Type of Ablative Technologies for Small Renal Masses

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MEDICINE

BRADY

Ablative Techniques

- Favored for treatment of small renal masses (<3cm)
  - Preservation of renal function imperative
    - CKD
    - Multiple tumors
    - Solitary kidney
  - Patients with significant co-morbidities
    - Need for anticoagulation
  - Long-term follow up for radiofrequency and cryoablation
- Contraindications
  - Uncorrected coagulopathy
  - Suitable location to create ablation zone
  - Active UTI

Recommendations

- AUA
  - “Clinicians should consider TA as an alternate approach for the management of cT1a solid renal masses <3 cm in size, prefer percutaneous approach.”
- ASCO
  - “percutaneous thermal ablation should be considered for patients who possess tumors such that complete ablation will be achieved”
- European Society of Medical Oncology (ESMO)
  - Acceptable option in patient with small (<3cm) renal tumors and particuly in patients who are frail ,high surgical risk, solitary kidney, compromised renal function, hereditary RCC or multiple bilateral tumors

- All recognize partial nephrectomy as preferred in appropriate patients

Ablate Planning Algorithm

TABLE 3: ABLATE Teaching Points

A (Axial tumor diameter)
Local treatment failures increase with increasing tumor size.
Ablation-related bleeding complications increase with increasing tumor size.
If the tumor is ≥ 3 cm in diameter, consider cryoablation.
If the tumor is ≥ 5 cm in diameter, consider preablation tumor embolization.
B (Bowel proximity)
Ablation-related bowel injury may result in long-term catheter drainage or surgery.
If the tumor is ≤ 1 cm from the colon or small bowel, patient repositioning or bowel displacement maneuvers will likely be necessary.
L (Location within kidney)
Ablation can be performed safely and effectively in locations other than just the posterior and lateral kidney.
If the tumor is in the anterior kidney, hydrodisplacement will likely be necessary to protect adjacent bowel.
If the tumor is in the anterolateral upper pole of the right kidney, a transhepatic approach may be necessary.
If the tumor is in the anteromedial upper pole of the kidney near the adrenal gland, close blood pressure monitoring and even preablation α-receptor blockade may be necessary.
If the tumor is in the medial lower pole of the kidney, displacement techniques may be required to protect the nerves that run along the anterior surface of the psoas muscle.
A (Adjacency to ureter)
Ablation-related ureteral injuries may require long-term stenting or surgery.
If the tumor is ≤ 1 cm from the ureter, retrograde pyeloperfusion via an externalized ureteral stent or ureteral displacement maneuvers will likely be necessary.
T (Touching renal sinus fat)
Local treatment failures are more common with treatment of central tumors (those that touch renal sinus fat).
Ablation-related renal collecting system injuries and major bleeding complications are more frequent with treatment of tumors that touch renal sinus fat.
If the tumor touches renal sinus fat, consider cryoablation.
E (Endo/exophytic)
Local treatment failures are more common with treatment of endophytic tumors (those that are completely contained within the renal capsule).
If the tumor is completely endophytic, consider ultrasound guidance, fusion guidance, or IV administration of contrast agent immediately before ablation for better lesion localization.

Schmitt et al, am J Roentgenol, 2014

Options for Ablation

- Most Common
  - Radiofrequency ablation (RFA) – largely replaced by other technologies
  - Cryoablation (Cryo)
  - Microwave ablation (MWA)

- Evolving
  - Irreversible electroporation (IRE)
  - Stererotactic ablative radiotherapy (SABR)

Kidney Cancer

Oncologic Outcomes Following Partial Nephrectomy and Percutaneous Ablation for cT1 Renal Masses

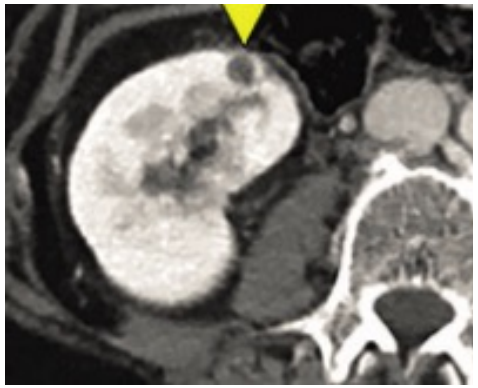
Jack R. Andrews [a], Thomas Atwell [b], Grant Schmit [b], Christine M. Lohse [c], A. Nicholas Kurup [b], Adam Weisbrod [b], Matthew R. Callstrom [b], John C. Cheville [d], Stephen A. Boorjian [a], Bradley C. Leibovich [a], R. Houston Thompson [a,]*

