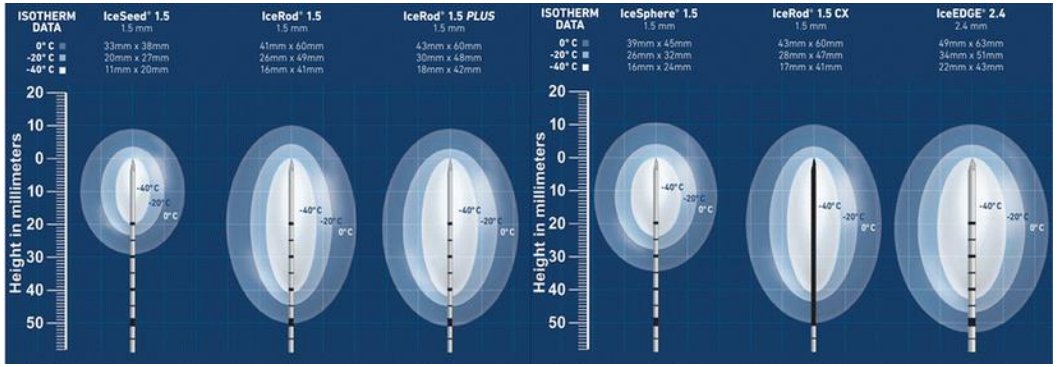
Vascular malformations



Locally recurrent rectal cancer

Challenges

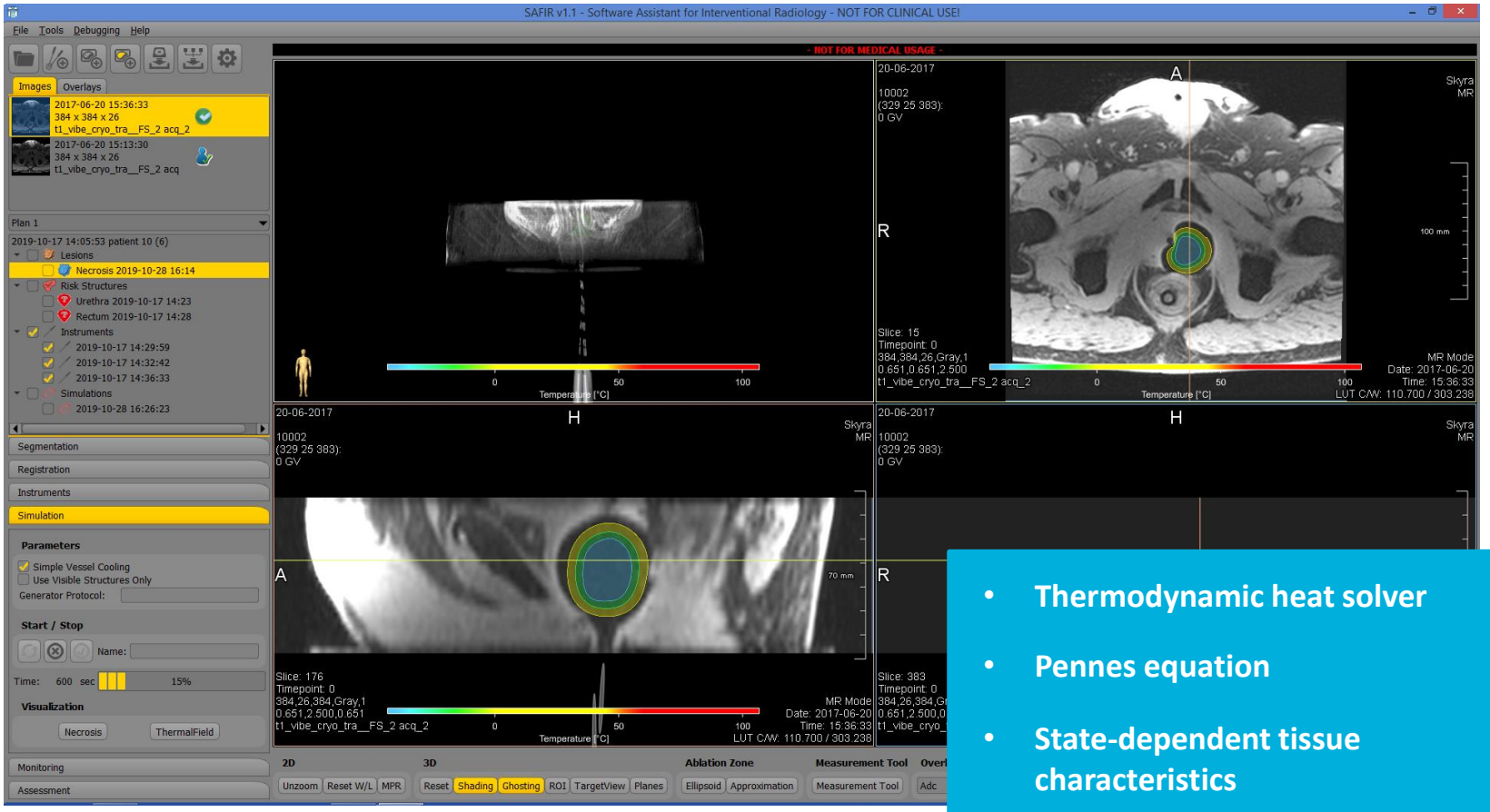
- **Treatment planning**



Ex vivo gel

In vivo perfused organ

Cryo treatment planning



- Thermodynamic heat solver
- Pennes equation
- State-dependent tissue characteristics

