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KIDNEY ABLATION | CLINICAL REVIEW

Renal cell carcinoma (RCC) is the ninth most common neoplasm in the USA and is rapidly increasing in prevalence worldwide[1, 2]. Historically, the treatment for RCC was radical nephrectomy, but partial nephrectomy became the standard of care for small tumors as it preserves renal function and therefore delays or prevents initiation of hemodialysis[3, 4]. More recently, tumor ablation, particularly percutaneous cryoablation, has emerged as an alternative to surgery in the treatment of RCC, specifically for early stage (≤ 4 cm, localized) RCC tumors. The marked increase in volume of percutaneous ablations is likely due in large part to a growing body evidence demonstrating comparable oncologic outcomes with partial nephrectomy, but with decreased complications and preservation of renal function. Included is an overview of the key data sets.

OUTCOME COMPARISON

The scorecard: How do cryoablation and ablation compare to partial nephrectomy across key outcomes?

Metric		How does cryo/ablation compare to partial nephrectomy (PN)?	Limitation
Oncological Outcomes	Local recurrence free survival	Level 1 Data Needed	Older data, meta-analyses include RF
	Metatastic free survival	Ablation = PN	
	Cancer-specific survival	Ablation = PN	
	Overall survival	Level 1 Data Needed	Selection bias – ablation patients tend to be older with more comorbidities
Renal Function		Cryo > PN	
Safety		Cryo > PN	
Cost		Cryo > PN	
Quality of Life		Cryo > PN	
Similar = | Better >			

SINGLE CENTER T1 STUDIES

Andrews et al., 2019

Title	**Oncologic Outcomes Following Partial Nephrectomy and Percutaneous Ablation for cT1 Renal Masses**					
Type of Study	Retrospective review of a prospectively maintained data base					
Number of Patients	**1,798** (1422 T1a: 1055 Partial Nephrectomy, 187 Cryoablation, 180 Radiofrequency Ablation) (376 T1b: 324 Partial Nephrectomy, 52 Cryoablation)					
Method	Partial Nephrectomy (PN)		Cryoablation (CRYO)		Radiofrequency Ablation (RFA)	
Survival Outcomes	3-year[23]	5-year	3-year	5-year	3-year	5-year
T1a Local recurrence free survival [a]	98%	97.4%	98%	93.4%	98%	94.5%
T1a Metastatic free survival [a]	99%	98%	100%	100%	93%	93.9%
T1a Cancer-specific survival [a]		99.3%		100%		95.6%
T1a Overall survival [c]	95%	92%	88%	77%	82%	72%
T1b Local recurrence free survival [b]	96%	91.6%	97%	92.7%		
T1b Metastatic free survival [b]	96%	94%	92%	90%		
T1b Cancer-specific survival [b]		98%		91%		
T1b Overall survival [c]	93%	90%	74%	56%		
Approach & Protocol			Average of 2 cryoprobes per tumor. Freeze until 5 mm margin is achieved during both freeze cycles.*			
Device used			Varian Perc-24 system. 2.4 mm diameter (13-gauge) probes			

9 minute freeze
10 minute thaw
9 minute freeze
10 minute active thaw

[a] Local recurrence, metastases, and cancer-specific survival were not statistically significantly different among PN, Cryo, and RFA for T1a.

[b] Local recurrence, metastases, and cancer-specific survival were not statistically significantly different among PN and Cryo for T1b

[c] Observed lower overall survival for cryo versus PN in T1a and T1b patients ($p < 0.001$), this is likely due to selection bias. Cryo patients were older and had higher Charlson scores.

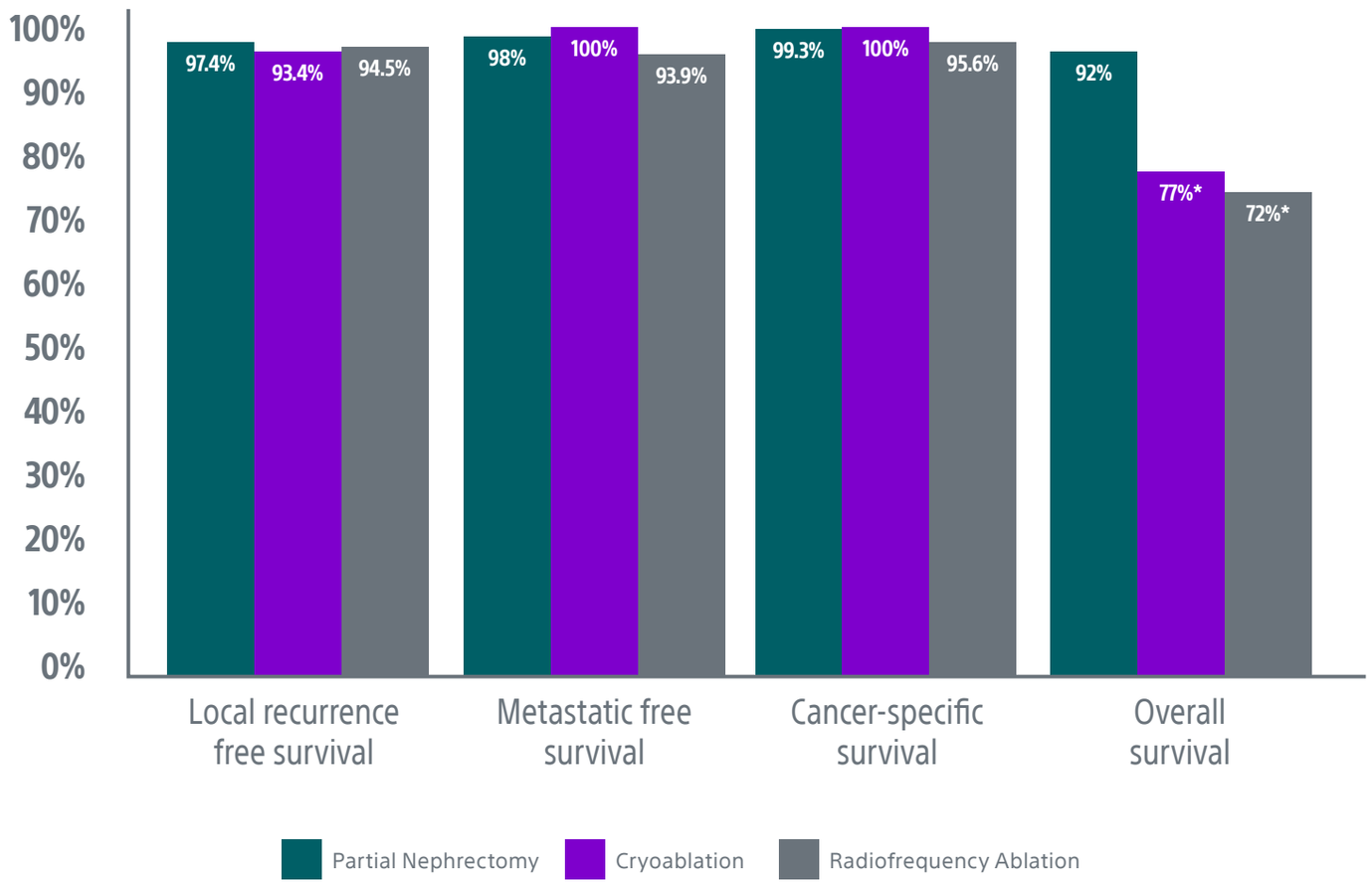
*Atwell TD, et al. Percutaneous renal cryoablation: experience treating 115 tumors. J Urol. 2008 Jun;179(6):2136-40; discussion 2140-1. doi: 10.1016/j.juro.2008.01.144. PMID: 18423719