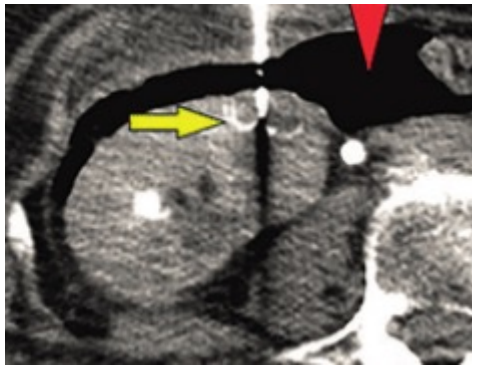
- Large cohort study comparing partial nephrectomy, RFA and CRYO where the 3 year local recurrence-free survival for each was NOT statistically different for cT1a tumors
- 98% for all if you included retreatment

EUROPEAN UROLOGY 76 (2019) 244–251

RFA

- Initial renal ablation technique –
  - radiofrequency power using alternating electrical current
- Thermal coagulation/necrosis and cell death temps > 60 ^{o} C





RFA

- Advantages
  - Extensive outcomes data
  - Single probe
  - Relatively short treatment times
  - Lower cost
- Disadvantages
  - Cannot see “kill zone” on imaging
  - Less effective
    - Larger tumors – charring
    - Central tumors (heat sink effect)

› Eur Urol. 2013 Mar;63(3):486-92. doi: 10.1016/j.eururo.2012.08.062. Epub 2012 Sep 5.

Long-term oncologic outcomes after radiofrequency ablation for T1 renal cell carcinoma

Sarah P Psutka [1], Adam S Feldman, W Scott McDougal, Francis J McGovern, Peter Mueller, Debra A Gervais

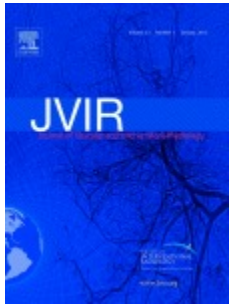
- Local recurrence
  - T1a – 4%
  - T1b – 14%
  - 5/6 treated with local salvage RFA
- Exophytic, small size and non central location favorable

PERCUTANEOUS RADIO FREQUENCY ABLATION OF RENAL MASSES: RESULTS AT A 2-YEAR MEAN FOLLOWUP

IOANNIS M. VARKARAKIS, MOHAMAD E. ALLAF, TAKESHI INAGAKI, SAM B. BHAYANI, DAVID Y. CHAN, LI-MING SU, THOMAS W. JARRETT, LOUIS R. KAVOUSSI AND STEPHEN B. SOLOMON*,†

From The James Buchanan Brady Urological Institute (IMV, MEA, TI, SBB, DYC, L-MS, TWJ, LRK, SBS) and Russell H. Morgan Department of Radiology (SBS), The Johns Hopkins Medical Institutions, Baltimore, Maryland

- 49 patients treated with RFA
- 3 local recurrences
  - All in patients with >3 cm and central tumors