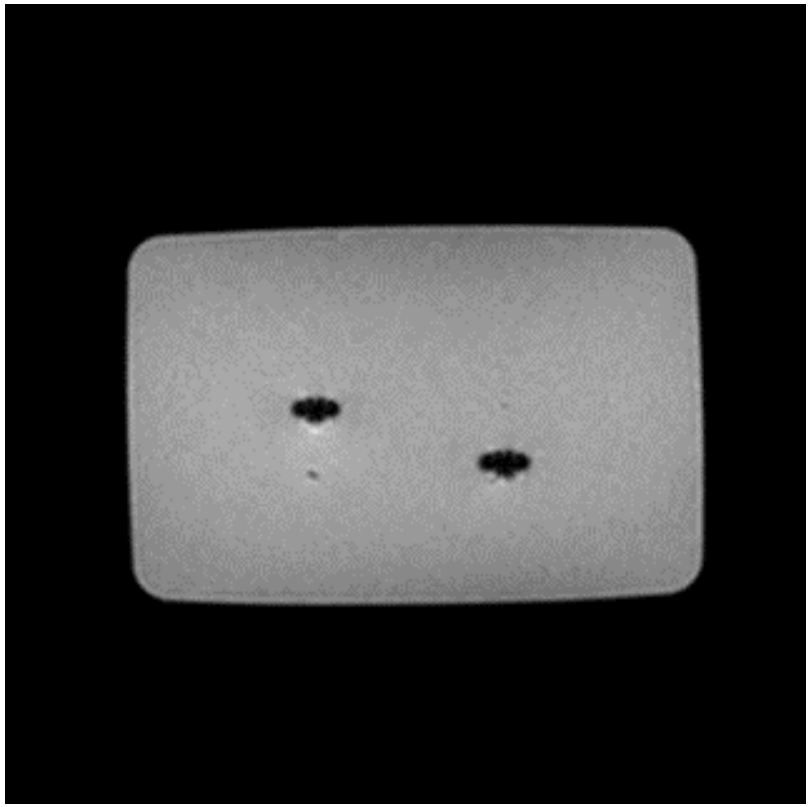
SAFIR
Software Assistant For Interventional Radiology

Fraunhofer MEVIS

Radboudumc

Cryo treatment planning

- Phantom experiment (n=4)
  - 2 cryo protocols
  - 1 or 2 cryoprobes



1x 10 min. freeze

3 min. passive thaw (right)
5 min. passive thaw (left)