SINGLE CENTER T1 STUDIES

Andrews et al., 2019 | Conclusion

With mature follow-up at a single institution, percutaneous ablation appears to have acceptable results for cT1 renal tumors and is appropriate for patients with a contraindication for surgery. **For cT1a patients, clinically relevant differences between PN and ablation are unlikely and treatment choice should involve shared decision making.** For cT1b patients, death from RCC was more common with cryoablation and large differences in this outcome cannot be ruled out.

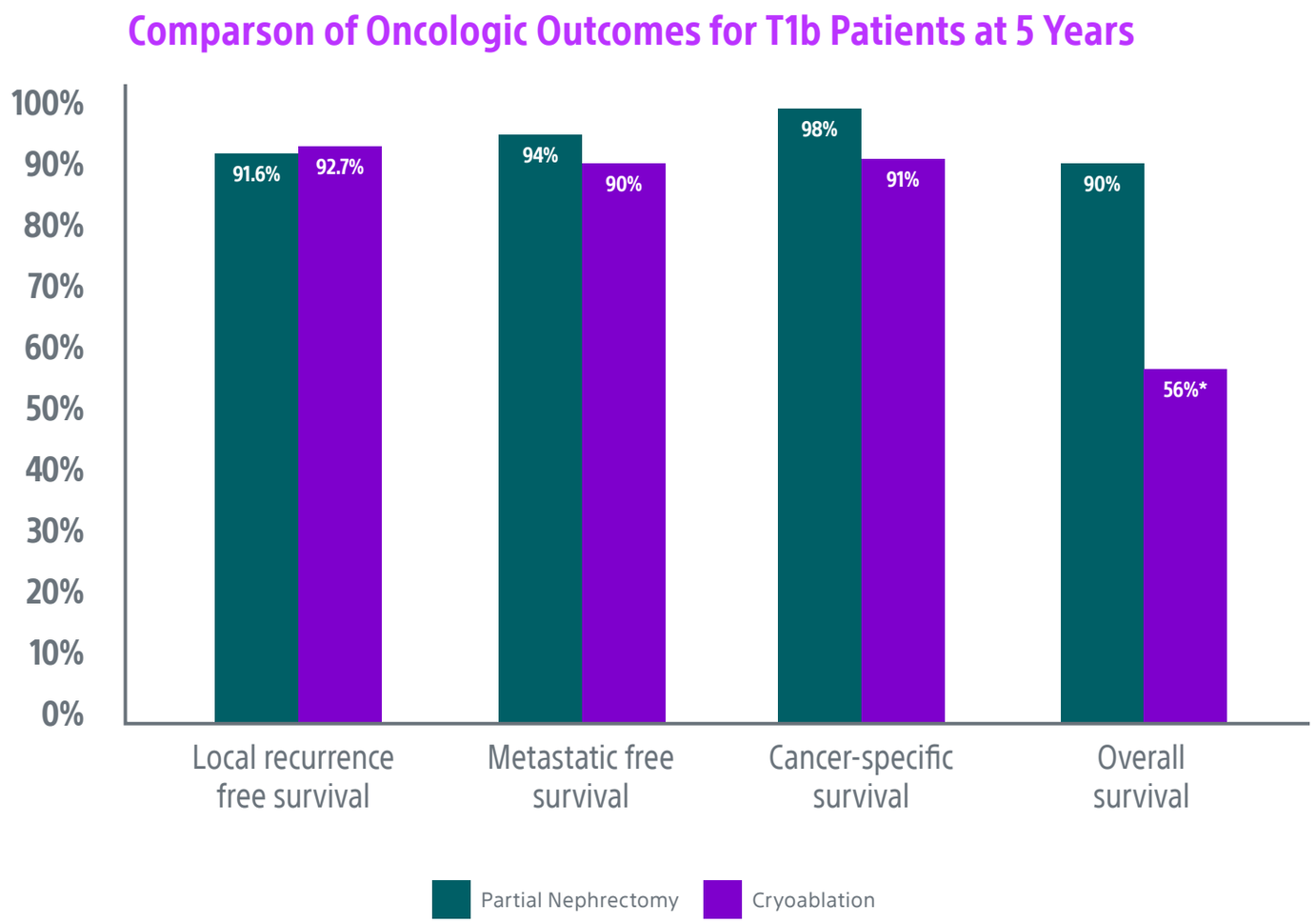
Comparson of Oncologic Outcomes for T1a Patients at 5 Years



