RADIOFREQUENCY ABLATION OF TUMORS

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OBJECTIVES

• Define and describe radiofrequency ablation (RFA)
• Identify the considerations relevant to administering RFA
• Illustrate its clinical utility with two examples – hepatocellular and renal cell carcinoma
• Assess advantages and disadvantages
• Identify new goals and ways to optimize RFA
RADIOFREQUENCY ABLATION – WHAT IS IT?

- Interventional procedure
- Uses radiofrequency voltage as source of thermal energy
- Creates an electric field within tumor, thus exciting ions
- Ionic movement = current $\rightarrow$ frictional energy dissipation $\rightarrow$ heat $\rightarrow$ death by coagulation necrosis
COAGULATION NECROSIS

• Coagulation necrosis* – a type of necrosis in which the affected cells or tissue are converted into a dry, dull, homogeneous eosinophilic mass without nuclei, as the result of the coagulation of protein

• For RFA purposes, this is achieved when tumor damage is irreversible

THE COMPONENTS

- RF voltage source
- Electrode
- Image guidance
  - CT
  - US
  - MRI
- The set-up

[Image: http://www.valleylab.com/static/cooltip/products.html]


THE COMPONENTS

VARIABLES

- Monopolar vs. bipolar electrode
- Length of electrode
- Gauge – needle-size
- Duration of heating
- Tumor size = most important factor
## ABLATION – SIZE DEPENDENCE

<table>
<thead>
<tr>
<th>Hepatic Tumor Diameter (cm)</th>
<th>Total Ablation* (% of cases)</th>
</tr>
</thead>
<tbody>
<tr>
<td>&lt; 2.5</td>
<td>&gt; 90%</td>
</tr>
<tr>
<td>2.5 – 3.5</td>
<td>70 – 90%</td>
</tr>
<tr>
<td>3.5 – 5.0</td>
<td>50 – 70%</td>
</tr>
<tr>
<td>&gt; 5.0</td>
<td>&lt; 50%</td>
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</tbody>
</table>

* Dupuy DE, Goldberg SN. *J Vasc Interv Radiol* 2001; 12:1135-1148
PATIENT PREPARATION

• No food or drink 6-8 hrs. pre-procedure

• Pre-procedure workup
  – IV placement
  – blood drawn
  – meeting w/radiologist
  – obtain consent
PROCEDURE

- Performed under conscious sedation: fentanyl and midazolam
- Prophylactic antibiotics, depending on hospital
- Percutaneous insertion of electrode using guidance (unless done surgically)
- Repeat insertions if necessary
PARAMETERS

- Radiofrequencies under 1 MHz
- Target temperature of 50-100 °C
- 0.5-1.0 cm margin around lesion
- 21- to 14-gauge needle
- Grounding: patient or internal
EXAMPLE – RF ABLATION OF HEPATOMA ON ULTRASOUND

PRE-RFA
Echogenicity represents bubbles produced from heating tumor

5 MIN. INTO RFA

15 MIN. POST- RFA

APPLICATIONS

- Originally was developed and is still used for its ability to treat cardiac arrhythmia.

- Commonly applied to hepatocellular carcinoma (HCC) and hepatic mets, but also effective for other neoplasms:
  - malignant: renal cell ca., lung ca., mets to bone
  - benign: osteoid osteoma, aldosteronoma
QUALITY CONTROL

• Is the patient a good candidate?
  – not a candidate for surgical resection

• Is the tumor the right size?
  – single HCC tumor < 4 cm diameter (usually)
  – multiple HCC tumors < 3 cm diameter each
QUALITY CONTROL

• Is the tumor the right shape?
  – multi-tine electrode can create spherical or elliptical region of necrosis, but multiple electrodes may be needed for other shapes

• Is it the right doctor?
  – RFA is an emerging technology; experienced radiologists are needed to ensure reproducible results
OTHER TYPES OF ABLATION

- Cryoablation
- Ethanol injection
- High-intensity US
- Microwave
- Laser
PATIENT 1
PATIENT 1

- 81-yr-old Chinese man p/w two episodes of RUQ pain, spaced one month apart
- Denies any baseline abdominal pain, N/V, fevers, chills, diarrhea, constipation
- No blood per rectum
- Negative hepatitis
- PMH - BPH
PATIENT 1 – FINDINGS

