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

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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 → frictional energy dissipation → heat → 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

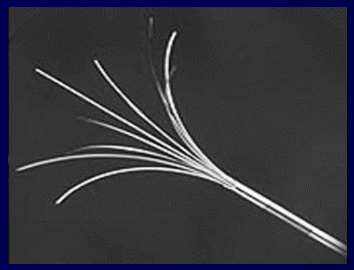
*Stedman's Concise Medical Dictionary, 4th ed., 2001.

THE COMPONENTS

- RF voltage source

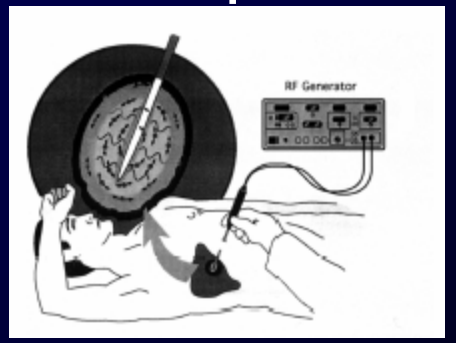
http://www.valleylab.com/static/cooltip/products.html

- Electrode



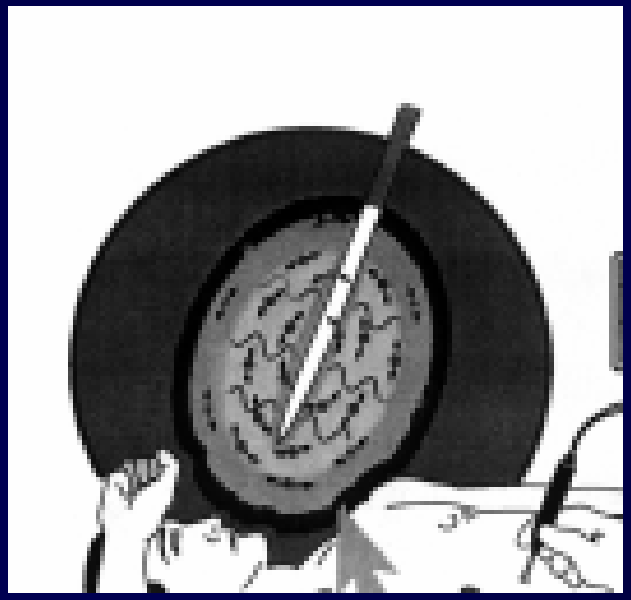
Posteraro AF, Dupuy DE, Mayo-Smith WW, Clin Radiol 2004; 59(9):803-11.

- Image guidance
  - CT
  - US
  - MRI
- The set-up



Goldberg SN and Dupuy DE
J Vasc Interv Radiol 2001; 12:1021-1032.

THE COMPONENTS



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VARIABLES

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

ABLATION – SIZE DEPENDENCE

Hepatic Tumor Diameter (cm)	Total Ablation* (% of cases)
< 2.5	> 90%
2.5 – 3.5	70 – 90%
3.5 – 5.0	50 – 70%
> 5.0	< 50%

* 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 ^{o}C
- 0.5-1.0 cm margin around lesion
- 21- to 14-gauge needle
- Grounding: patient or internal

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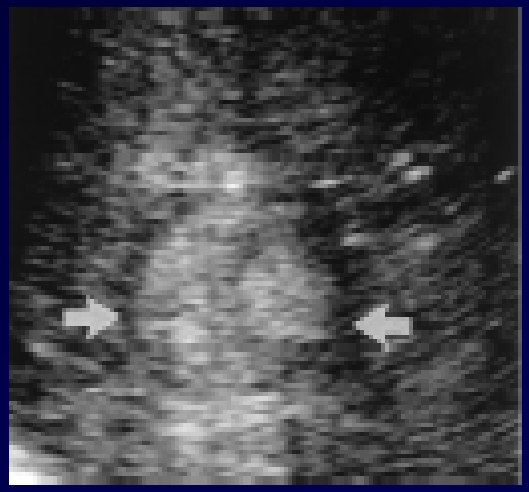
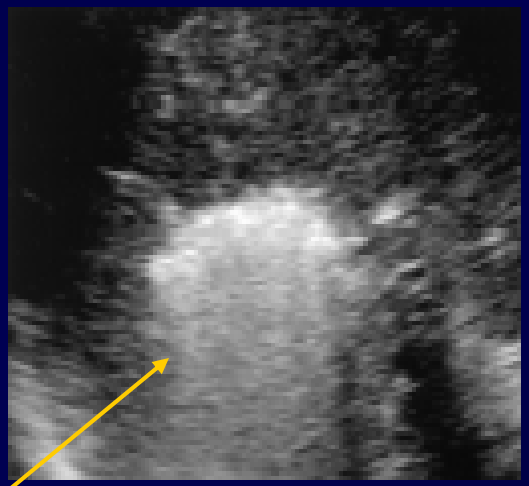
EXAMPLE – RF ABLATION OF HEPATOMA ON ULTRASOUND



PRE-RFA



Echogenicity represents bubbles produced from heating tumor

5 MIN.
INTO RFA

15 MIN.
POST- RFA

Images from Goldberg SN, Dupuy DE. *J Vasc Interv Radiol* 2001; 12:1021-1032.