Cryo treatment planning

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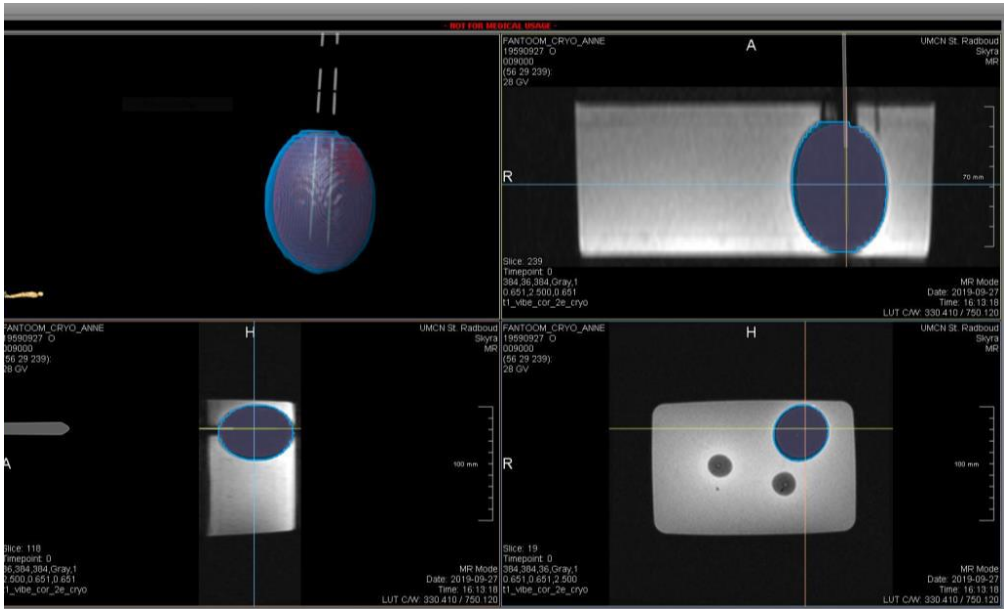
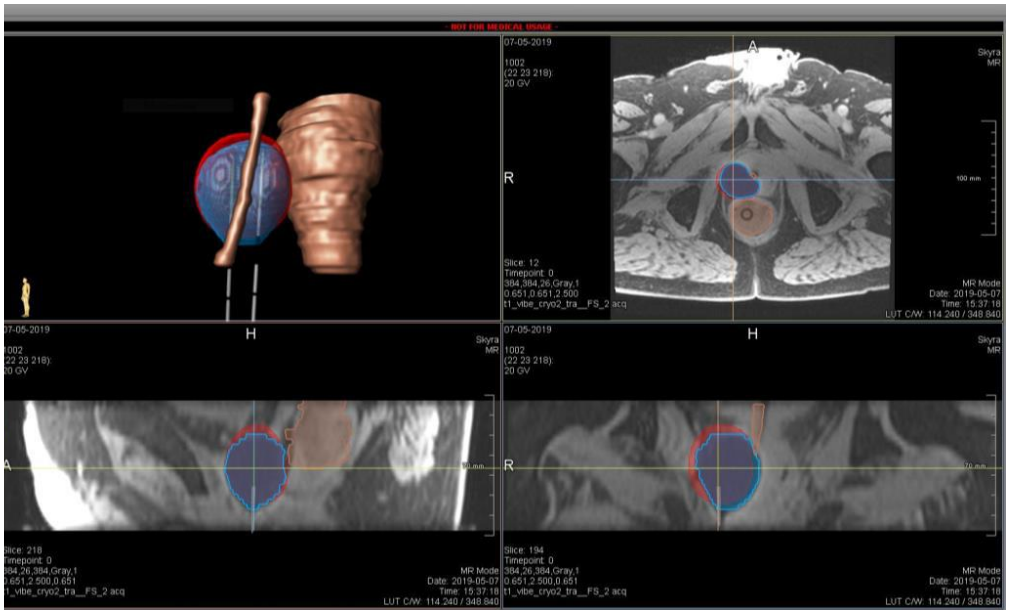


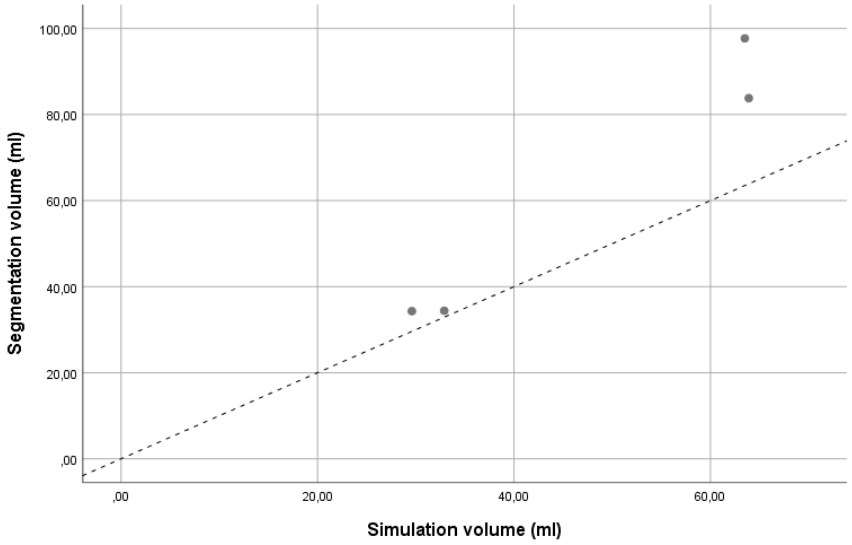
Cryo treatment planning

- Patient data (n=7)
  - Intra-op needle positions
  - MRI of final ice formation

