Current Status Of Image Guided Interventions In Hepatocellular Carcinoma

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Introduction

- 31,000 new cases of RCC each year in USA
- 12,100 deaths every year
- increasing each year
- overall 5-year survival rate for patients with symptomatic lesions was 53%

Introduction - incidental cases

- increase in of renal masses detected with the widespread use of cross-sectional imaging
- increasingly smaller size
- lower clinical stage
- more favorable histologic features
- better survival outcomes than symptomatic lesions
- overall 5-year survival rate for patients 85% for incidental lesions
Introduction

- treatment of RCC has evolved over the past 15 to 20 years
- will continue to evolve with the advent of new percutaneous therapies
- desire for less invasive treatment
- the necessity in some patients with limited renal function to preserve as much functioning renal tissue as possible to avoid dialysis.

- Nephron-sparing surgery Vs in situ tumor destruction
  - 16.3 vs. 2.2%

BARGAIN VASECTOMY CLINIC
“Come on, make my day!”
Together we can!

Working together as a team means winning together as a team.
Ablative therapies

- Radiofrequency
- Cryosurgery
- High intensity focused ultrasound
RFA Principles

Radiofrequency Ablation

Ionic agitation from alternating current causes tissue coagulation through frictional heating. Tissue desiccation increases impedance which eventually decreases current flow.
RFA Principles

Fig. 2 Schematic representation of the RF circuit
RFA technique

The volume of the zone of ablation depends on the

• type or configuration of the electrode
• duration of ablation
• surface area of the electrode
• RF current
• Radius from the electrode
• Patho-physiology of tumour e.g. vascularity

RFA technique

- Coagulation necrosis is tightly correlated with local mean temperature during RFA.
- Necrosis not seen ≤ 50°C.
- Temperature ↑ resulting in diameter of coagulation necrosis ↑.
- 1 cm at 71°C.
- Maximum of 1.6 cm at 80°C with a single straight-needle electrode in ex vivo tissue.

Techniques to increase the volume of tissue necrosis

- multi-tined expandable electrodes
- cluster electrodes
- internally cooled electrodes
- Intra-parenchymal injection of saline before and/or during the RFA,
- pulsed RF current

RFA types of systems
RFA Principles

Fig. 3 Schematic representation of cooled needle, wet needle and expandable needle
RFA Principles
RFA Patient Selection

Goals for RFA are twofold:

- to treat patients who are otherwise at high risk for surgery
- to preserve renal function in patients with limited reserve and/or multifocal RCC
RFA Patient Selection

evaluated by the urology and interventional radiology services

• a previous total unilateral or partial nephrectomy
• advanced age
• a comorbid condition that makes a surgical approach risky, poor renal function
• multiple RCCs
• von Hippel-Lindau disease and multiple primary RCCs are candidates for RFA
  – usually present at a younger age
RFA Patient exclusion

- without co-morbid conditions
- life expectancies longer than 10 years
- metastatic RCC
- without a safe path for percutaneous RFA
RFA tumour selection

- Size and location are predictors of success
RFA tumour selection

- **Tumor size** is an important predictor of successful RFA.
- Generally the range of 1 to 5 cm in single treatments depending on the system and type of electrode.
- Small RCCs are ideal for RFA.
- Larger tumors:
  - multiple overlapping ablations
  - return visits for additional ablation sessions
- Based on the current reported experience, the ideal tumor is 3 to 4 cm or smaller, although tumors up to 5.5 cm have been ablated successfully.
RFA tumour selection

- **Tumor location**
  - present challenges to RFA
  - can influence the likelihood of success.

- **RCCs**
  - Exophytic (extending beyond the renal parenchyma and thus in contact with the perirenal fat)
  - Central (extend into the renal sinus but not peripheral to the renal parenchyma)
  - Mixed tumors (components within the renal sinus and the perinephric fat)
RFA tumour selection

• exophytic renal tumors are treated more successfully than are centrally located tumors.