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

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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

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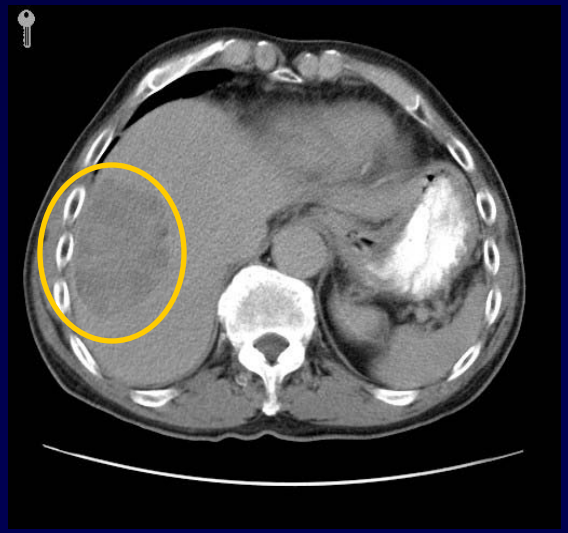
PATIENT 1 – FINDINGS

- 6.0 X 7.4 cm enhancing, hypervascular lesion in r. lobe of liver – biopsy-proven HCC



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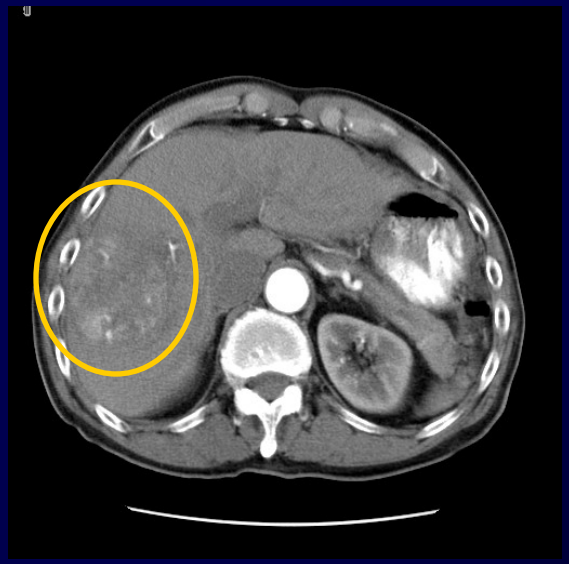
CT W/O CONTRAST



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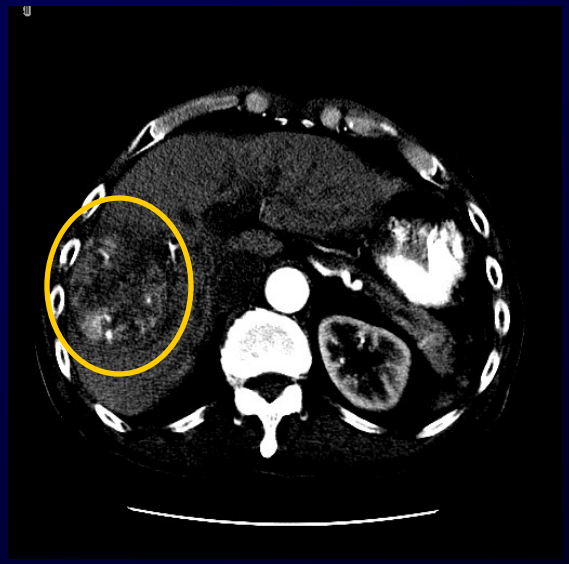
CT W/CONTRAST