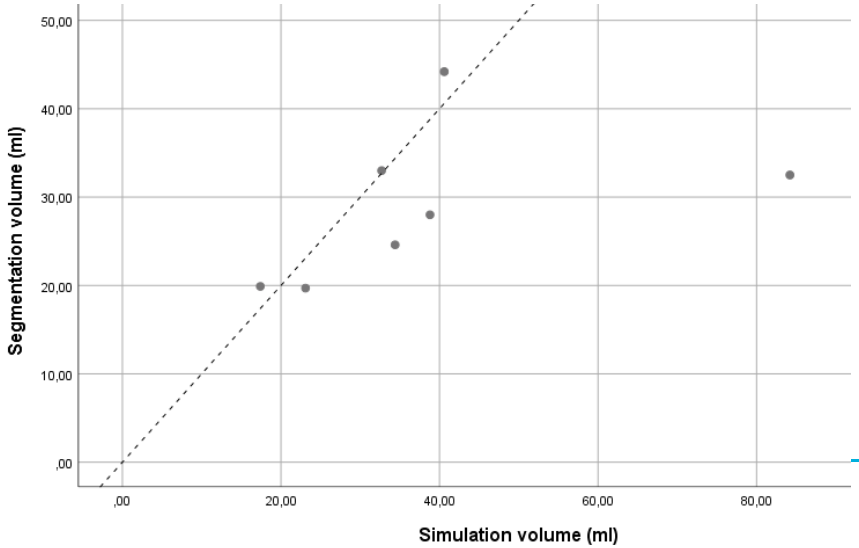


Cryo treatment planning

Phantom



Patients

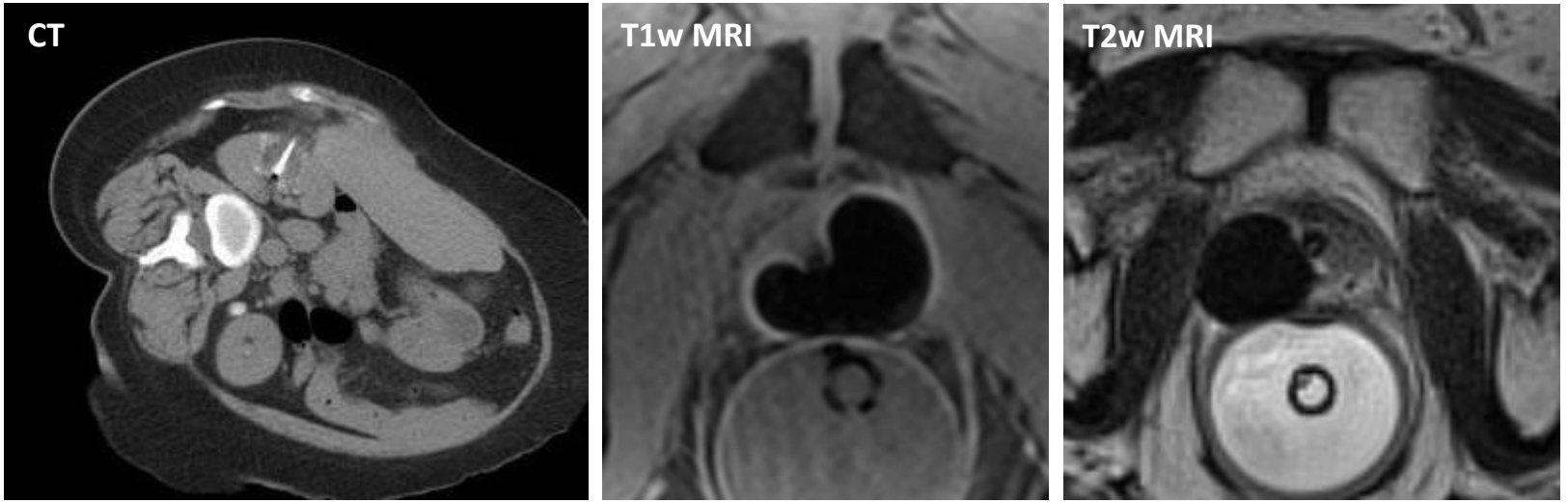


	Vol. Δ (ml)	Rel. % vol.
In vitro (n=2) *1 probe*	-3.1 ± 2.3	**-10%**
In vitro (n=2) *2 probes*	-27.1 ± 10.1	**-43%**
In vivo (n=7) *2 or 3 probes*	+9.9 ± 19.3	**+15%**