 *Statistically significant

SINGLE CENTER T1 STUDIES

Andrews et al., 2019 | Conclusion



*Statistically significant

SINGLE CENTER T1 STUDIES

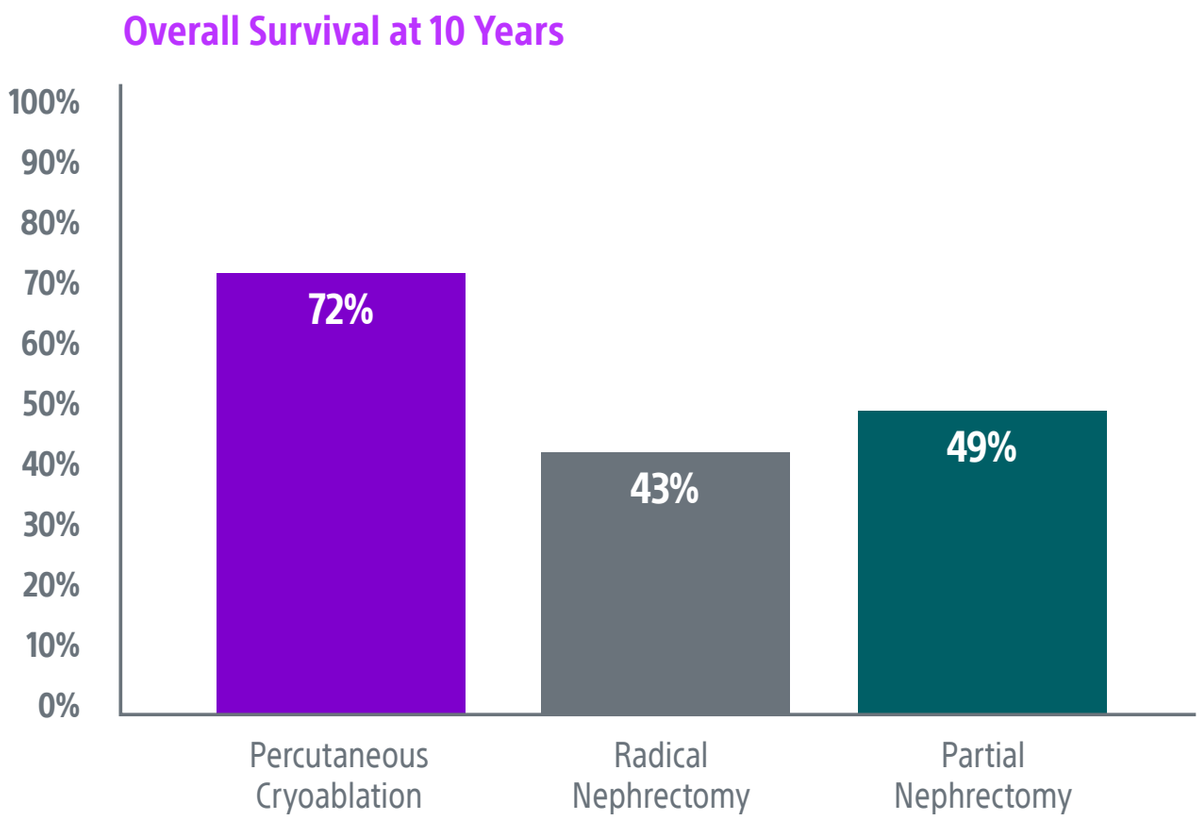
Morkos et al., 2020

Title	**Percutaneous Cryoablation for Stage 1 Renal Cell Carcinoma: Outcomes from a 10-year Prospective Study and Comparison with Matched Cohorts from the National Cancer Database**					
Type of Study	Prospective observational study. Single center.					
Number of Patients	**134**					
Method	Percutaneous Cryoablation (PCA)		Partial Nephrectomy (PN)		Radical Nephrectomy (RN)	
Survival Outcomes (primary objectives)	5-year	10-year	5-year	10-year	5-year	10-year
Recurrence free survival	85%	69%				
Disease-specific survival	94%	**94%**	**10 year disease specific survival of 94%** is comparable to that reported for surgical interventions			
Overall survival	**87%**	**72%**	78%	49%	67%	43%
	PCA group outperformed both PN and RN subgroups in overall survival at both 5 and 10 years, a trend that became more pronounced for patients with comorbidities (higher CDCC scores).					
Other Outcomes (secondary objectives)						
Risk for metachronous RCC	6%					
Risk for hemodialysis	**2.3%**	Comparable to that reported in literature for surgical treatments, which ranges from **2.5%-2.7%**				
Rate of complications	**8%**	Low compared to reported surgical complications				
Approach and Protocol		Biopsy planned at the time of ablation unless patient had prior diagnostic biopsy. Objective to generate iceball extending 5 mm beyond tumor margin. Baseline non contrast CT obtained with patient prone. If nontarget organ was within iceball, 22-gauge spinal needle inserted between RCC and that organ provided air and/or hydrodissection. **10 minute freeze** → **8 minute thaw** → **10 minute re-freeze**				

SINGLE CENTER T1 STUDIES

Morkos et al., 2020 | Conclusion

Biopsy-proven renal cell carcinoma showed that **percutaneous cryoablation was associated with a high disease-specific survival (94%) and better overall survival compared with partial or radical nephrectomy at 10 years.**



SINGLE CENTER T1 STUDIES

Breen et al., 2018

Title	**Image-guided Cryoablation for Sporadic Renal Cell Carcinoma: Three- and 5-year Outcomes in 220 Patients with Biopsy-proven Renal Cell Carcinoma**	
Type of Study	Retrospective evaluation of prospectively maintained database. Single center.	
Number of Patients	**433 patients undergoing cryoablation** with 220 patients with biopsy-proved RCC and > 3-month follow-up	
Survival outcomes for biopsy-proven RCC with > 3-month follow-up (220)	3-year	5-year
Local recurrence free survival	97.2%	**93.9%**
Metatastic free survival	97.7%	94.4%
Overall survival	93.2%	84.8%
Outcomes for all patients (433)		
Treatment efficacy after primary ablation (no residual enhancing tumor by 3 months)	453/474 tumors – 95.6%	
Overall treatment efficacy after secondary ablation	465/474 tumors – 98.1%	
Major complication rate	**23/473 procedures – 4.9%**	
Overall survival	91.7% at 3 years, 78.8% at 5 years	
Mean hospital stay	1 day for Cryo, 4 days for PN	
Approach and Protocol	All patients in prone-oblique position. Average of 4, 17-gauge probes used per procedure. Tinted saline hydro dissection for displacement of critical structures (bowel, pancreatic tail) in 47% of procedures. CT monitoring at 4 min intervals to ensure extension of iceball 5 mm beyond tumor margin	
Device Used	17-gauge Boston Scientific needles	

Larger tumors (T1b) did not have a lower local recurrence-free survival rate compared to T1a tumors.

Transfusions and embolizations due to complications were significantly lower than previous publications by the same group. This was attributed to use of 17 G Boston Scientific probes compared to thicker probes from competitors.