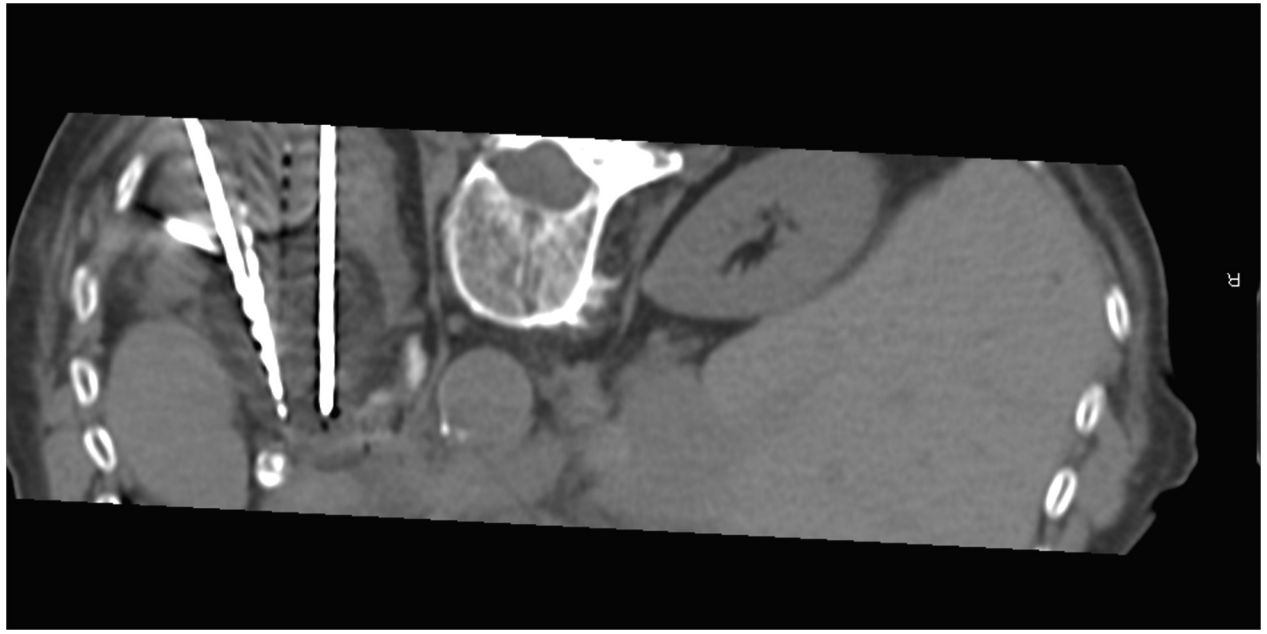
Complications following 573 Percutaneous Renal Radiofrequency and Cryoablation Procedures

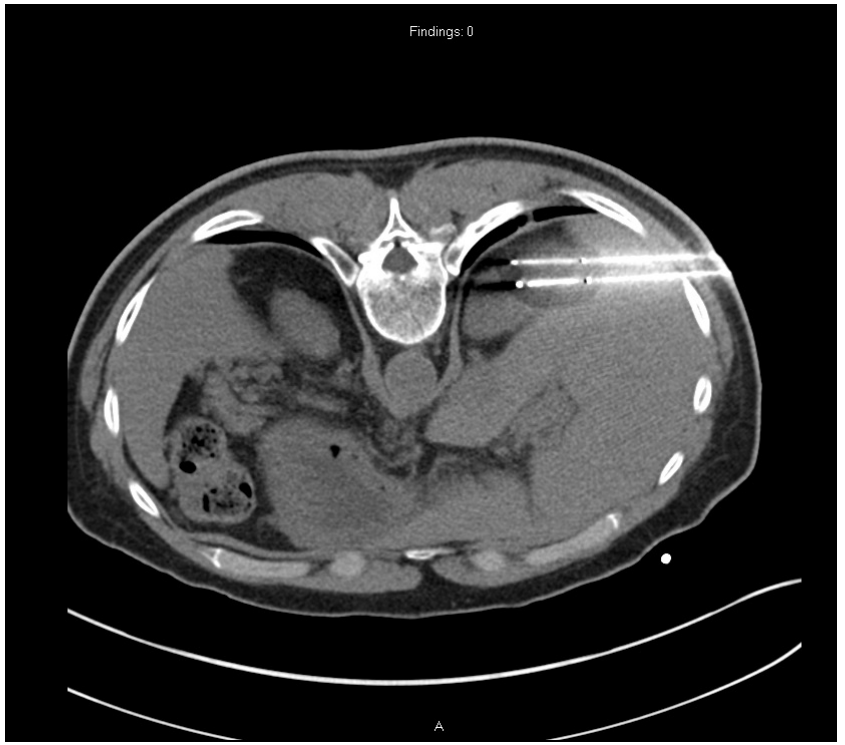
Thomas D. Atwell, MD, Rickey E. Carter, PhD, Grant D. Schmit, MD, Carrie M. Carr, MD, Stephen A. Boorjian, MD, Timothy B. Curry, MD, PhD, R. Houston Thompson, MD, A. Nicholas Kurup, MD, Adam J. Weisbrod, MD, George K. Chow, MD, Bradley C. Leibovich, MD, Matthew R. Callstrom, MD, PhD, and David E. Patterson, MD

- Complication (major) rate – 9.8%
  - Nerve injury – 4%
  - Urothelial injury 5%
  - Bleeding -1%

Cryoablation

- Argon based gas -
  - Low temperatures (-40^{o} C) cell death
- Coagulative necrosis cell death temp < -25^{o} C





