The Role of Interventional Radiology in Cancer and Palliative Care

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Disclosures

• None
Objectives

• Give an overview of the role Interventional Radiology can play in Cancer and Palliative Medicine
• Review principles of radiation safety
Interventional Radiology

• What we’re known for...
  • **Vascular access** (ports, PICCs, dialysis and plasmapheresis catheters)
  • Abscess, biliary, pleural, peritoneal **drainage**
  • **Biopsies** (solid organ and bone)
  • **Gastrostomy tubes** (3rd in line after GI and Surgery)
  • **IVC filter** placement
  • Peripheral vascular intervention (ischemia, claudication)
  • Endovascular repair of AAA
  • Dialysis graft evaluation and intervention (declot)
  • Bone intervention (vertebroplasty)
  • Embolization (uterine fibroids, GI bleeds, trauma)
  • Pain management (epidural injections etc)
Interventional Radiology

- IR Applications in Cancer and Palliative Medicine:
  - **Vascular access** (ports, PICCs) for chemotherapy
  - Biliary, pleural and peritoneal drainage for palliation
  - **Biopsies** (solid organ and bone) for diagnosis and staging
  - **Gastrostomy tubes** (3rd in line) – head and neck cancer for nutrition
  - IVC filter placement
  - Bone intervention (vertebral augmentation, and osteoplasty)
  - **Embolization** (chemoembolization, radioembolization) for cure, local control, palliation
  - Thermal ablation for cure, local control, palliation
Interventional Oncology

• Venous access
  • Ports (over 5 million placed in the US annually)
Interventional Oncology

- Venous access
  - Ports (over 5 million placed in the US annually)
  - Tunneled and nontunneled PICCs (over 3 million placed in US annually)
Interventional Oncology

• Venous access
  • Ports (over 5 million placed in the US annually)
  • Tunneled and nontunneled PICCs (over 3 million placed in US annually)
  • Tunneled and nontunneled plasmapheresis catheters
Interventional Oncology

- Drainage
  - Biliary
    - External
    - Internal/External
Interventional Oncology

• Drainage
  • Pleural (malignant effusion)
    • Thoracentesis vs tunneled pleural drain placement (PleurX or Aspira catheters)
Interventional Oncology

• Drainage
  • Ascites (malignant ascites, Ovarian CA)
    • Paracentesis vs Tunneled drain pain cement (PleurX and Aspira)
Interventional Oncology

• Gastrostomy and Gastrojejunal tubes
  • Enteral nutrition for patients with head and neck cancer, esophageal cancer
Interventional Oncology

• IVC filter placement
  • Pulmonary and venous thromboembolism in the setting of hypercoagulability
  • Retrievable versus permanent
Interventional Oncology

- Vertebroplasty
  - Can be used in combination with ablative therapies (pain relief and locoregional control)
  - Chemical and thermal effects
  - Access the fractured level, inject bone cement to stabilize fracture and treat underlying lesion
  - 6 month follow up, 65-76% of patient reporting persistent pain relief; improved mobility, QoL
Interventional Oncology

• Chemoembolization
  • Hepatocellular CA & metastatic colorectal CA

• TransArterial ChemoEmbolization (TACE)
  • Takes advantage of preferential perfusion of tumor (hepatic artery) vs liver (portal vein)
  • Selective catheterization of the hepatic artery to bring a catheter to upstream of a tumor
  • Inject chemotherapy directly into the artery feeding the tumor (CHEMO) and block off flow (EMBOLIZATION) – First described in Japan in 1970s.
    • Conventional TACE” – Lipiodol, Doxorubicin, Mitomycin C, Cisplatin, PVA particles
    • Drug eluting beads ("DEB TACE")
Interventional Oncology

- **Chemoembolization**
  - Showing promise in early disease (intermediate-stage)
    - Indicated for locoregional control in patients with inoperable HCC
    - Useful in downstaging HCC to help patients become eligible for liver transplantation
  - Cost: cTACE (under $1000), DEB ($1500 per vial)
  - Survival rates
    - HCC 2 year survival rates may exceed 50% (untreated, 2-yr survival is 11%)
  - Can be combined with other interventions (thermal or chemical ablation)
Interventional Oncology