• Exophytic
  – surrounded by perirenal fat acts a heat insulator
  – permits achievement of higher temperatures
  – the oven effect

• central tumors
  – the absence of perinephric insulating fat
  – central blood vessels (Heat Sink) quickly dissipate
  – effect is most marked for tumors larger than 3 cm.
RFA procedure

- Out-patient
- Conscious sedation
- Coagulation studies
  - prothrombin time
  - partial thromboplastin time
  - baseline hematocrit
  - platelet count,
- histologic examination and/or findings of an enhancing solid mass CT or MRI
- ??? Biopsy
RFA image guidance

- Critical for
  - Accurate placement
  - Assessment of ablation
  - Spot complications early

- US
- CT Fluoroscopy
- MRI Fluoroscopy Thermometry
RFA image guidance

CT and ultrasound
- for targeting only & not for treatment monitoring
- overlapping ablations on the basis of tumor size and geometry
- diameter is compared with the expected in vivo burn diameter of the electrode being used.
- repositioning the needle electrode to ablate the entire tumor.
  - simply pulling back the electrode to cover the length of tumor parallel to the electrode
  - involve withdrawal from the tumor and reinsertion at slightly different angle.
RFA post-procedure

- Prophylactic antibiotics are generally not used
- although their use remains controversial
- Imaging after the procedure need not performed on the same day unless the physician suspects a complication
  - higher than expected degree of pain
  - gross hematuria
  - hypotension
RFA follow-up imaging

- The tumor remains in situ, follow-up imaging is vital so as not to allow residual tumor to grow or go unnoticed.

- MRI before and after the administration of gadolinium:
  - Renal insufficiency with serum creatinine levels higher than 2.0 mg/dL or a history of contrast reactions.
  - Beware progressive massive fibrosis.
**complete ablation**

- absence of enhancement in an area of previously defined tumor enhancement on initial assessment
- based on radiologic and pathologic correlations with liver tumors [38].
- Contrast enhancement measurements are objectively determined by relative increases in Hounsfield units for CT scan and qualitative increases in the intensity of contrast enhancement for MRI
- CT and MRI pre and post CM
### Table 1: Percutaneous and laparoscopic radio frequency ablation for small renal masses

<table>
<thead>
<tr>
<th>Author</th>
<th>RCC/tumor</th>
<th>Tumor size (cm)</th>
<th>Follow-up (months)</th>
<th>Results (CSS, RFS)</th>
<th>Re-treatment rate</th>
</tr>
</thead>
<tbody>
<tr>
<td>McDougall et al. [28]</td>
<td>16/20</td>
<td>3.2 (1.1–7.1)</td>
<td>55.2 (48–60)</td>
<td>94% CSS</td>
<td>5/16</td>
</tr>
<tr>
<td>Zagoria et al. [29**]</td>
<td>125</td>
<td>2.7 (0.6–8.8)</td>
<td>13.8 (1–75.8)</td>
<td>98% CSS</td>
<td></td>
</tr>
<tr>
<td>Park et al. [30]</td>
<td>38/55</td>
<td>2.4 (1–4.1)</td>
<td>24.3 (12–48)</td>
<td>98.5% CSS</td>
<td></td>
</tr>
<tr>
<td>Varkarakis et al. [31]</td>
<td>27/56</td>
<td>2.2 (1–4)</td>
<td>27.5 (12–48)</td>
<td>86.4% RFS</td>
<td></td>
</tr>
</tbody>
</table>

Mean (range). CSS, cancer-specific survival; RCC, renal cell carcinoma; RFS, recurrence-free survival.
Outcomes


- 16 patients with a total of 20 tumors
- reduction in the ablation defect with sequential imaging,
- approaching 92% at 4 years.
- longest follow-up of biopsy-proven RCC RFA treated
Outcomes


- A total of 104 patients with 125 biopsy-proven RCC
- Followed with contrast-enhanced CT or MRI
- 93% complete ablation rate (mean follow-up of 13.8 months)
- 1 RFA in 109 tumors
- 7 of the 16 failures salvaged by repeat RFA or cryoablation.
- All 95 tumors < 3.7 cm completely ablated 1 RFA session
- 14/30 tumors larger than 3.7 cm were treated successfully by a single RFA session.
Outcomes