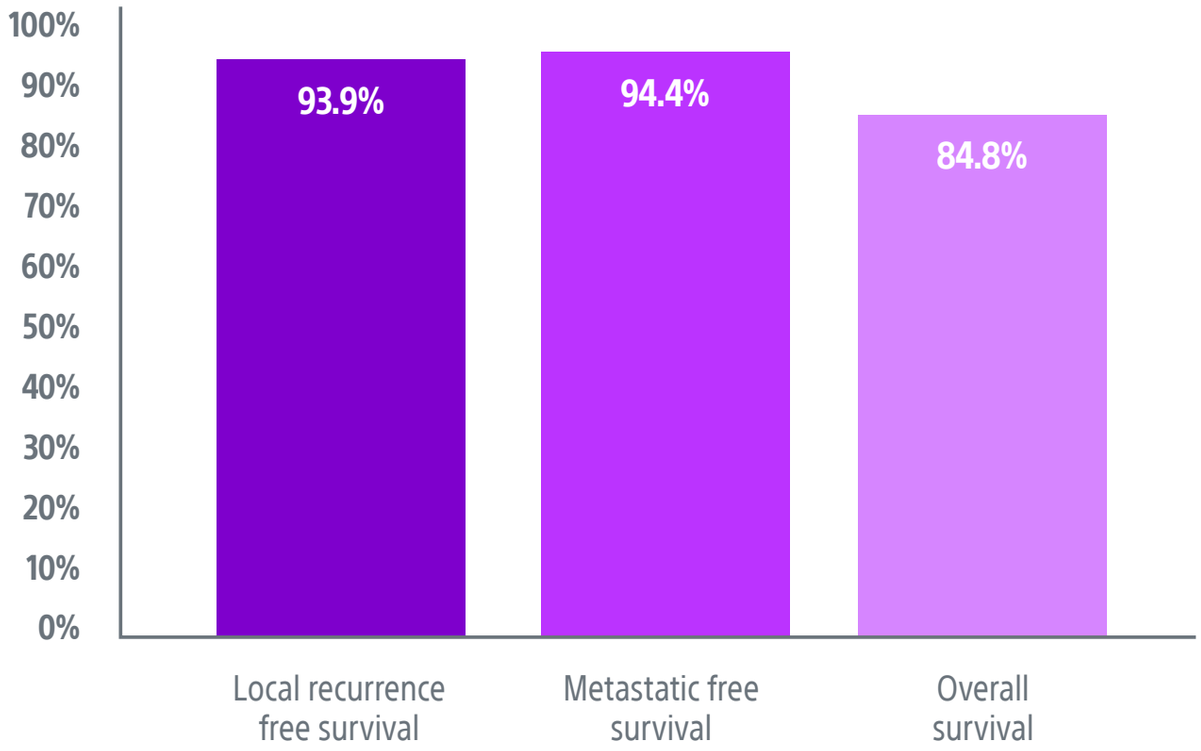
10 minute freeze
8 minute thaw
10 minute freeze

SINGLE CENTER T1 STUDIES

Breen et al., 2018 | Conclusion

Oncologic outcomes of image-guided renal cryoablation for RCC are competitive with those of partial nephrectomy and are associated with a low complication rate. While active surveillance is common, particularly in elderly patients with small tumors and reasonable life expectancies, it is predicated on the risk of surgery. Given the low complication rate associated with cryoablation, renal **cryoablation may present a useful, less-invasive treatment option for these patients.**

Oncologic Outcomes for Cryoablation at 5 Years for Biopsy-Proven RCC



SINGLE CENTER T1 STUDIES

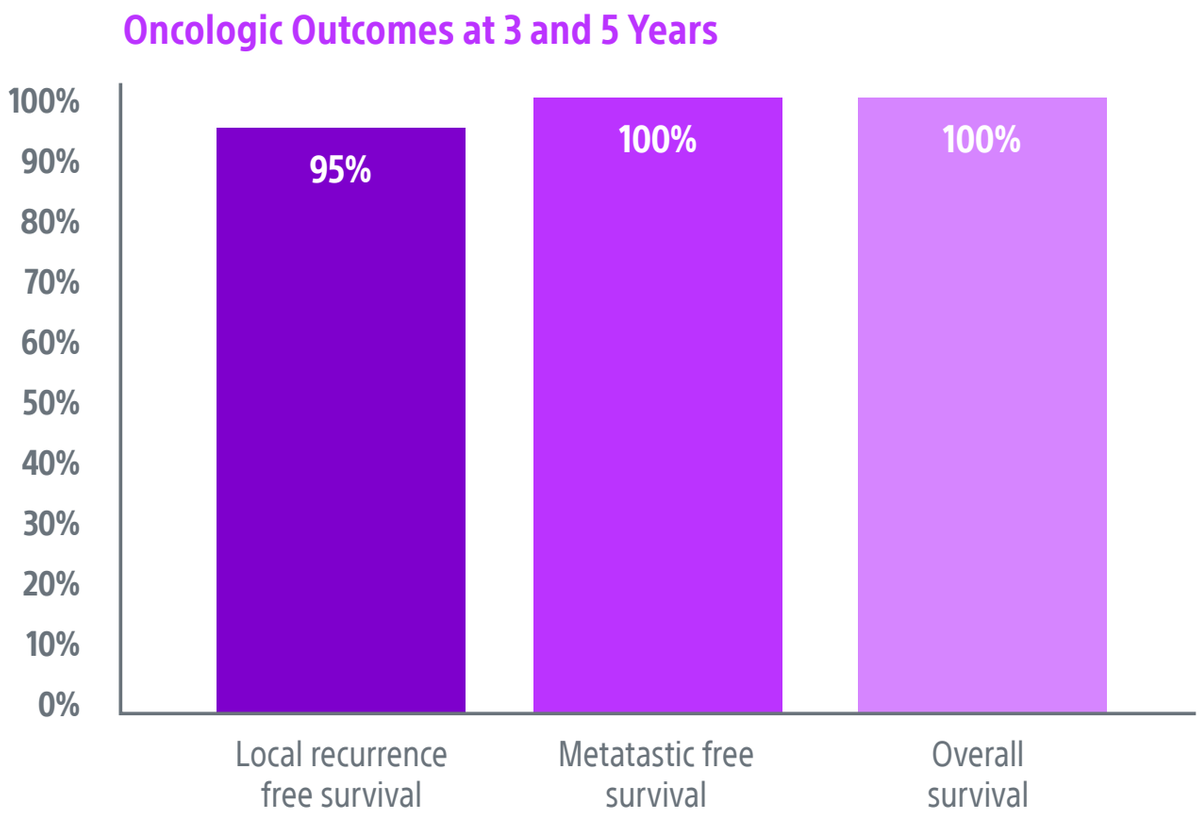
Lim et al., 2020

Title	**Outcomes of Renal Tumors Treated by Image-Guided Percutaneous Cryoablation: Immediate and 3- and 5-Year Outcomes at a Regional Center**	
Type of Study	Retrospective review of a prospectively maintained databased. Regional center.	
Number of Patients	**180** (168 T1a, 17 T1b)	
Oncologic Outcomes	3-year	5-year
Local recurrence free survival	98.3%	94.9%
Metatastic free survival	100%	100%
Disease-specific survival	100%	100%
Other Outcomes		
Technical success (iceball coverage of 5 mm beyond tumor margin)	98.9%	
Major complication rate (Clavien-Dindo > grade III)	2.2% Bleed from lumbar artery Bleed in collecting system Pneumothorax Pulmonary embolus	
Renal function	No significant difference in eGFR before and immediately after procedure, or a 2-year follow-up.	
Approach and Protocol	**10 minute freeze** → **8 minute thaw** (6 min passive, 2 min active) → **10 minute freeze** → **8 minute thaw** (6 min passive, 2 min active) CT scans at 5 and 10 minutes to monitor iceball and assess complications.	
Device Used	17-gauge Boston Scientific needles	