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CT LIVER WINDOW

PATIENT 1 – TREATMENT WITH RF ABLATION

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

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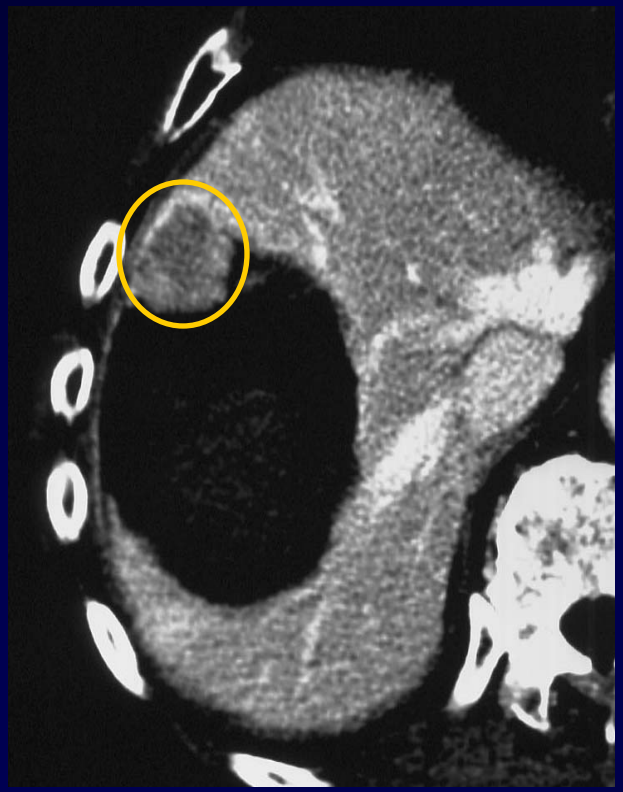
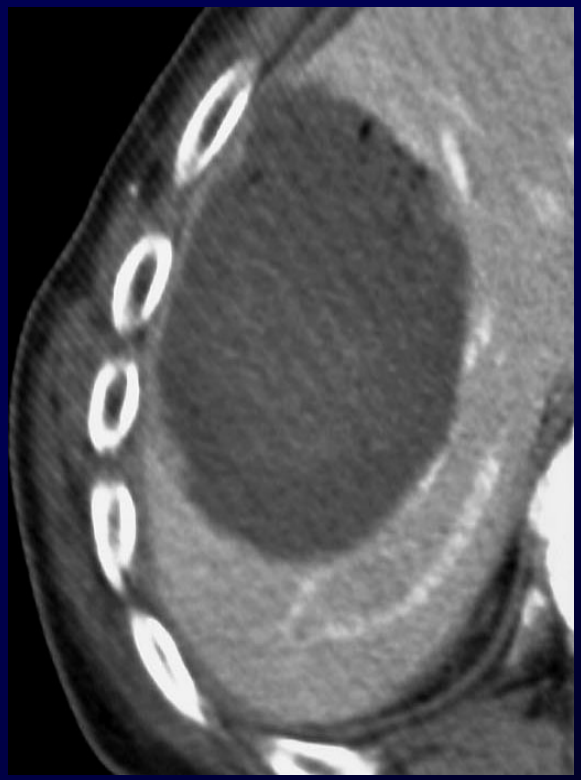
PATIENT 1 - RESULTS



courtesy of Dr. Goldberg, BIDMC

2 WKS. POST-ABLATION



courtesy of Dr. Goldberg, BIDMC

RE-TREATMENT

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PATIENT 1 - RESULTS

courtesy of Dr. Goldberg, BIDMC

PRE-ABLATION

courtesy of Dr. Goldberg, BIDMC

18 MOS. POST-ABLATION

courtesy of Dr. Goldberg, BIDMC

18 MOS. POST-ABLATION
PORTAL VENOUS PHASE

PATIENT 1 - RESULTS

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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