Cryo

- Advantages
  - Extensive data
  - Visualization of ice-ball - confirms ablation zone 3-5 mm inside edge
  - Safer near collecting system
  - Larger tumors > 4 cm
- Disadvantages
  - Long treatment times
  - Multiple probes/Complex set up/Higher cost
  - Higher risk of bleeding

Clinical Study

Percutaneous Cryoablation of Stage T1b Renal Cell Carcinoma: Technique Considerations, Safety, and Local Tumor Control

Thomas D. Atwell MD [a], Jay J. Vlaminck MD [a], Stephen A. Boorjian MD [b], Anil N. Kurup MD [a], Matthew R. Callstrom MD, PhD [a], Adam J. Weisbrod MD [a], Christine M. Lohse MS [c], William R. Hartman MD, PhD [d], Andrew H. Stockland MD [a], Bradley C. Leibovich MD [b], Grant D. Schmit MD [a], Robert H. Thompson MD [b]

- 47 patients – tumor size 4.1-6.4cm –(mean4.8)
- ingle recurrence at 9 months
- Prophylactic embolization in 15%

Complications following 573 Percutaneous Renal Radiofrequency and Cryoablation Procedures

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- Major complication rate – 12.2%
- Bleeding most common – 7.44%

Kidney Cancer

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- Similar to RFA in meta comparison
- 92% with primary treatment and 97% with multiple treatments

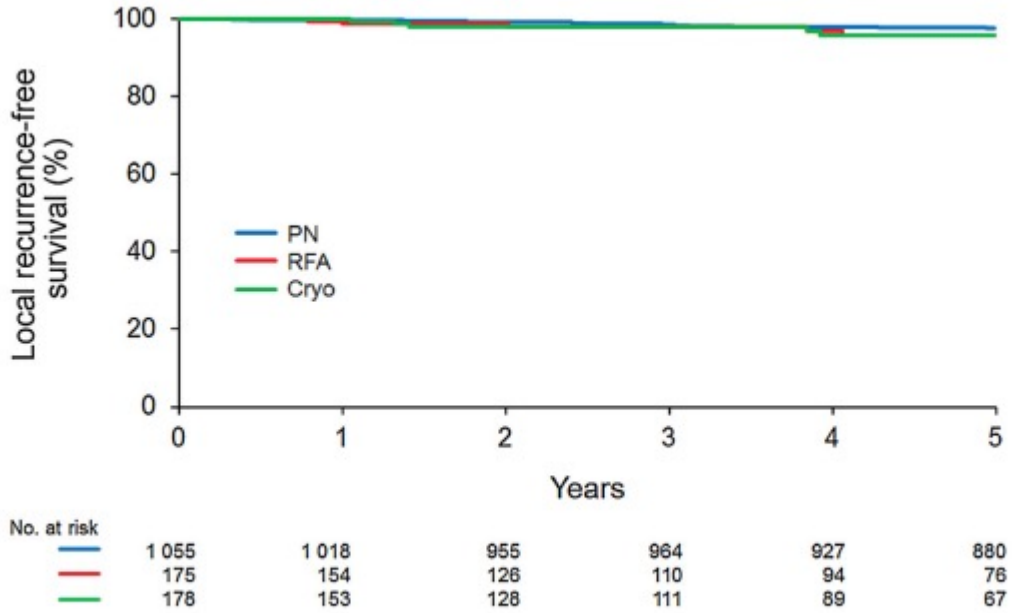
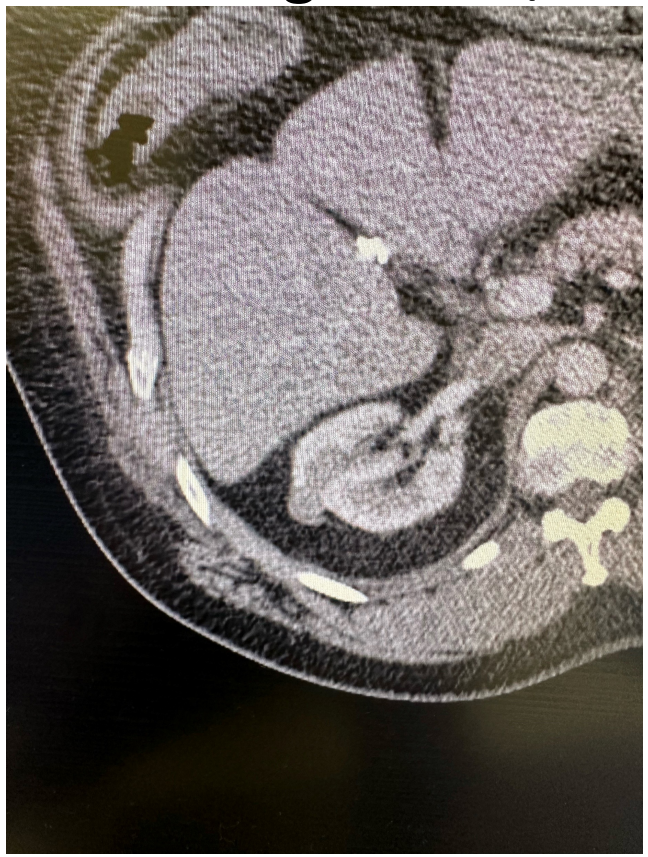