SINGLE CENTER T1 STUDIES

Lim et al., 2020 | Conclusion

In conclusion, image-guided cryoablation offers a promising treatment option for cT1 RCC, **offering long-term oncologic outcomes that rival more invasive methods with the benefit of an improved safety profile.**



SINGLE CENTER T1B STUDIES

Gunn et al., 2019

Title	Percutaneous Cryoablation of Stage T1b Renal Cell Carcinoma: Safety, Technical Results, and Clinical Outcomes		
Type of Study	Retrospective review. Single center.		
Number of Patients	37		
Oncologic Outcomes	1-year	2-year	3-year
Recurrence-free survival	96.5%	86.1%	62.6% [a]
Cancer-specific survival	100%	100%	100%
Overall survival	96.7%	91.8%	77.6% [b]
Other Outcomes	**88.2%** Technical success (coverage of lesion by iceball and absence of enhancement or tumor enlargement within 3 months of ablation)		
Complications	16.2% complications CIRSE grade 2 or above. [c]		
Approach & Protocol	Median number of probes used: 3 Mean number of cryoablation procedures per patient: 1.5 Pre-ablation biopsy performed in 62.2% of patients Angio-embolization used in 8.1% of patients Hydro-dissection in 5.4% of patients	10 minute freeze 8 minute thaw 10 minute freeze Active thaw	
Device Used	IceForce™ 2.1 mm, IcePearl™ 2.1 mm, IceSphere™ 1.5 mm, IceRod™ 1.5 mm (Boston Scientific), Perc-24 2.4 (Varian)		

[a] Current guidelines note that thermal ablation of larger tumors should be utilized with caution due to higher rates of local recurrence compared to partial nephrectomy. However, these guidelines are based largely on experience with laparoscopic cryoablation and RFA rather than percutaneous cryoablation (see citations)

[b] Charlson comorbidity index was the only variable associated with overall survival

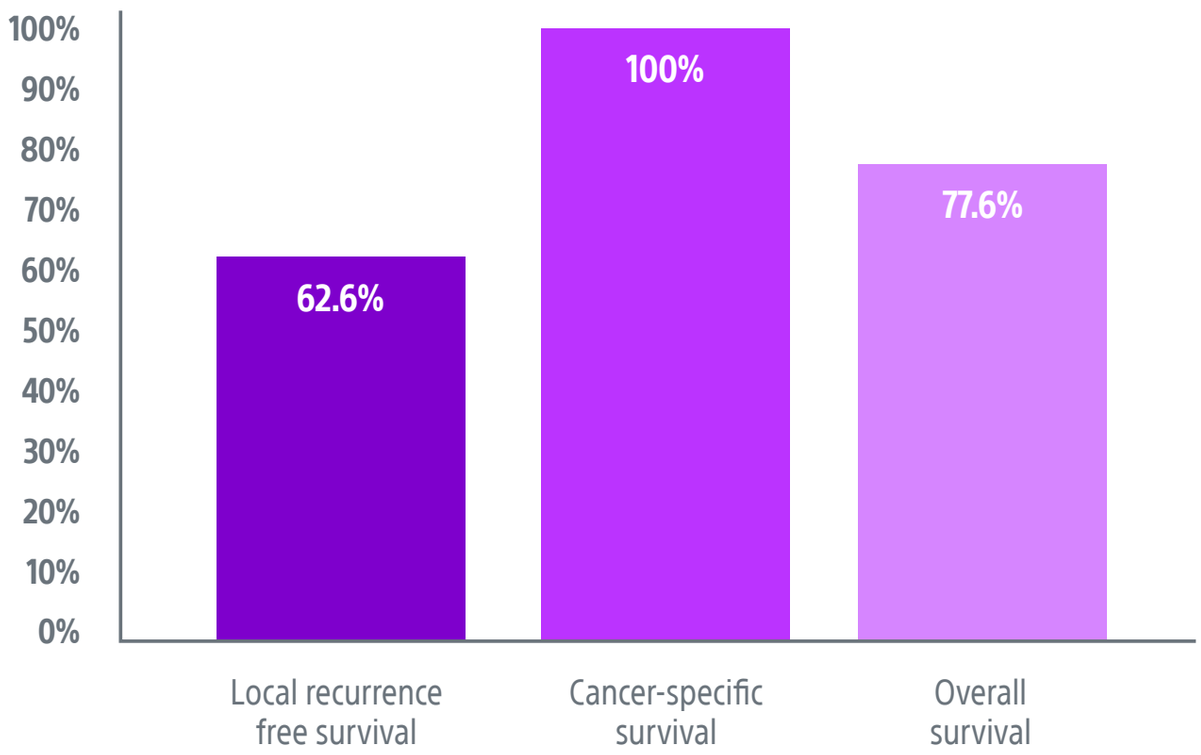
[c] Complications not associated with tumor size or number of cryoablation probes. The variables associated with complications were: endophytic/mixed tumors, involvement of renal sinus, and displacement/infiltration of collecting system. Endophytic/mixed tumors were 12x more likely to have complications than exophytic. Patients with tumors involving renal sinus were 6x more likely to experience an adverse event.

SINGLE CENTER T1B STUDIES

Gunn et al., 2019 | Conclusion

Percutaneous cryoablation is a viable option for T1b RCC with low rates of high-grade complications. Local recurrence remains a concern in the cryoablation of these tumors, however high rates of technical success may be achieved with excellent cancer-specific survival at 1, 2, and 3 years.

Oncologic Outcomes at 3 Years (T1b)