- **Issues at tissue transitions**
- **Perfusion components**

Challenges

- **Image-guidance and end point determination**



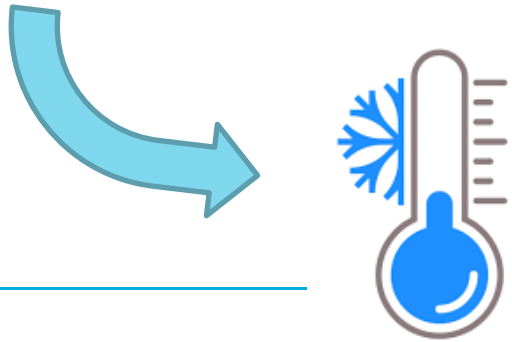
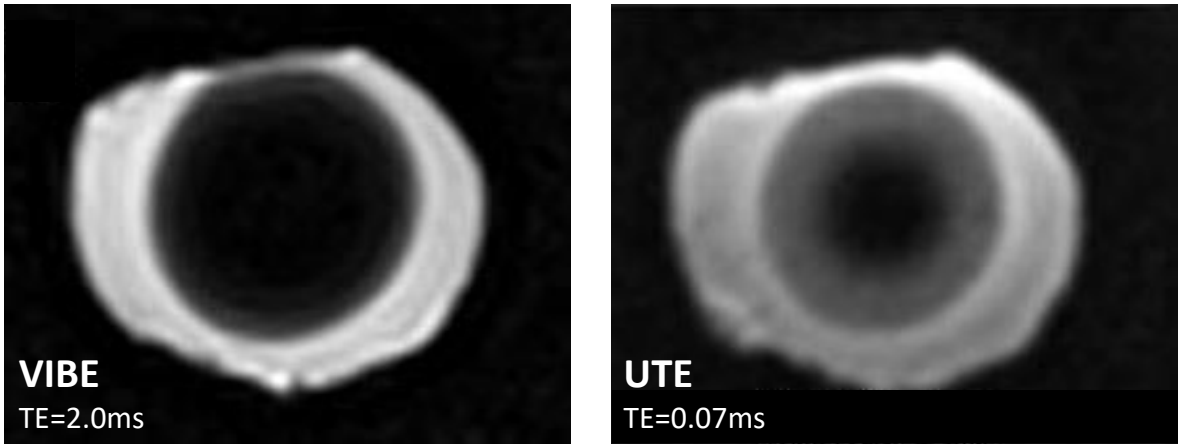


Image guidance

- MR thermometry using 3D UTE MRI
  - Short T2* in frozen tissue
  - Ultrashort TE