- 6.0 X 7.4 cm enhancing, hypervascular lesion in r. lobe of liver – biopsy-proven HCC
PATIENT 1 – TREATMENT WITH RF ABLATION

• 20-gauge tandem bipolar needle
• 6 re-positionings
• 2000 mA
• 45-minute RFA procedure
• Intravenous Doxil chemotherapy
PATIENT 1 - RESULTS

courtesy of Dr. Goldberg, BIDMC

2 WKS. POST-ABLATION

courtesy of Dr. Goldberg, BIDMC

RE-TREATMENT
PATIENT 1 - RESULTS

PRE-ABLATION

courtesy of Dr. Goldberg, BIDMC

18 MOS. POST-ABLATION

courtesy of Dr. Goldberg, BIDMC

18 MOS. POST-ABLATION
PORTAL VENOUS PHASE

courtesy of Dr. Goldberg, BIDMC
PATIENT 1 - RESULTS

36 mos. post-RFA:

No local recurrence.

Continuing follow-up.
ADVANTAGES OF RFA

• Multimodality therapy: combine with radiotherapy, chemoembolization; synergistic with chemotherapy
• Image guidance - vs. targeted radiation tx, which can be compromised by normal organ movement
• Decreased tx-related toxicity vs. radio-and chemotherapy; few complications
ADVANTAGES OF RFA

• Can exploit the physiology and pathology
  – fibrotic tissue in a cirrhotic HCC patient actually insulates the tumor, helping to sustain the heat generated by RFA
  – similar insulation by air in the lungs and by cortical bone
LIMITATIONS OF RFA

• “Heat sink” effect – high vascularity of tumor periphery diverts heat and prevents uniformly high temperatures

• Location of lesion is important
  – Must avoid heat-sensitive tissue, such as hollow organs; may need to create “ascites” to separate sensitive organs from target
POTENTIAL COMPLICATIONS

- Burns from grounding pad (if used)
- Perforation of heat-sensitive organs
- Strictures
PATIENT 2
PATIENT 2

- 74-yr-old woman w/developing dementia p/w weight loss, blood in stool, and painless hematuria

- PMH – Hypothyroidism, hyperlipidemia

- PSH – Rectocele repair, cystocele repair
PATIENT 2 – FINDINGS

CT W/CONTRAST

PACS, BIDMC
PATIENT 2 – FINDINGS

- 1.6 X 1.2 cm lesion in posterior upper pole of r. kidney – biopsy-proven RCC
PATIENT 2 – TREATMENT PLAN

• 900-1000 mA
• 6 min.
• Heating to > 60°C
PATIENT 2 – POST-TREATMENT

- Lack of enhancement
- Residual air bubbles
- Peripheral fat-stranding
- Continuing follow-up
## CURRENT DATA

<table>
<thead>
<tr>
<th>Lesion</th>
<th>Results*</th>
</tr>
</thead>
<tbody>
<tr>
<td>hepatic tumor &lt; 3.5 cm</td>
<td>&gt; 90% total ablation</td>
</tr>
<tr>
<td>colorectal mets</td>
<td>85% local control at 8 mos.</td>
</tr>
<tr>
<td>osteoid osteoma</td>
<td>up to 90% treatable</td>
</tr>
<tr>
<td>adrenal neoplasms</td>
<td>11 of 13 locally controlled†</td>
</tr>
</tbody>
</table>

*Dupuy DE, Goldberg SN. *J Vasc Interv Radiol* 2001; 12:1135-1148
†Mayo-Smith WW, Dupuy DE. *Radiology* 2004; 231:225-230
OPTIMIZATION

- Internally cooled electrodes – creates reverse heat sink to prevent overheating adjacent to electrode tip/tines
- Saline injection – improves electrical conductivity within tumor
- Occluding blood flow during procedure
- Multimodality therapy
GOALS FOR RFA THERAPY

• Debulking
• Palliation
• Communication among institutions
• Establish algorithms
SUMMARY

• Emerging and powerful tool, especially for small to moderate size lesions
• Principle = heat generated by electric current destroys neoplastic tissue
• Success depends on tumor size and shape as well as RFA apparatus and radiologist
• Most data have yet to be accumulated: communication among institutions is essential
REFERENCES

• Tanabe KK, Curley SA, Dodd GD, Siperstein AE, Goldberg SN. Radiofrequency ablation: The experts weigh in. *Cancer* 2003; 100:641-649
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