SINGLE CENTER T1B STUDIES

Shimizu et al., 2021

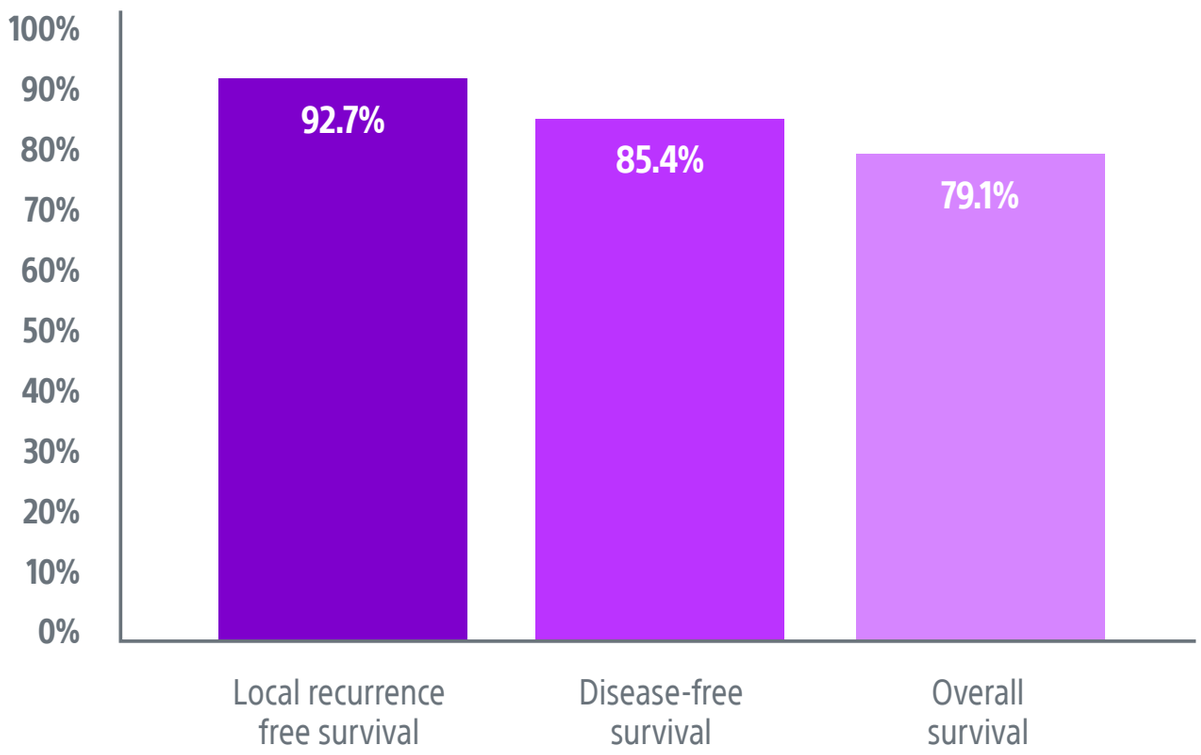
Title	**Image-guided percutaneous cryoablation of T1b renal cell carcinomas in patients with comorbidities**			
Type of Study	Retrospective review. Single center.			
Number of Patients	**28**			
Oncologic Outcomes	1-year	2-year	3-year	5-year
Local recurrence-free survival	92.7%	92.7%	92.7%	92.7%
Disease-free survival	89.1%	85.4%	85.4%	85.4%
Overall survival	96.3%	96.3%	92.3%	79.1%
	Patients were classified into either high-risk or low-risk cohorts, based on their Charlson Comorbidity Index (ACCI) and their Renal Nephrometry Scores (RNS). This study found no significant difference in overall survival, local recurrence-free survival, and disease-free survival between the high and low-risk group.			
Other Outcomes				
Technical success (complete tumor ablation)	**96.4%** 27/28 patients had complete tumor ablation after first procedure. The 1 patient received second ablation procedure resulting in complete ablation of the tumor.			
Renal Function	This study found that having only a single kidney was the only risk factor in predicting worsening renal function after percutaneous cryoablation.			
Approach & Protocol	**15 minute freeze** → **5 minute thaw** → **15 minute freeze**			
Device Used	17-gauge Boston Scientific			

SINGLE CENTER T1B STUDIES

Shimizu et al., 2021 | Conclusion

PCA is a safe and feasible nephron-sparing treatment for stage T1b RCCs, although some patients require a large number of cryoneedles or repeat PCA. Even patients with multiple comorbidities can achieve local tumor control similar to that of low-risk patients.

Oncologic Outcomes at 5 Years (T1b)



SINGLE CENTER T1B STUDIES

Hebbaj et al., 2017

Title	**Safety Considerations and Local Tumor Control Following Percutaneous Image-Guided Cryoablation of T1b Renal Tumors**		
Type of Study	Retrospective review. Single center.		
Number of Patients	**27**		
Oncologic Outcomes	1-year	2-year	3-year
Local tumor control	82.6%	72.3%	**60.3%** [a]
Cancer-specific survival	95.7%	95.7%	95.7%
Other Outcomes	**Technical efficacy (no contrast enhancement and no enlargement of ablation area at 3 months)** **87.5%** In 3 non-efficacious cases, 1 received PN, 1 received repeat ablation with complete efficacy, and 1 was lost to follow-up after 3 months		
Complications	**11.1% experienced complications grade 2 or above on the Clavien-Dindo scale**		
Approach & Protocol	Mean number of probes used: 5.3 Embolization used in 33.3% of patients Hydro-dissection in 77.8% of patients	**10 minute freeze** **10 minute thaw** **10 minute freeze**	
Device Used	IceForce, IceSphere, IceRod, IceEdge (Boston Scientific)		

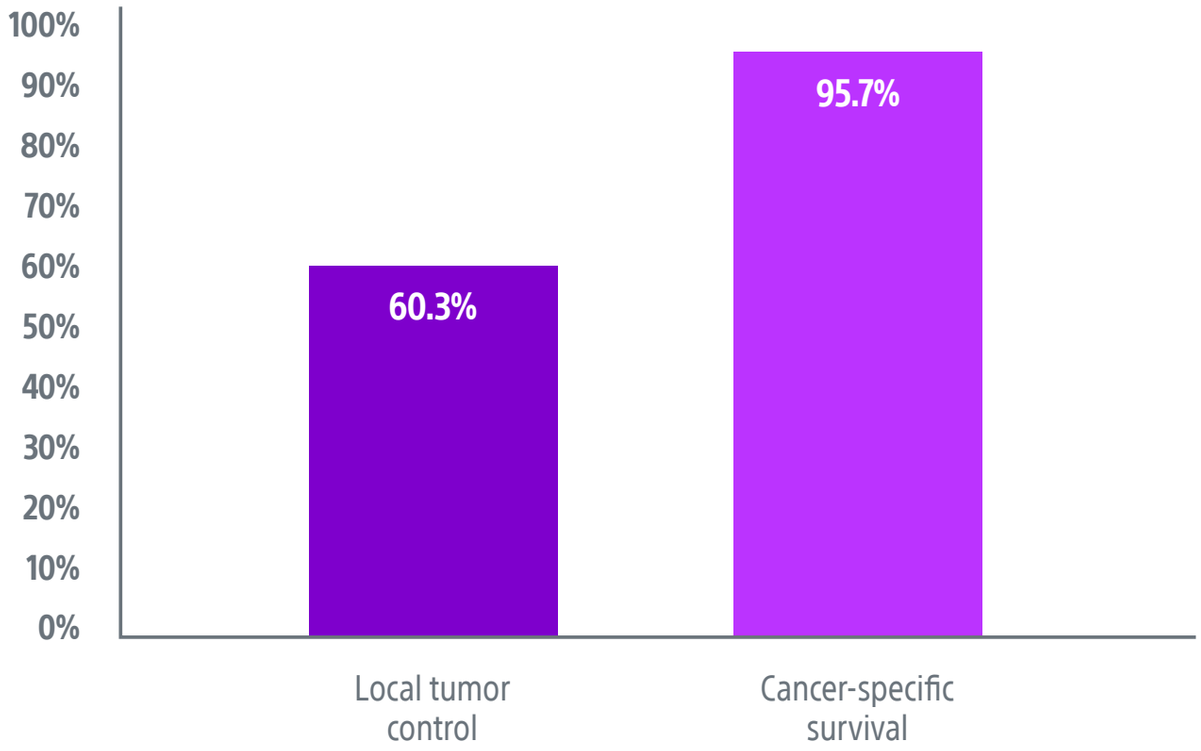
[a] LRFS decreased at 3 years, but few patients completed follow up at 3 years.