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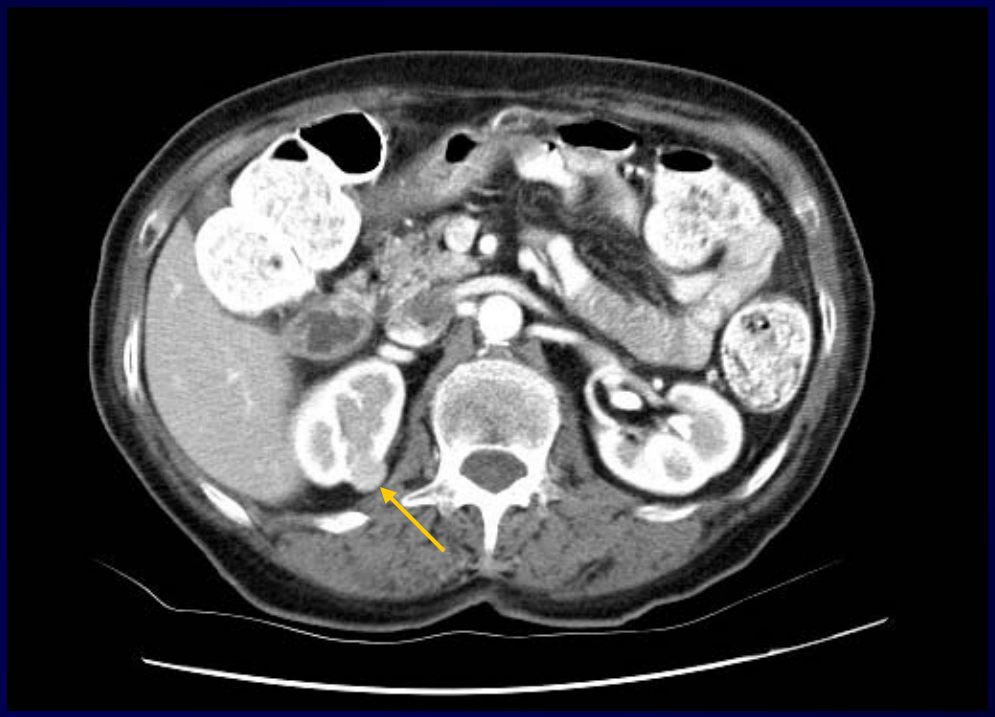
PATIENT 2

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



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CT W/CONTRAST

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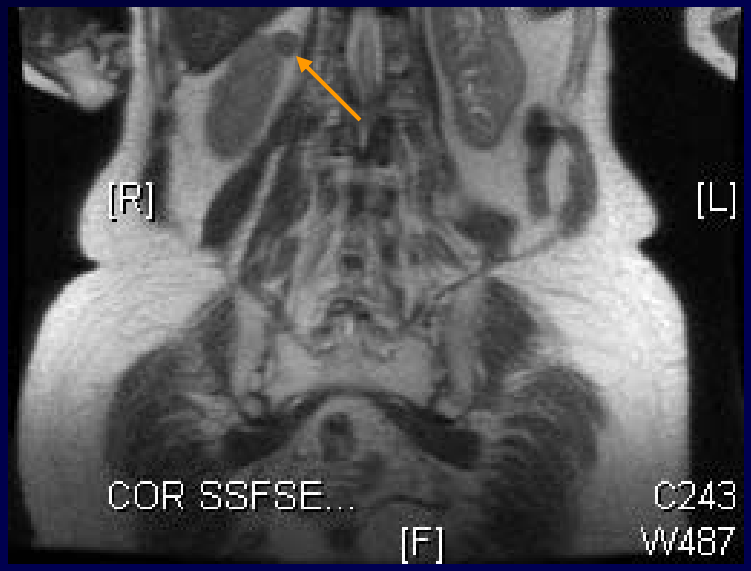
PATIENT 2 – FINDINGS



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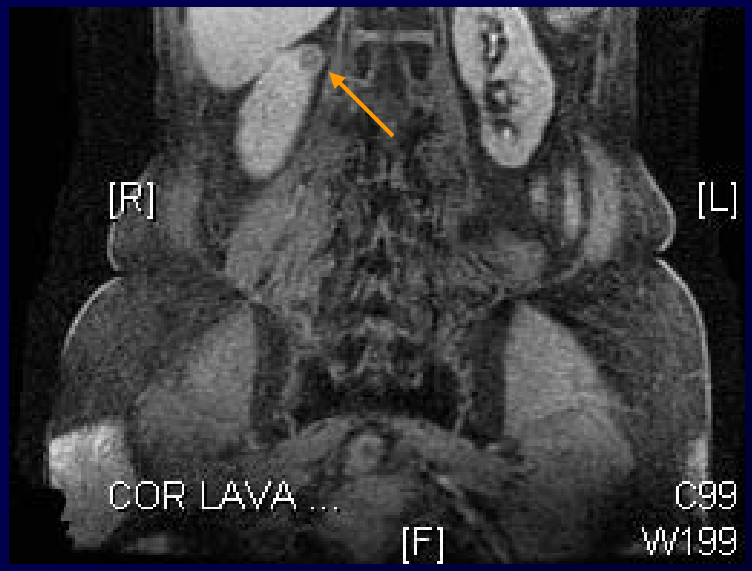
T2 HASTE MRI



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T1 POST-GADOLINIUM

- 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^{o}C

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PATIENT 2 – POST-TREATMENT

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

CURRENT DATA

Lesion	Results*
hepatic tumor < 3.5 cm	> 90% total ablation
colorectal mets	85% local control at 8 mos.
osteoid osteoma	up to 90% treatable
adrenal neoplasms	11 of 13 locally controlled†

*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

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