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	Learn what is Intra-operative mesh brachytherapy.
Learning Objectives	Learn mesh brachytherapy procedure and treatment planning.
	Learn how to start a program and use recommended dosimetric parameters for evaluating mesh brachytherapy procedures.

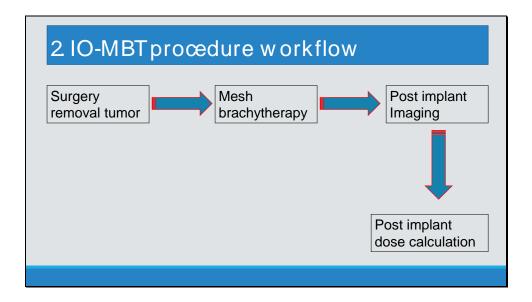
1. Introduction of Intra-operative Mesh Brachytherapy

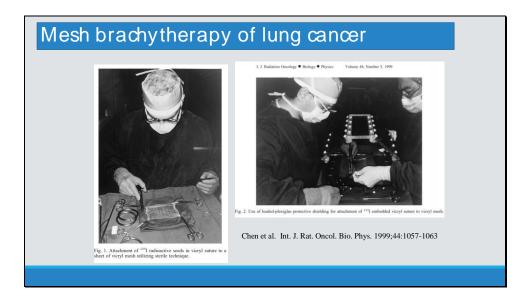
- •Intra-operative mesh brachytherapy (IO-MBT) is a special type of a permanent brachytherapy implant.
- Mesh brachytherapy uses low-energy radioactive seeds in an absorbable mesh that is sutured onto the tumor bed immediately after a surgical resection.
- •Mesh brachytherapy offers low additional risk to the patient, as the implant procedure is carried out as part of the tumor resection surgery and serves as an adjuvant therapy.

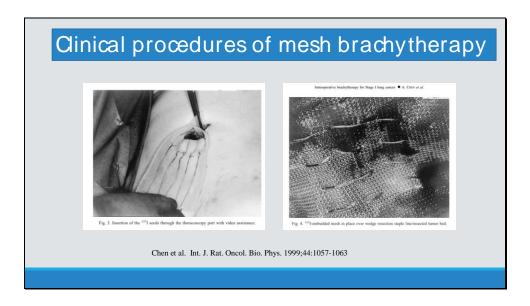
Unique Benefits of IO-MBT

- Mesh brachytherapy utilizes identification of the tumor bed through direct visual evaluation during surgery or through medical imaging following surgery, thus it is a quick and accurate procedure.
- Mesh brachytherapy is customizable for individual patients when situation changes in the OR room.

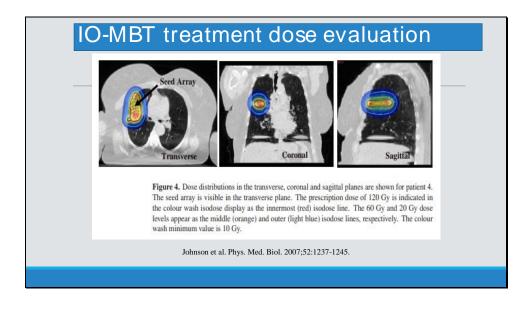
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3. How to start a mesh brachytherapy program? The brachytherapy team should conduct discussions on the topics of:

- 1)Select radionuclide (125I, 103Pd, or 131Cs).
- 2) Choose mesh type: standard template vs. custom-made in the OR, including mesh preparation and surgical implantation procedures.
- **3)Discuss** pros and cons of low-tech vs. high-tech methods, such as lookup tables vs. image-based evaluation of target for treatment-planning estimations.

--- How to start a mesh brachytherapy program?

- **4) Choose** imaging modalities (CT, kV, ultrasound, etc.) for the procedure;
- 5) **Define** the tumor bed, target volume, and what characterizes a good implant for example, that 95% of prescription dose covers 90% of the PTV;
- 6) **Discuss** dosimetry considerations, including the prescription volume, area, or point(s), TPS commissioning, pre-implant treatment planning and post-treatment dose assessment, and algorithm(s) to be used;

-- How to start a mesh brachytherapy program?

- 7) List the day-of-implant considerations, including source strength, physical configuration, radiation safety and patient release criteria;
- 8) Clarify the implant geometry, including mesh size, use of standard or custom mesh, appropriate coverage;
- 9) Get familiar with the method of performing and how to execute the post-implant dosimetric evaluation.

The above items should be discussed in the mesh brachytherapy team!