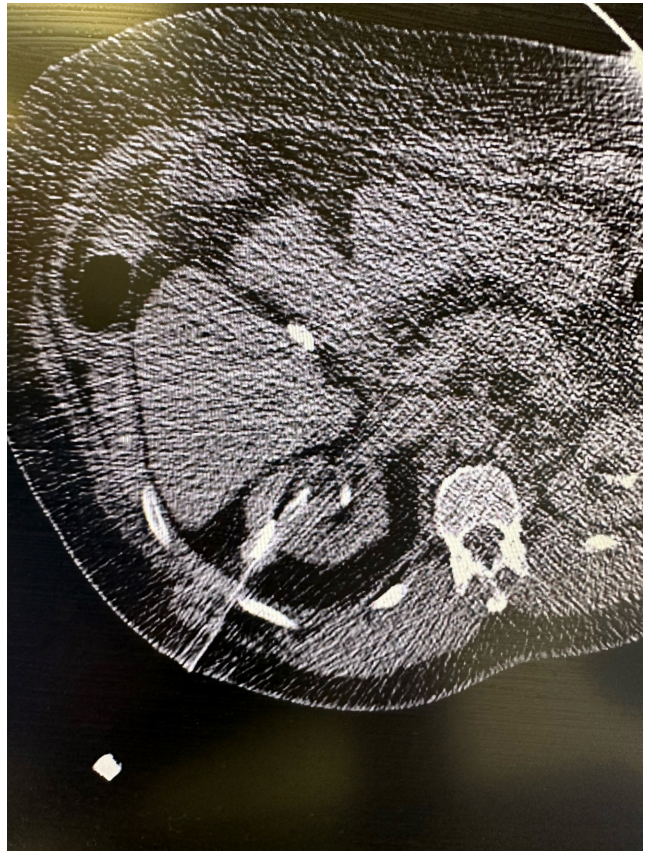
Fig. 1 – Local recurrence-free survival after PN, percutaneous RFA, and percutaneous cryoablation for cT1a patients. Cryo = cryoablation; PN = partial nephrectomy; RFA = radiofrequency ablation.

O, 2019

MWA

- Electromagnetic waves– temperatures > 60^0C
- Thermal coagulation/necrosis





MWA

- Advantages
  - Single probe (antenna)
  - More efficient heating compared to RFA for quicker treatment times with less heat sink
    - Faster treatment
    - Larger and endophytic tumors
- Disadvantages
  - Less predictable ablation zone - Potential for more severe injuries
  - Less data – recent shows equivalent results to standard established therapies
  - Requires general anesthesia

A Comparison of Microwave Ablation and Cryoablation for the Treatment of Renal Cell Carcinoma: A Systematic Literature Review and Meta-analysis

Timothy McClure, Austin Lansing, Nicole Ferko, George Wright, Sudip K. Ghosh, Sajjad Raza, Iftekhar Kalsekar, Kerise Clarke, and Adam Talenfeld

- MWA with lower local tumor recurrence rates one year

Table 1. Summary of single-arm meta-analyses.

