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Emerging Technologies for IORT: Unidirectional Planar Brachytherapy Sources

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Disclosures

Rush University is participating in a pancreatic cancer study sponsored by CivaTech and funded by the NIH. I am a Co-PI on the study.

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Outline

- Background and Rationale
- Description of the CivaDots and CivaSheet IORT device
- Clinical implementation of an IORT program using the CivaSheet
- Our initial clinical experience with the device
- Discussions and Conclusions

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Background and Rationale

- Do we really need more IORT modalities?
- It depends who you ask
  - Patients (they probably do not know)
  - Surgeons (probably yes)
  - Radiation Oncologists (sure why not)
  - Medical Physicists (sure but do we have the resources)
  - Administrators (yes but what is the ROI)

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Background and Rationale

- Can we safely, effectively, and efficiently treat all the clinical conditions with existing technology?
  - The answer is most likely not
- What clinical situations present serious challenges?
  - Large resection cavities in the abdomen (+ or close margins expected postoperatively)
  - Tumors encasing laminar, cylindrical or spherical organs (ureters, pancreas, colon, muscles, bladder, etc)
- Why?
  - Size of the region that needs to be treated
  - Location and access to the tumor bed is restricted
  - The need to protect nearby critical structures
  - The need to avoid or minimize overlaps between treatment fields

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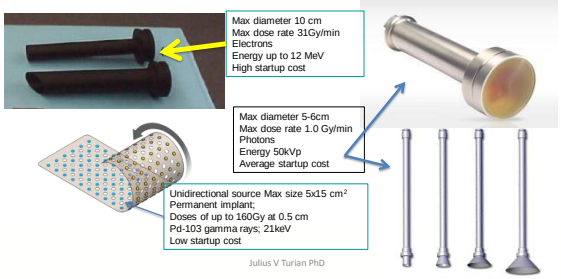
IORT Device selection



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CivaDots and CivaSheet

- Pd-103, $T_{1/2}$=17 days
- ϕ ~= 2.5 mm, h~=0.5 mm
- Unidirectional with Au shielding on one side
- AKS up to 4.6 U/dot
- Flexible bio-absorbable sheet
- Uniform Spacing: 8mm
- Up to 5cm x 15cm (108 dots) per CivaSheet
- Dose at 0.5 cm up to 160Gy

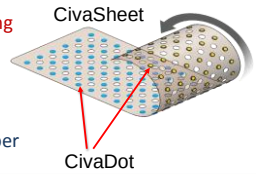

Figure courtesy of CivaTech™

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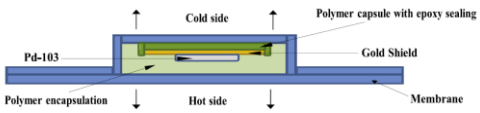
CivaDot source design



Gold
- Directional shielding
- Radio-opaque marker

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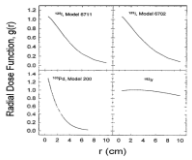
Why Pd-103

Isotope	Half-Life (Days)	Average Energy (keV)	90% Dose Delivered (Days)
Cesium-I3I	9.7	30.4	33
Iodine-125	59.4	28.5	204
Palladium-103	17.0	20.8	58



- **Low Energy**
  - **localized treatment**
- **Short half-life**
  - **fast delivery**

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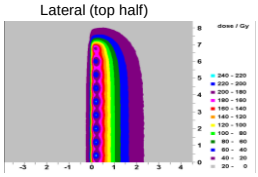
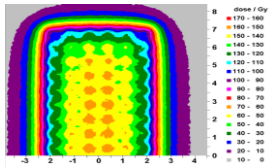
Civa Sheet dosimetry

Lateral (top half)



Front Surface, *d*=0.5 cm



Slide courtesy of Rivard

Figure courtesy of CivaTech™

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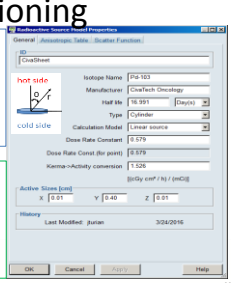
TPS commissioning

- Varian BrachyVision ver 11 instead of Variseed
- TG43 source modeling
- Source parameters provided by the vendor
  - Dose rate constant
  - Radial dose function
  - Anisotropy function
- All data have been calculated using MC

- Independently verified by us using MCNP and film (WE-AB-605-7)
  - Λ within 1.7%
  - g(r) within 0.5% with MC, 2.7% with film
  - F(r,θ) within 0.9% (0-85° 100-180°)
- Single source dose distributions were calculated and some points manually verified



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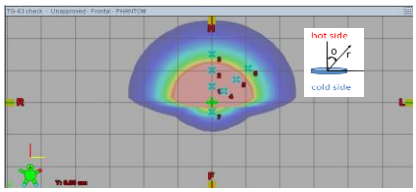
TPS commissioning

- TPS vs. Manual TG-43 Calculation



Point	%Diff
calc1	0.00%
calc2	-0.01%
calc3	0.04%
calc4	0.59%
calc5	0.34%
calc6	-0.22%
calc7	0.05%

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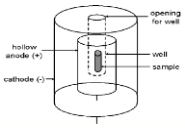
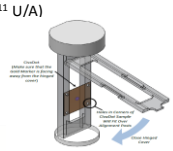
AKS calibration

- NIST → UW ADCL → RUMC
- An HDR 1000 plus Well-typed Ion Chamber with a CivaDot-specific insert was sent to Wisconsin ADCL
- An AKS calibration factor was obtained (7.912x10^{11} U/A)





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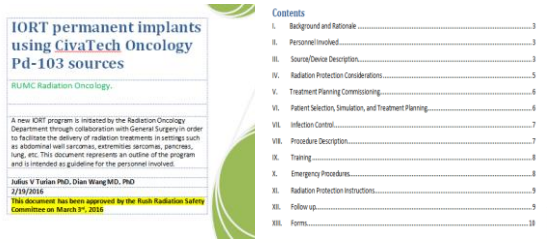
Clinical Program Setup



IORT permanent implants using CivaTech Oncology Pd-103 sources

RUMC Radiation Oncology.