Overduin et al. JMRI 2017

Image guidance

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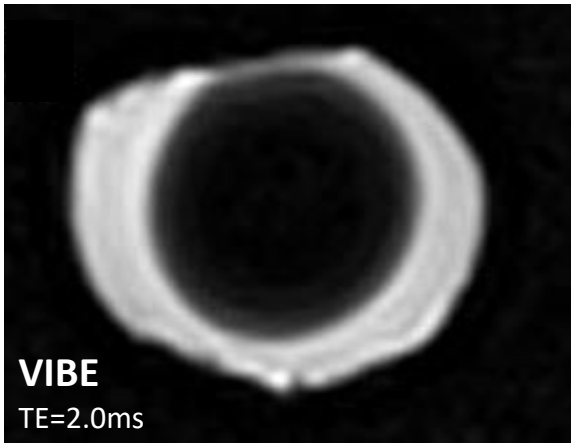
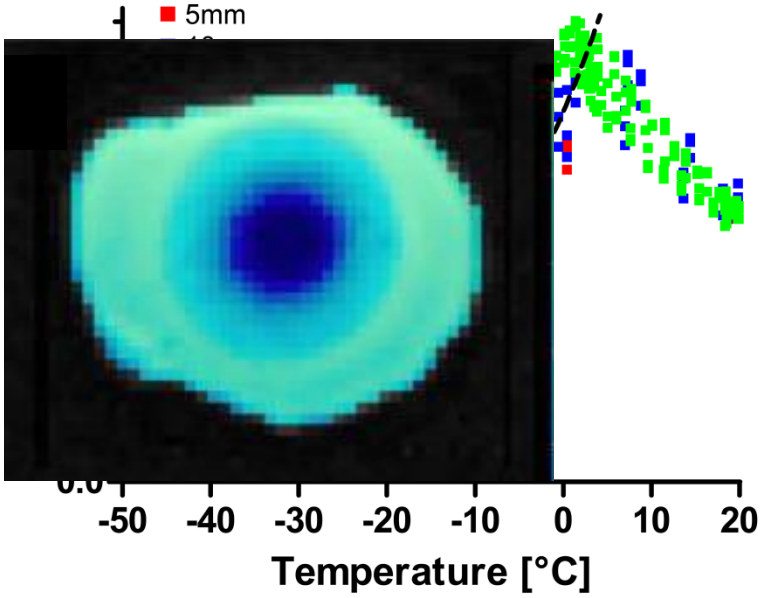




Overduin et al. JMRI 2017

Image guidance

- MR thermometry using 3D UTE MRI

single cryoprobe

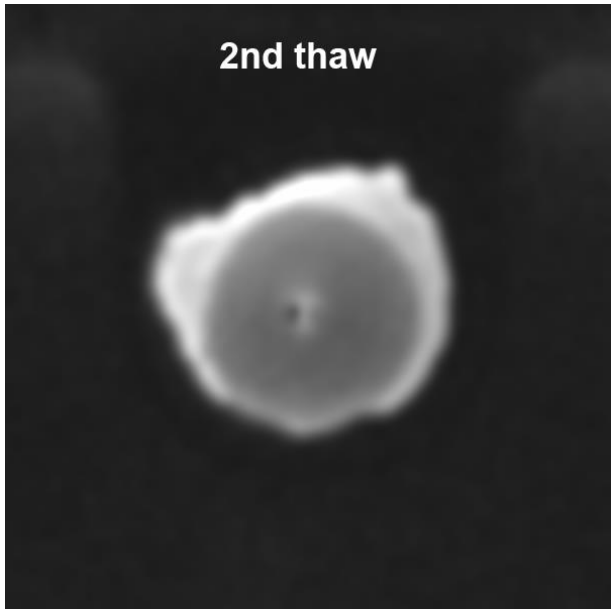
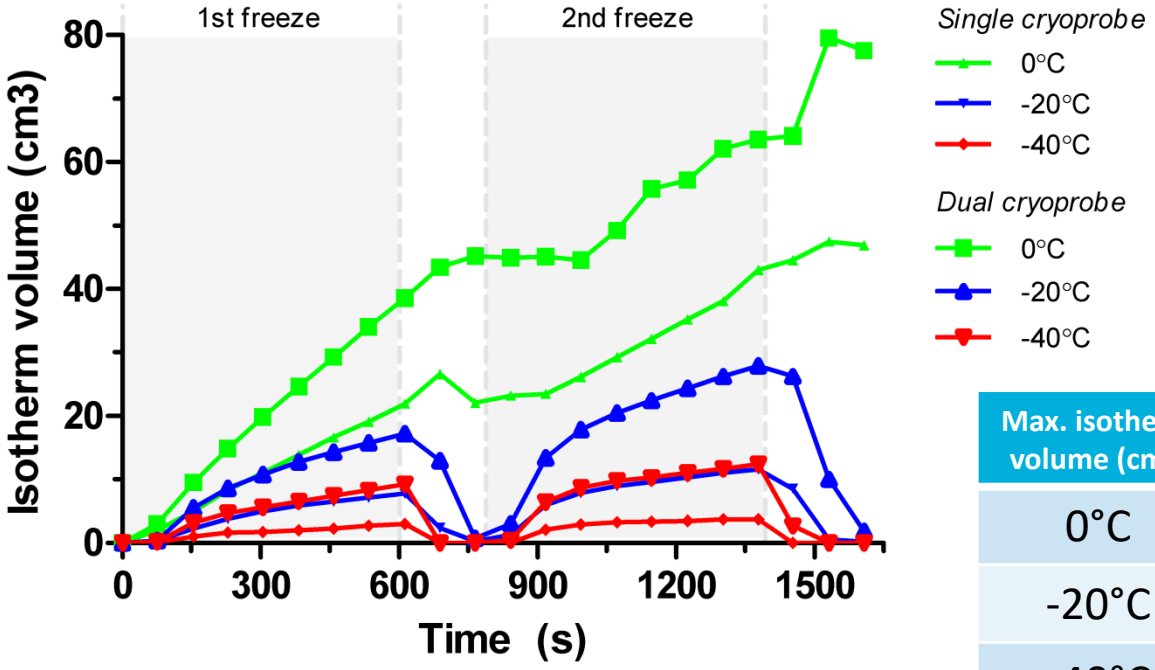