SINGLE CENTER T1B STUDIES

Hebbaj et al., 2017 | Conclusion

Early oncological efficacy of T1b renal tumors undergoing percutaneous CA was confirmed with acceptable complication rates. Due to the lack of prospective randomized studies comparing the outcome of CA to PN, the former should be still strictly proposed to ''non-surgical'' candidates presenting with T1b renal tumors; hence, further studies are mandatory to confirm the long-term efficacy of this procedure.

Oncologic Outcomes at 3 Years (T1b)



META ANALYSES AND DATABASE POPULATION STUDIES

Chan et al., 2022

Title		**Ablative therapies versus partial nephrectomy for small renal masses - A systematic review and meta-analysis**
Type of Study		Systematic review and meta-analysis
Number of Patients		**31 studies reporting on 74,946 patients**
Results		
T1a	**Cancer-specific survival (7 studies, 4,181 patients)**	CSS for AT similar to PN (HR 0.68, p = 0.10) No significant differences nor heterogeneities observed between different AT treatment modalities
	Overall survival (11 studies, 17,002 patients)	OS significantly worse in AT compared to PN (HR 1.64, p < 0.001) However, this difference is mainly due to the significant older age of AT cohorts compared to the PN cohort (Mean Difference 5.70, p <0.001)
	Local recurrence-free survival (13 studies, 3,211 patients)	LRFS for AT significantly worse compared to PN (HR 2.55, p < 0.001) However, when only studies with follow-up over five years were included, LRFS was no longer significantly different between AT and PN (HR 1.54, p = 0.131)
	Metastatic-free survival (5 studies, 3,076 patients)	MFS for AT similar to PN (HR 1.01, p = 0.98)
	Disease-free survival (6 studies, 1,320 patients)	DFS for AT similar to PN (HR 1.44, p = 0.18)
	Post-operative complications (16 studies, 4,815 patients)	AT has significantly lower risk in developing any post-operative complications compared to PN. However, percutaneous ablation seems to have similar rates of complications compared to PN (Risk Ratio 0.93, p = 0.74).
	Change in estimated glomerular flow rate (eGFR) post-operatively (6 studies, 887 patients)	Decreases in eGFR significantly smaller for AT compared to PN (Mean Difference – 7.42, p = 0.01)
T1b	**Cancer-specific survival (7 studies)**	Similar for AT and PN in both matched and long-term follow-up cohorts. However, one exception (Pecocraro et al.) noted cancer-specific mortality worse for AT compared to PN (HR 2.50, p = 0.03)
	Overall survival (7 studies)	Similar between AT and PN in most studies, contradicting Andrews et al.
	Local recurrence-free survival (4 studies)	2 studies showed LRFS for AT similar to PN 2 studies showed LRFS for percutaneous cryoablation significantly worse compared to PN
	Post-operative complications (6 studies, 598 patients)	AT and PN have similar overall, minor, and major complication rates (Risk Ratio 0.97, p = 0.91)

Conclusion: AT have similar long-term oncological durability; lower rates of complications and superior kidney function preservation compared to PN. Given the low quality of evidence, AT is a reasonable alternative to PN in frail and co-morbid patients. Long-term high-quality studies are needed to confirm the potential benefits of AT, especially in T1b patients.

META ANALYSES AND DATABASE POPULATION STUDIES

Xing et al., 2018

Title			Comparative Effectiveness of Thermal Ablation, Surgical Resection, and Active Surveillance for T1a Renal Cell Carcinoma: A Surveillance, Epidemiology, and End Results (SEER) Medicare-linked Population Study							
Type of Study			Medicare SEER database analysis							
Number of Patients			10,218							
Cohort	**Method**	**No. Patients**	Cancer-Specific Survival	3-year	5-year	9-year	Overall Survival	3-year	5-year	9-year
PN vs TA [a]	**PN**	**691**		98.3%	97.4%	96.4%		95.5%	92.6%	91.1%
	TA	**691**		97.6%	96.7%	96.3%		92.9%	89.3%	88.6%
RN vs TA	**RN**	**733**		97.0%	96.5%	96.1%		94.5%	91.8%	90.5%
	TA	**733**		97.1%	96.4%	96.0%		93.9%	92.0%	91.3%
AS vs TA [b]	**AS**	**647**		96.0%	95.5%	95.4%		87.0%v	85.3%	84.1%
	TA	**647**		97.7%	96.9%	96.8%		94.0%	92.6%	91.8%

Other data worth calling out: "When compared with patients in the TA group, patients in the PN group had increased rates of renal, cardiovascular, and thromboembolic events by approximately 2.1-, 2.3-, and 5.3-fold, respectively (P< .001 for all) in the first 30 days after the procedure. These differences decreased but remained significant at 31 days to 1 year after the procedure for renal (P< .001), cardiovascular (P< .001), and thromboembolic (P< .001) events."

Conclusion: For T1aN0M0 RCC, thermal ablation confers cancer-specific survival and overall survival similar to those seen with surgical management, with significantly fewer adverse outcomes at 1-year after the procedure and similar rates of secondary cancer events compared with surgery.