• **TransArterial RadioEmbolization**
  • Similar strategy to TACE
  • Yttrium 90 Radioactive Spheres
    • Y90 – beta particle emitter upon decay (maximum penetration 10 mm)
      • Half-life 64 hrs
      • 94% of radiation delivered in 11 days
      • Preferential arterial flow to tumor
    • SIR spheres (glass) vs Theraspheres (resin)
      • SIR – metastatic colorectal CA
      • Theraspheres – unresectable HCC
Interventional Oncology

a. $^{90}$Y-injection
Interventional Oncology

- **TransArterial RadioEmbolization**
  - Select patients with favorable anatomy
    - Requires a “shunt study” and arteriography to evaluate liver anatomy
  - Cost $15-20K per vial
  - Outcomes
    - Slower treatment response (6 months)
Interventional Oncology

• Thermal ablation
  • Radiofrequency ablation
    • Deliver high pulses of high frequency alternating current, rapid vibration of water molecules (friction heating)
    • Achieve temperatures of 500-1050°C
    • Good for HCC < 3 cm, can be used elsewhere
Interventional Oncology

- **Thermal ablation**
  - **Microwave ablation**
    - Use a microwave probe to encompass a tumor in a zone of thermal damage
    - Useful applications for lung, liver, kidney
Interventional Oncology

- Thermal ablation
  - Cryoablation
    - Commonly used in renal cell CA, (patients unable to have partial nephrectomy)
    - Multiple freeze-thaw cycles results in cell rupture (ice) and microvascular occlusion and ischemia (thaw)
Interventional Oncology

• Thermal ablation (a work in progress)
  • High Intensity Focused Ultrasound (HIFU)
    • In US, starting to see applications in prostate cancer (FDA approved in 2015)
    • In Asia, HIFU applied to HCC treatment
Interventional Oncology

• Requires a multidisciplinary approach including
  • IR (chemoembo, radioembo, thermal ablation)
  • Surgical Oncology
  • Medical Oncology
  • Transplant surgery
  • GI/Hepatology
  • Radiation Oncology (SBRT)
  • Palliative Medicine
Radiation Safety Review

• Radiation is all around us
• Natural and man made sources combined = 620 mrem
  • Natural sources (310 mrem/year)
    • Radon/Thoron (200 mrem)
    • Human Body (40 mrem)
    • Rocks/Soil (28 mrem)
    • Cosmic Rays (27 mrem)
      • Sea level 30 mrem/yr
      • 10,000 feet - 140 mrem/yr
Radiation Safety Review

• Manmade sources (310 mrem/year)
  • Medical procedures (300 mrem); CT makes up half of this
  • Consumer products (10 mrem)

• Fun facts
  • A single transcontinental US flight (2 mrem)
  • Sleeping with another person (1 mrem)
  • Eating one banana per day for a year (3.6 mrem)
    • Bananas are radioactive enough to cause false alarms on radiation sensors used to detect illegal smuggling of nuclear material at US ports
  • 10 mrem exposure = 40 Tb of peanut butter = 1000 bananas = 1.5 cigarettes
Radiation Safety Review

• Types of Ionizing radiation:
  • Alpha (paper)
  • Beta (wood, Al plates)
  • X-ray (lead)
  • Gamma (need 1.3 feet of lead)
  • Neutron (concrete or water)
Radiation Safety Review

• Theories of Radiation Injury
  • Direct Theory (Target Action Theory)
    • An effect occurs when the energy of a photon or secondary electron ionizes biological macromolecules
      • Macromolecules are changed by absorption of energy, transfer of energy between unstable intermediate molecules, or formation of damaged stable molecules
      • Abnormal molecules result from macromolecule dissociation and/or crosslinking (now biologically a different molecule)
    • Consequences:
      • DNA cannot pass information properly or be replicated properly
      • Cell death
      • Radiation induced malignancy
      • Radiation induced mutation
Radiation Safety Review

• Theories of Radiation Injury
  • Direct Theory (Target Action Theory)
    • Depends on:
      • Extent of damage to DNA
      • Intensity and type of radiation
      • Time between exposures (recovery period)
      • Ability of cell to repair damage
Radiation Safety Review

• Theories of Radiation Injury
  • Indirect Theory (Poison Chemical Theory)
    • Absorption of photons energy causes formation of toxins which damage cells
    • Water is ionized resulting in free radicals which also damage biological molecules
Radiation Safety Review