Image guidance

- Isotherm volumes

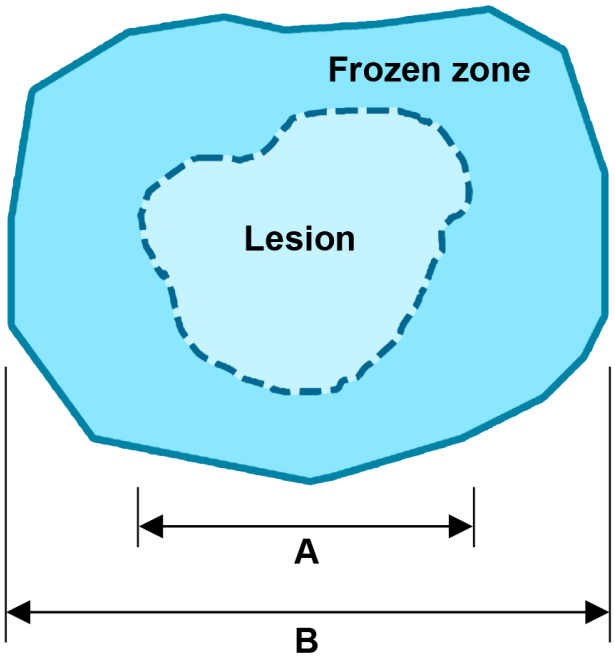


Max. isotherm volume (cm^3)	Single	Dual	↑
0°C	47.5	79.6	***67%***
-20°C	11.7	27.9	***138%***
-40°C	3.7	12.5	***237%***

Overduin et al. iMRI 2016

Endpoint determination

- 3D ablative margin analysis



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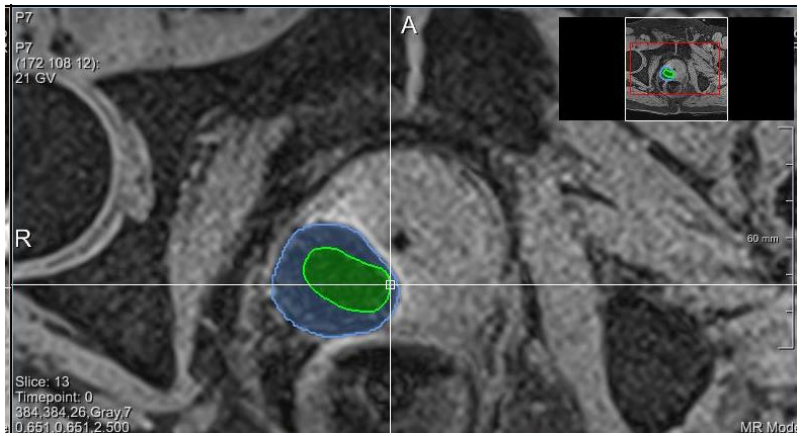
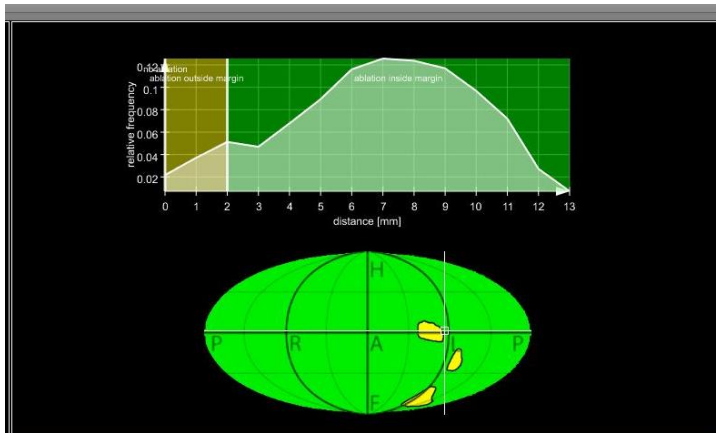
Endpoint determination