A new IORT program is initiated by the Radiation Oncology Department through collaboration with General Surgery in order to facilitate the delivery of radiation treatments in settings such as abdominal wall sarcomas, extremities sarcomas, pancreas, lung, etc. This document represents an outline of the program and is intended as guideline for the personnel involved.

Julius V Turian PhD, Dian Wang MD, PhD
2/19/2016
This document has been approved by the Rush Radiation Safety Committee on March 3rd, 2016

Contents

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Clinical sites

- Retroperitoneal sarcomas
- Other abdominal malignancies
- Pancreas (protocol received IRB approval and it is open for accrual)

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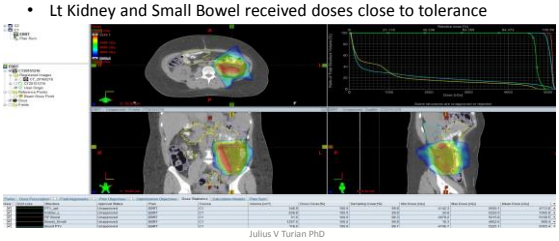
Case report

- IMRT; 49.91 Gy in 2.17 Gy x 23 fx's, surgery to follow
- Lt Kidney and Small Bowel received doses close to tolerance



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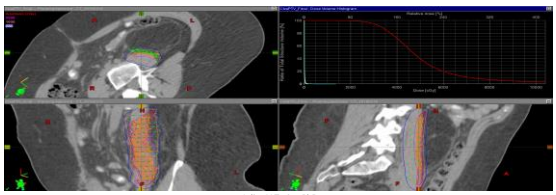
IORT Treatment planning

- PTV: surface of the psoas muscle; Rx 30 Gy to 0.5cm
- 108 seeds, 0.8 U/seed, 86.4 U, one 5x15 cm^2 sheet ordered



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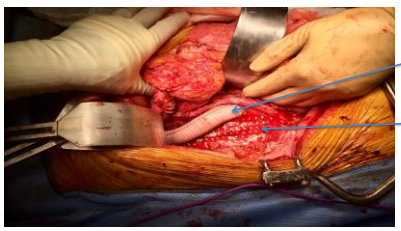
OR device placement



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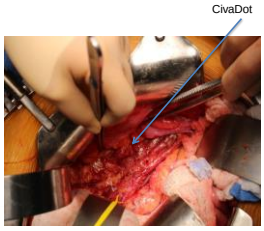
Medical Physicist Involvement day of the procedure

- Paradigm similar to other permanent implant procedures (i.e. prostate LDR)
  - Independent source calibration verification with well chamber
  - Device transportation to the OR
  - Device handling
  - Consultation with RO and surgeon regarding size, proper placement suggestion and verification
  - OR survey
  - ICU and hospital floor nursing instructions
  - Unused sources handling
- RSO help is crucial if available



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Post implant study (2.5 weeks post procedure)

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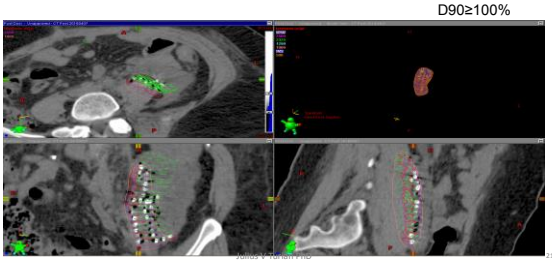
Post implant study

D90≥100%



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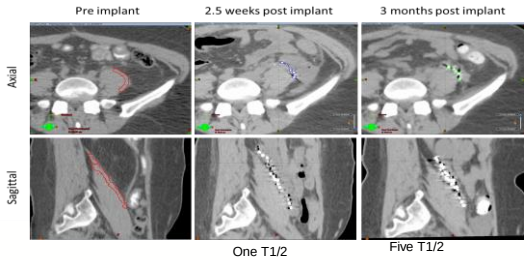
Imaging follow-up



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Benefits and Drawbacks

- Pros
  - Easy to conform to uneven surfaces and tight spaces
  - Ability to treat large areas
  - Ability to deliver high doses with rapid fall-off
  - Low startup costs
  - Identical paradigm with other permanent implants
- Cons
  - Difficult to perform pre-planning (surgeon input)
  - Difficult to identify the orientation of the sources for post implant dosimetry
  - High cost per patient for the device
  - Radiation exposure to the staff (especially the surgeon)

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Conclusions

- IORT using unidirectional CivaDots sources assembled into CivaSheet device is a feasible alternative to other modalities
- Large areas can be treated without the need for field matching.
- Sites that can NOT be access with cylindrical applicators can be easily treated
- With proper placement of the device great sparing of the normal tissue can be achieved
- Monotherapy, boost, or salvage therapy can be performed
- Radiation safety considerations are similar to other permanent implants
- We have treated 4 patients so far. Follow up still underway

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References

- Aima *et al*. Med Phys 42, 2015.
- Rivard Brachytherapy 16, 2017.
- AAPM 2017 Summer School
- CivaTech Oncology (see it at booth4005)