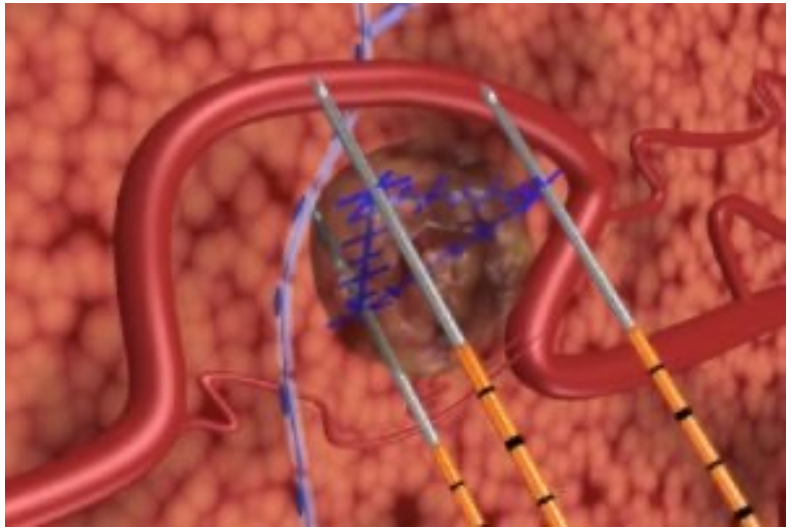
	Cryoablation		MWA	
Outcome	Number of Study Arms	Estimate (95% CI)	Number of Study Arms	Estimate (95% CI)
	Local tumor recurrence			
1-year LTR	18	6% (4%-9%)	15	2% (2%-4%)
2-year LTR	6	5% (3%-9%)	6	3% (2%-6%)
3-year LTR	4	4% (2%-10%)	4	4% (2%-8%)
5-year LTR	4	6% (3%-14%)	4	5% (2%-12%)
	Overall survival			

- Improved ablation times – difference of 24 minutes

2023

IRE

- Nonthermal ablation technique
- Multiple probes place creating electric field between them leading to “apoptotic like” cell death
- Preserves non cellular tissue within the kill zone



Interventional News, 2023

IRE

- Advantages
  - Lower risk for collateral damage – no thermal injury
  - Once probes placed quick treatment time

- Disadvantages
  - New technology – minimal data
  - Multiple probes needed to create field –
  - Interpretation of ablation zone on follow up imaging
  - General anesthesia, deep muscle relaxation, ECG synchronized pulsing
  - cost

Imaging and Noninvasive Therapy

Irreversible Electroporation for the Treatment of Small Renal Masses: 5-Year Outcomes

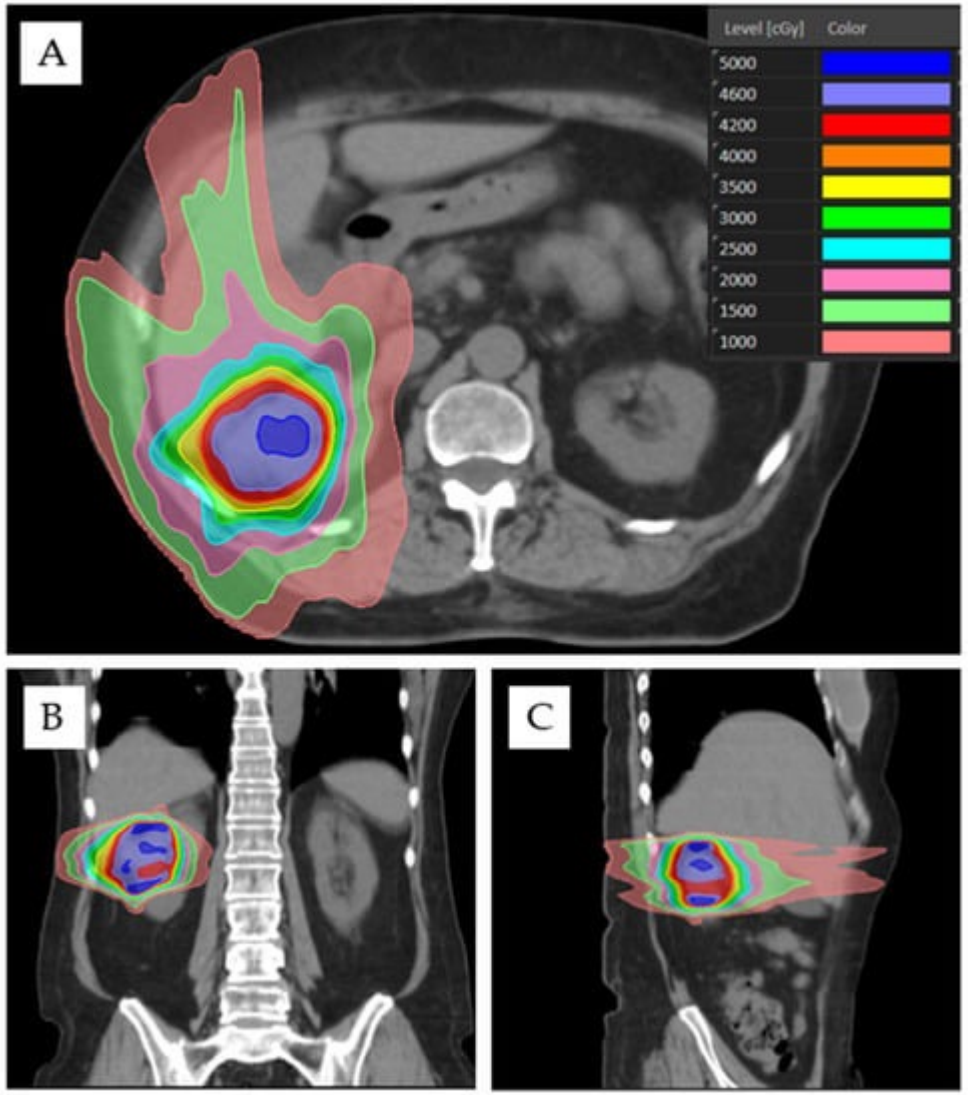
Jessica C. Dai, MD [1], Tara N. Morgan, MD [1], Ryan L. Steinberg, MD [2], Brett A. Johnson, MD [1], Alaina Garbens, MD, PhD [1], and Jeffrey A. Cadeddu, MD [1]