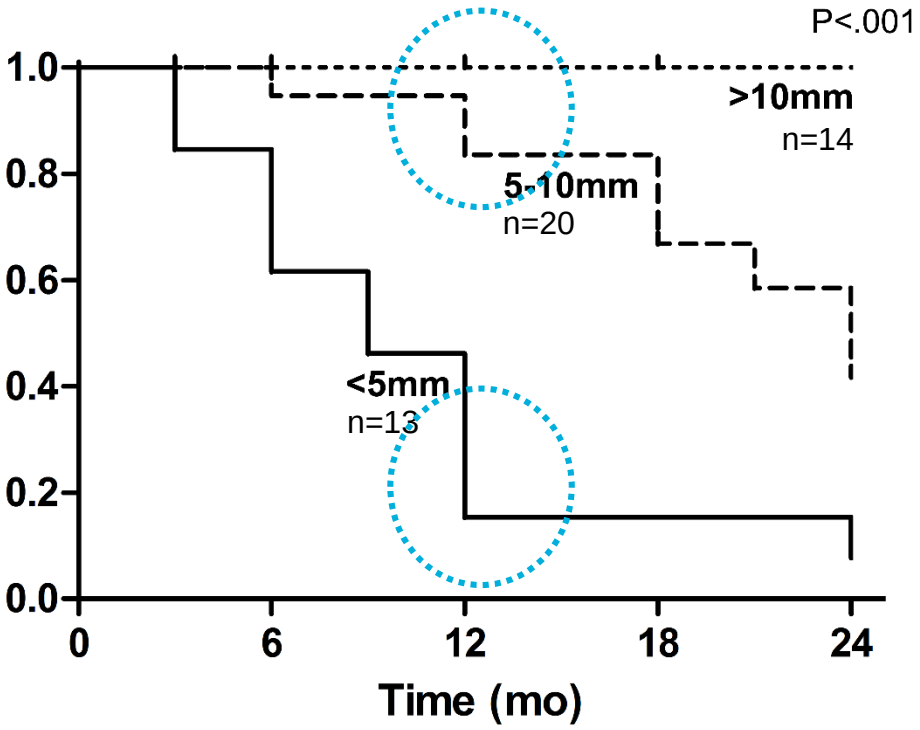
- 3D ablative margin analysis
  - Co-registration of pre and post ablation imaging
  - Tumor and iceball annotation





Endpoint determination

- Local recurrence free survival



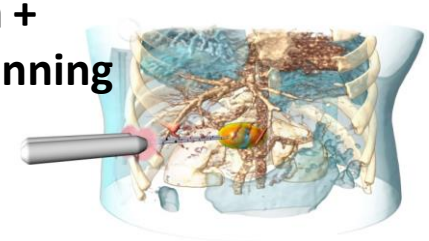
	1-yr
<5 mm	15%
5-10 mm	84%
>10 mm	100%

! Ice extending at least 5 mm beyond tumor edge

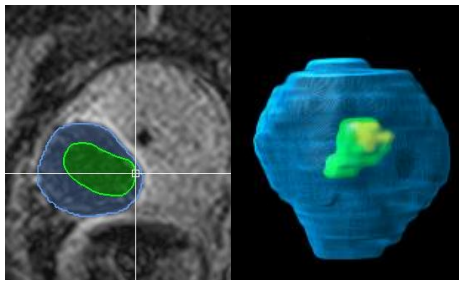
Overduin et al. Eur. Radiol 2017

Ideal procedure

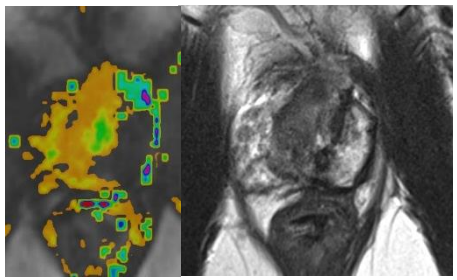
Indication + treatment planning



Real-time feedback



Intra-op verification



Patient outcome

Thank you

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MINIMALLY INVASIVE IMAGE-GUIDED INTERVENTION CENTER

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