- 37 percutaneous RFAs on 35 renal tumors in 29 patients (age range, 47–90 years; mean, 69 years).
- 1.0 to 4.0 cm, with a mean size of 2.2 cm
- 28 exophytic and 7 intraparenchymal
- Follow-up imaging was performed at 3-month intervals, with a mean follow-up of 9 months (range, 0–23 months)
- 94% successfully treated 1 RFA
- 85% demonstrated no residual or recurrent enhancement on follow-up CT imaging.
Probe ablative treatment for small renal masses: cryoablation vs.
radio frequency ablation
Raj K. Goel and Jihad H. Kaouk

Purpose of review
Localized renal cell carcinoma has an excellent 5-year survival when treated surgically. Apart from extirpative treatment, ablative techniques are becoming more popular to minimize patient morbidity. Clinically, radio frequency ablation and cryoablation can be performed percutaneously or laparoscopically. Oncological effectiveness of ablative techniques is encouraging as 3-year data are emerging. Our review highlights the current literature demonstrating the effectiveness of cryoablation and radio frequency ablation performed laparoscopically or percutaneously.

Recent findings
Cryoablation performed laparoscopically or percutaneously offers excellent oncological outcomes with single-session therapy. With 3-year cancer-specific survival of 98%, laparoscopic cryoablation is safe and can be performed with minimal insult to overall
RFA vs Cryo

Cryoablation

- laparoscopically or percutaneously
- 3-year cancer-specific survival of 98%,
- is safe
- minimal insult to overall renal function.
- Local recurrence rates and metastatic progression
  - cryoablation over radio frequency ablation
    (4.6 vs. 11.7% and 1.2 vs. 2.3%, respectively).
RFA vs Cryo

- RFA offers similar survival rates
- re-treatment rates are higher (8.8%).
- a higher rate of collecting system injuries when performed percutaneously.
RFA vs Cryo

- Cryoablation and radio frequency ablation are effective treatment modalities for small renal masses in the infirm patient.
- Given patient and technical variability, superiority of either radio frequency ablation or cryoablation cannot be confirmed based on available literature.
- There is a trend towards higher recurrence and re-treatment rates after radio frequency ablation.
Nicotinamide adenine dinucleotide diaphorase (NADH) staining has been used to assess viable cancer cells postablation.

- Tumor recurrence may not develop despite a positive NADH stain.
- The effectiveness of destroying all cancer cells following ablative procedures currently relies on post-procedural imaging.
Combination therapies
What is focused Ultrasound?

- MRgFUS
- Ultrasound is frequencies above 20 kHz
- Well known as an imaging system
  - Imaging is about 0.05 W power
  - Surgery is about 200 W power
How does it work?

- Ultrasound waves are focused on targeted cells.
- Targeted cells heat up and destroyed.
- 56 deg. C for 1-3 seconds.
Operator experience

- Experience from technology-based treatments such as laparoscopic surgery and other health technologies revealed the importance of operator experience and learning curve in new surgical procedures.

### Operator experience

**Table 2**

<table>
<thead>
<tr>
<th>RFA approach and treatment outcomes of study population (group I vs group II)</th>
<th>Group I (42 patients, 63 RFA sessions)</th>
<th>Group II (42 patients, 53 RFA sessions)</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>RFA approach</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Percutaneous</td>
<td>35 (55.6%)</td>
<td>9 (17%)</td>
</tr>
<tr>
<td>Open surgical</td>
<td>27 (42.9%)</td>
<td>37 (69.8%)</td>
</tr>
<tr>
<td>Laparoscopic</td>
<td>1 (1.5%)</td>
<td>7 (13.2%)</td>
</tr>
<tr>
<td>Incomplete ablation</td>
<td>4 (6.3%)</td>
<td>2 (3.7%)</td>
</tr>
<tr>
<td>Post operative complications</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Post operative bleeding</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Liver abscess</td>
<td>1</td>
<td></td>
</tr>
<tr>
<td>Pleural effusion</td>
<td>2</td>
<td>2</td>
</tr>
<tr>
<td>Post operative fever</td>
<td>1</td>
<td>1</td>
</tr>
<tr>
<td>Survival rate</td>
<td></td>
<td></td>
</tr>
<tr>
<td>1 year</td>
<td>69%</td>
<td>93%</td>
</tr>
<tr>
<td>2 year</td>
<td>46%</td>
<td>89%</td>
</tr>
</tbody>
</table>