- 46 tumors
- Local recurrence rate = 6/46 (13%)
- Steep learning curve
- Recommend use for only tumors that are purely central and not candidates for standard percutaneous therapies

2022

SABR

- Completely non invasive modality
- Renal cell cancers originally thought to be relatively radioresistant
- Newer technology allows for highly conformal ablative doses to be delivered
  - Important due to presence of adjacent rad sensitive luminal intestinal organs
- Can be delivered in single or multiple fractions
- Motion management - Four-dimensional to accumulate tumor positions throughout all respiratory phases to create an internal target volume (ITV)



Barbour et al, Cancers, 2023

SABR

- Advantages
  - Non invasive – delivery of ablative doses of radiation therapy >6Gy per fraction
  - Patients who desire treatment but are not eligible for surgical procedures or thermal ablative therapies
  - Good local control and low toxicity profile
- Disadvantages
  - Limited short term data
  - Precise targeting an potential treatment of radiosensitive organs (bowel)

5-year outcomes after stereotactic ablative body radiotherapy for primary renal cell carcinoma: an individual patient data meta-analysis from IROCK (the International Radiosurgery Consortium of the Kidney)

Shankar Siva, Muhammad Ali, Rohann J M Correa, Alexander Muacevic, Lee Ponsky, Rodney J Ellis, Simon S Lo, Hiroshi Onishi, Anand Swaminath, Mark McLaughlin, Scott C Morgan, Fabio L Cury, Bin S Teh, Anand Mahadevan, Irving D Kaplan, William Chu, William Grubb, Raquibul Hannan, Michael Staehler, Andrew Warner, Alexander V Louie

- Multi institution
- Single fraction 81, multifraction 109
- Mean tumor size = 4 cm (2.8-4.9)
- 75% deemed **not** operative candidates
- Local recurrence rate = 5.5%

Modality	Efficacy	Safety	Large/Central tumors	Ease/Learning curve	Ablation time	Cost
CA	+	++	+	-	-	-
RFA	+	+	-	+	+	++
MWA	+	+	+	++	++	+
IRE	?	?	?	-	++	--
SABR	?	+/-	+	+	-	-

Summary

- All three established energy sources (RFA, CA, MWA) effective from cancer and safety point of view
  - RFA and CA long-term data
  - Emerging data for MW
  - IRE and SABR still investigational but accumulating data for multiple tumors
- CA has advantage of ice-ball visualization
- Some advantages with MWA with regard to larger and endophytic tumors over RFA

Conclusions

- Partial nephrectomy remains the standard for treatment of small renal masses
  - Definitive diagnosis
  - Highest primary (single) treatment success rates
- Ablation techniques have been used increasingly with similar functional and oncologic outcomes especially with multiple treatments
- In elderly and co morbid patients, tumor ablation is valuable option
- Always consider active surveillance

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