• Effect on Biological Molecules
  • Proteins
    • Denaturation and formation of intermolecular and intramolecular cross links
    • Inactivation of enzymes preventing catalysis and inhibition of normal cell function
  • Nucleic Acids
    • Breakage and cross linking of DNA strands (create double strands from a single and vice versa)
  • Inhibition of mitosis
  • Apoptosis
Radiation Safety Review

• To understand dose-response consider different kinds of plots
  • Threshold – dose at which effects are produced; below which no effect (C and D)
  • Non-threshold – any dose produces a response (A and B)
  • Linear – the response is directly related to dose (A, B, and C)
  • Non-linear – the response is not proportionate to dose (D)
Radiation Safety Review

• Types of Radiation Effects
  • Somatic effects
    • Radiation effects produced in an exposed person during their lifetime
    • Deterministic – causal relationship between dose and effects (proportional), effects will happen above a particular threshold (radiation dermatitis, enteritis, cataracts, etc.)
    • Stochastic – effects occur without regard to a threshold level, risk increases with dose, but severity does not (you either get cancer or you don’t; every exposure puts you at risk)
  • Genetic effects
    • Defects or mutations not seen in the exposed individual; instead passed on to future generations
Radiation Safety Review

• Types of Radiation Effects
  • **Deterministic** – causal relationship between dose and effects (proportional), effects will happen above a particular threshold (radiation dermatitis, enteritis, cataracts, etc.)
  • We know this from H-bomb blast survivors and other exposures in the last century

<table>
<thead>
<tr>
<th>Organ</th>
<th>Effects</th>
<th>Single Dose</th>
<th>Multiple Yearly Doses</th>
</tr>
</thead>
<tbody>
<tr>
<td>Gonads</td>
<td>Temporary sterility</td>
<td>0.1</td>
<td>0.4</td>
</tr>
<tr>
<td></td>
<td>Permanent sterility</td>
<td>3-6</td>
<td>0.4</td>
</tr>
<tr>
<td>Eye</td>
<td>Cataracts</td>
<td>0.5</td>
<td>2.0</td>
</tr>
<tr>
<td>Bone marrow</td>
<td>Marrow depression</td>
<td>0.5</td>
<td>0.5</td>
</tr>
<tr>
<td>Skin</td>
<td>Transient erythema</td>
<td>2.0</td>
<td>—</td>
</tr>
<tr>
<td></td>
<td>Desquamation</td>
<td>2-10</td>
<td>—</td>
</tr>
<tr>
<td></td>
<td>Temporary hair loss</td>
<td>4.0</td>
<td>—</td>
</tr>
<tr>
<td></td>
<td>Dermal necrosis</td>
<td>25.0</td>
<td>—</td>
</tr>
<tr>
<td></td>
<td>Skin atrophy</td>
<td>10.0</td>
<td>1.0</td>
</tr>
<tr>
<td>Whole body</td>
<td>Acute radiation sickness</td>
<td>1.0</td>
<td>—</td>
</tr>
</tbody>
</table>
Radiation Safety Review

• Radioactivity vs Radiation dose (SEVERAL INDICES)
  • Exposure (ionization of air) = Roentgen, R (0.000258 Coulomb/kg)
  • Absorbed dose or Radiation Absorbed Dose: Amount of energy absorbed by a tissue (rad or Gray); 1 Gy = 100 rads
  • Equivalent dose: Accounting for tissue susceptibility, dose take into consideration biologic effect (rem or Sievert); 1 Sv = 100 rems
  • Radioactivity: number of decay events (Curie, Ci or Becquerel, Bq); 1 Bq = 1 disintegration per second (number of subatomic particles or photons released from the nucleus of an atom per second)
Radiation Safety Review

- Medical radiation
  - Chest radiograph
    - 0.1 mSv = 10 days of background radiation
  - CT Abd & Pelvis
    - 10 mSv = 3 years of background radiation
  - Spine radiograph
    - 1.5 mSv = 6 months of background radiation