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Table 1. Energies and half-lives for radionuclides used in permanent mesh brachytherapy implant

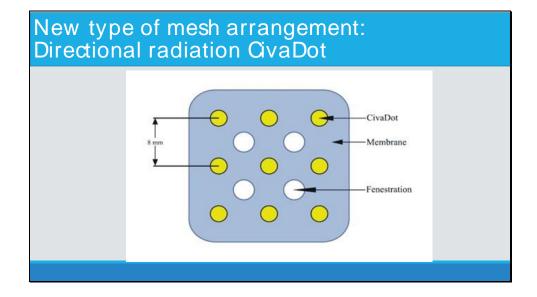
radionuclide	mean energy (keV)	half-life (day)
¹²⁵	28.4	59.41
¹⁰³ Pd	20.7	16.99
¹³¹ Cs	30.4	9.69

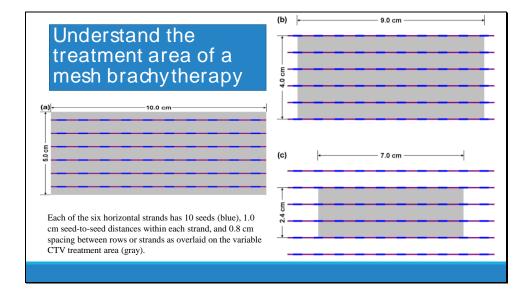
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 $\label{thm:control_and_bound} \textbf{Table 2.} \ \ \text{Available BT source models for permanent mesh implant that meet AAPM dosimetric prerequisites for brachytherapy sources (last updated January 1, 2019).}$

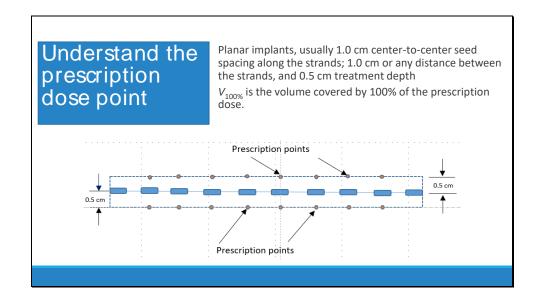
manufacturer, model	strandable	available in both strand and mesh
I-125		
Best, 2301	yes	no
IsoAid, IAI-125A	yes	no
Theragenics, AgX100	yes	yes
Pd-103		
Best, 2335	yes	no
CivaTech, CS10	yes	yes
IsoAid, IAPd-103A	yes	no
Theragenics, 200	yes	yes
Cs-131		
Isoray, CS-1 Rev2	yes	yes

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4 Mesh brachytherapy dosimetric parameters

For mesh brachytherapy, the preimplant dosimetry calculation can be performed days beforehand or expediently in the operating room with the use of lookup tables.

- 1. Doses at prescription points, namely the prescription dose D_{Rx}
- 2. source strength, unit is U,
- 3. target coverage parameters, D90, D100, V90, V100;
- 4. D2cc, D1cc, D0.1cc for each OAR.

Mesh brachytherapy prescription doses

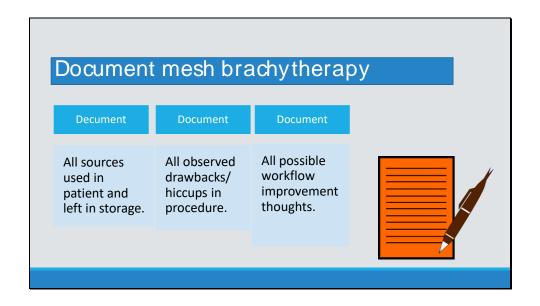
Table 3. The 2016 ABS dose recommendations for LDR thoracic mesh BT.

radionuclide	monotherapy	boost or Reirradiation
¹²⁵	100 to 125 Gy	50 to 80 Gy
¹⁰³ Pd	80 to 125 Gy	50 to 80 Gy
¹³¹ Cs	80 to 100 Gy	50 to 80 Gy

Stewart A, Parashar B, Patel M, et al. American Brachytherapy Society consensus guidelines for thoracic brachytherapy for lung cancer. Brachytherapy. 2016;15(1):1-11.

Table 4. Example of mesh geometry and prescription dose. A lookup table for the model CS-1 Rev2 $^{131}\mathrm{Cs}$ seed (Isoray Medical, Richland, WA) planar implants for 10 seeds per strand (covered length of 9.5 cm), assuming 1.0 cm seed center-to-seed center spacing along the strands, 1.0 cm between the strands, and 0.5 cm treatment depth $V_{100\%}$ is the volume covered by 100% of the prescription dose.

prescription dose (Gy)	covered width (cm)	V _{100%} (cm³)	source strength (U)
100	1.9 (2 strands)	14.66	3.25
	3.8 (4 strands)	32.02	2.70
	5.8 (6 strands)	46.34	2.40
80	1.9 (2 strands)	14.66	2.60
	3.8 (4 strands)	31.94	2.15
	5.8 (6 strands)	47.58	1.95
60	1.9 (2 strands)	14.66	1.95
	3.8 (4 strands)	31.78	1.60
	5.8 (6 strands)	46.94	1.45





Condusions

- Mesh BT is like other OR-administered BT, such as interstitial HDR BT, and prostate seed implant BT, physicist's involvement is important.
- 2. Physicists need to design the workflow and prepare the equipment.
- 3. A thorough discussion involving all BT team members is important.
- A look-up table needs to be made and tested by the team, so that its parameters can be fully understood by team members.
- Mesh BT technique is still evolving, dynamic aspects of addressing surgical margins and physically placing the permanent implant (with good radiobiology) permits potentially better dose distributions and outcomes than EBRT.

Thanks for listening! Wenzheng Feng, Mark J. Rivard, Elizabeth M. Carey, Robert A. Hearn, Sujatha Pai, Ravinder Nath, Yongbok Kim, Cynthia L. Thomason, Dale E. Boyce, Hualin Zhang
