Emerging Technologies for IORT: Unidirectional Planar Brachytherapy Sources

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8/2/2017

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.

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
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)

• 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

IORT Device selection

Max diameter 10 cm
Max dose rate 1.0 Gy/min
Electrons
Energy up to 12 MeV
High startup cost

Max diameter 5/8 cm
Max dose rate 1.0 Gy/min
Photons
Energy 50 keV
Average startup cost

Unidirectional source Max size 5x5 cm²
Permanent implant:
Doses of up to 160 Gy at 0.5 cm
Pa: 103 gamma rays, 2/week
Low startup cost
CivaDots and CivaSheet

- Pd-103, $T_{1/2}=17$ days
- $\phi \approx 2.5 \text{ mm, } h \approx 0.5 \text{ mm}$
- 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

CivaDot source design

- Gold
  - Directional shielding
  - Radio-opaque marker

Why Pd-103

- Low Energy
- Localized treatment
- Short half-life
- Fast delivery
Civa Sheet dosimetry

Front Surface, d=0.5 cm

Slide courtesy of Rivard

Figure courtesy of CivaTech®

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)
  - g(r) within 0.5% with MC, 2.7% with film
  - F(r,θ) within 0.9% (0°-180°)
- Single source dose distributions were calculated and some points manually verified

TPS commissioning

- TPS vs. Manual TG-43 Calculation

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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)

Clinical Program Setup

Clinical sites

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

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 cm² sheet ordered

OR device placement

- Ureter encased in a protective tube
- CivaDots
Medical Physicist Involvement

- 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

Post implant study (2.5 weeks post procedure)

Post implant study

D90≥100%
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)

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
References

• Rivard Brachytherapy 16, 2017.
• AAPM 2017 Summer School
• CivaTech Oncology (see it at booth4005)