<table>
<thead>
<tr>
<th>Procedure</th>
<th>Approximate effective radiation dose</th>
<th>Comparable to natural background radiation for</th>
</tr>
</thead>
<tbody>
<tr>
<td>Computed Tomography (CT) — Abdomen and Pelvis</td>
<td>10 mSv</td>
<td>3 years</td>
</tr>
<tr>
<td>Computed Tomography (CT) — Abdomen and Pelvis, repeated with and without contrast material</td>
<td>20 mSv</td>
<td>7 years</td>
</tr>
<tr>
<td>Computed Tomography (CT) — Colonography</td>
<td>6 mSv</td>
<td>2 years</td>
</tr>
<tr>
<td>Intravenous Pyelogram (IVP)</td>
<td>3 mSv</td>
<td>1 year</td>
</tr>
<tr>
<td>Radiography (X-ray) — Lower GI Tract</td>
<td>8 mSv</td>
<td>3 years</td>
</tr>
<tr>
<td>Radiography (X-ray) — Upper GI Tract</td>
<td>6 mSv</td>
<td>2 years</td>
</tr>
<tr>
<td>Radiography (X-ray) — Spine</td>
<td>1.5 mSv</td>
<td>6 months</td>
</tr>
<tr>
<td>Radiography (X-ray) — Extremity</td>
<td>0.001 mSv</td>
<td>3 hours</td>
</tr>
<tr>
<td>Computed Tomography (CT) — Head</td>
<td>2 mSv</td>
<td>8 months</td>
</tr>
<tr>
<td>Computed Tomography (CT) — Head, repeated with and without contrast material</td>
<td>4 mSv</td>
<td>16 months</td>
</tr>
<tr>
<td>Computed Tomography (CT) — Spine</td>
<td>6 mSv</td>
<td>2 years</td>
</tr>
<tr>
<td>Computed Tomography (CT) — Chest</td>
<td>7 mSv</td>
<td>2 years</td>
</tr>
<tr>
<td>Computed Tomography (CT) — Lung Cancer Screening</td>
<td>1.5 mSv</td>
<td>6 months</td>
</tr>
<tr>
<td>Radiography — Chest</td>
<td>0.1 mSv</td>
<td>10 days</td>
</tr>
</tbody>
</table>

Radiation Safety Review

• ALARA
  • “As Low as Reasonably Achievable”
    • Time (duration of exposure)
    • Distance (inverse square law)
    • Shielding
Radiation Safety

• Annual dose limits
  • Regulated by the Nuclear Regulatory Commission
  • Whole body = 5,000 mrem/yr
  • Lens = 15,000 mrem/yr
  • Extremities, skin, and tissues = 50,000 mrem/yr
  • Minors = 500 mrem/yr
  • Embryo/fetus(pregnant worker) = 500 mrem/9 months
  • General public = 100 mrem/yr
Self Assessment Questions...
Self Assessment Question #1

What is ALARA?

a. A new electric car designed by Toyota
b. A concept employed to reduce radiation exposure
c. A cosmetic used to hide age spots
d. Amazon’s proprietary Artificial Intelligence loaded on every ‘Echo’ device
Self Assessment Question #2

Which of the following is NOT a strategy to limit radiation exposure?

a. Minimizing the duration or time of an exposure
b. Increasing distance from the radiation source during an exposure
c. Utilizing lead shielding during an exposure
d. Taking a shower after an exposure
Self Assessment Question #3

Which of the following is NOT an example of a deterministic or nonstochastic effect?

a. Radiation skin burn
b. Cancer
c. Cataracts
d. Sterility
Self Assessment Question #4

Which one of the following decay particles is able to penetrate lead?

a. Alpha
b. Beta
c. Gamma
d. Theta
Self Assessment Question #5

Which of the following is NOT a percutaneous strategy for control of primary liver cancer

a. Chemoembolization
b. Radioembolization
c. Thermal ablation
d. Stereotactic Body Radiation Therapy (SBRT)
Self Assessment Question #6

Which of the following is a comfort care intervention usually reserved for end of life?

a. Paracentesis or thoracentesis for malignant ascites
b. Mediport placement
c. Placement of a tunneled peritoneal or pleural drain for malignant ascites
d. Gastrostomy tube placement
Self Assessment Question #7

Which of the following is NOT a thermal ablative technique

a. Cryoablation
b. Radiofrequency ablation
c. Microwave ablation
d. Chemical ablation
The End

Any Questions?