[a] Thermal ablation had statistically similar survival compared with partial nephrectomy or radical nephrectomy. These similarities held true in subgroup analyses of older (age >75 years) and higher-risk (age >75 years and Charlson comorbidity index > 2) patient cohorts. THUS --> **In elderly patients with nonmetastatic node-negative renal cell carcinoma 4 cm in diameter or smaller, thermal ablation should be considered an equivalent therapeutic option to surgery**

[b] Active surveillance had significantly lower cancer-specific survival and overall survival when compared with thermal ablation and partial nephrectomy. THUS --> **In elderly patients with nonmetastatic node-negative renal cell carcinoma 4 cm in diameter or smaller, thermal ablation confers survival benefits when compared with active surveillance**

META ANALYSES AND DATABASE POPULATION STUDIES

Yoon et al., 2018

Title	Focal therapy versus robot-assisted partial nephrectomy in the management of clinical T1 renal masses
Type of Study	Systematic review and meta-analysis
Number of Patients	7 studies, reporting on 1,166 patients
Results	
Oncologic outcomes	
Local recurrence rate (7 studies)	FT had significantly increased risk of local recurrence ($p < 0.001$) [a]
Distant metastasis rate (3 studies)	FT had significantly increased risk of distant metastases ($p = 0.006$) [b]
Perioperative outcomes	FT had lower estimated blood loss (EBL) compared to RPN ($p < 0.001$) Operative time and lengths of stay were similar between FT and RPN FT had lower overall complication rates compared to RPN (but not statistically significant $p = 0.39$) FT had lower major complication rate compared to RPN (but not statistically significant $p = 0.61$)
Functional outcomes	FT associated with significantly low decrease of estimated glomerular flow rate (eGFR) compared to RPN ($p = 0.04$)

Conclusion: RPN has a substantial advantage in oncologic control, such as local recurrence and distant metastasis. However, in the era of minimally invasive surgery, FT has the advantage in renal function preservation and is associated with less bleeding.

a HOWEVER, 2 propensity score matched studies that paired patients with similar basic characteristics showed no difference in local recurrence between RPN and FT.

b HOWEVER, overall follow-up period was longer in the FT group, which could result in bias regarding relatively high metastatic recurrence. Notes that when secondary efficacy is included (second ablation), risk of recurrence is reduced.

META ANALYSES AND DATABASE POPULATION STUDIES

Pierorazio et al., 2016

Title	**Management of Renal Masses and Localized Renal Cancer: Systematic Review and Meta-Analysis**
Type of Study	Meta analysis
Number of Studies	**107**
Results	
Cancer Specific Survival	95-100% across all management strategies (RN, PN, TA), with no significant differences among different treatments.
Metastasis-Free Survival	90.5%-100% across all management strategies (RN, PN, TA), with no significant differences among different treatment modalities.
Local Recurrence-Free Survival	RN vs TA (2 studies): **RN 97.4% and 100%** / **TA 81% and 93%**; PN vs TA (14 studies): **PN median 98.9% (IQR 94.6% to 100%)** / **TA median 93.0% (IQR 89.9% to 96%)** [a]
Overall Survival	TA and AS had decreased overall survival outcomes compared to RN and PN. However, many studies recognize that patients undergoing TA and AS are older and have multiple comorbidities compared to those undergoing RN or PN. In addition, patients undergoing thermal ablation or active surveillance are unsuitable for extirpative surgery.
Renal Function	RN caused a greater decrease in estimated glomerular filtration rate (eGFR) following surgery compared to TA. Risk of stage 3 chronic kidney disease was 3.48-fold higher with RN compared to TA Renal function outcomes were similar between PN and TA.
Perioperative Outcomes and Harms	TA had the most favorable perioperative outcomes: fewer conversions to open or radical surgery, shorter length of stay, less estimated blood loss, fewer blood transfusions. Minor and major complications were similar for RN, PN, and TA

Other data worth noting: Study found that differences in overall survival and cancer-specific survival were largely driven by patient and tumor characteristics, rather than by which treatment they received. Data that indicated age, tumor size, and tumor grade was the greatest predictor of cancer specific survival. Data that indicated age and comorbidities was the greatest predictor of overall survival.

Conclusion: Comparative studies reveal similar cancer specific survival across management strategies, with some differences in renal functional outcomes, perioperative outcomes and postoperative harms that should be considered when choosing a management strategy. Further research and data are needed to strengthen many aspects of the evidence base.

[a] TA lower than both RN and PN in LRFS. However, when considering secondary ablation, LRFS rates increased to 95%-100% and differences between PN and TA were no longer significant.

RENAL FUNCTION PRESERVATION, SAFETY, AND QUALITY OF LIFE

Junker et al., 2022

Quality of life and complications after nephron-sparing treatment of renal cell carcinoma stage T1-a systematic review
Junker and colleagues conducted a meta-analysis on 11 studies that examined quality of life and complications following nephron-sparing treatment of T1 RCC.

- All cryo patients returned to baseline QoL 12 months after procedure
- Across studies, **complication rate up to 20% after partial nephrectomy and up to 12.5% after ablation therapy.**

Conclusion: Nephron-sparing treatment appears to be superior or comparable to other treatment alternatives with regard to QoL outcomes. Partial nephrectomy appears to have a higher complication rate compared with ablation therapies.

Complication rate for partial nephrectomy **20%**

Complication rate after ablation therapy **12.5%**

RENAL COLLECTING SYSTEM

Rosenberg et al., 2011

Title	**Percutaneous Cryoablation of Renal Lesions With Radiographic Ice Ball Involvement of the Renal Sinus: Analysis of Hemorrhagic and Collecting System Complications**
Type of Study	Retrospective review. Single Center.
Overview	The purpose of this study was to determine incidence of collecting system and hemorrhagic complications resulting from CT-guided percutaneous cryoablation of renal tumors in which radiographic iceball abuts or involves the renal sinus
Patients	**107 patients, 129 percutaneous renal cryoablation procedures.** In n = 67 (52%) cases, iceball directly abutted or extended into renal sinus. These were considered central ablations and were included in this study. Mean overlap 6.2 mm. In 41 cases (32%), overlap was 6 mm or more. Mean tumor size 2.5 cm. In n = 62 (48%) procedures, 1 mm margin between iceball and renal sinus. These were deemed noncentral ablations.
Approach & Protocol	In n = 14 cases, bowel was close to lesion of interest. Hydrodissection was performed with 18-gauge needle between bowel loop and lesion under CT guidance. Mean number of cryoprobes used for central ablations was 2.5. **10 minute freeze** **8 minute thaw** **10 minute freeze** CT performed during late stage of initial freeze
Results/adverse events	No cases of collecting system injury were identified for any ablation as evidence by urinoma, collecting system fistula, caliectasis, pelvocaliectasis due to collecting system stricture. One patient had a significant hematoma during treatment, requiring transcatheter embolization. Follow up inspection showed that hematoma formed during probe positioning and was due to arterial injury from probe tip rather than actual cryoablation.
Recurrence	n = 7 patients (6%) had radiologic evidence of residual recurrent tumor manifesting abnormally and requiring repeat ablation.
Device Used	2.4 mm diameter (13.5 gauge) Perc-24 by Varian

Conclusion: Cryoablation does not cause serious injury to the collecting system and renal blood system. This is in contrast to numerous reported complications associated with radiofrequency ablation (RFA) near or in the renal sinus.

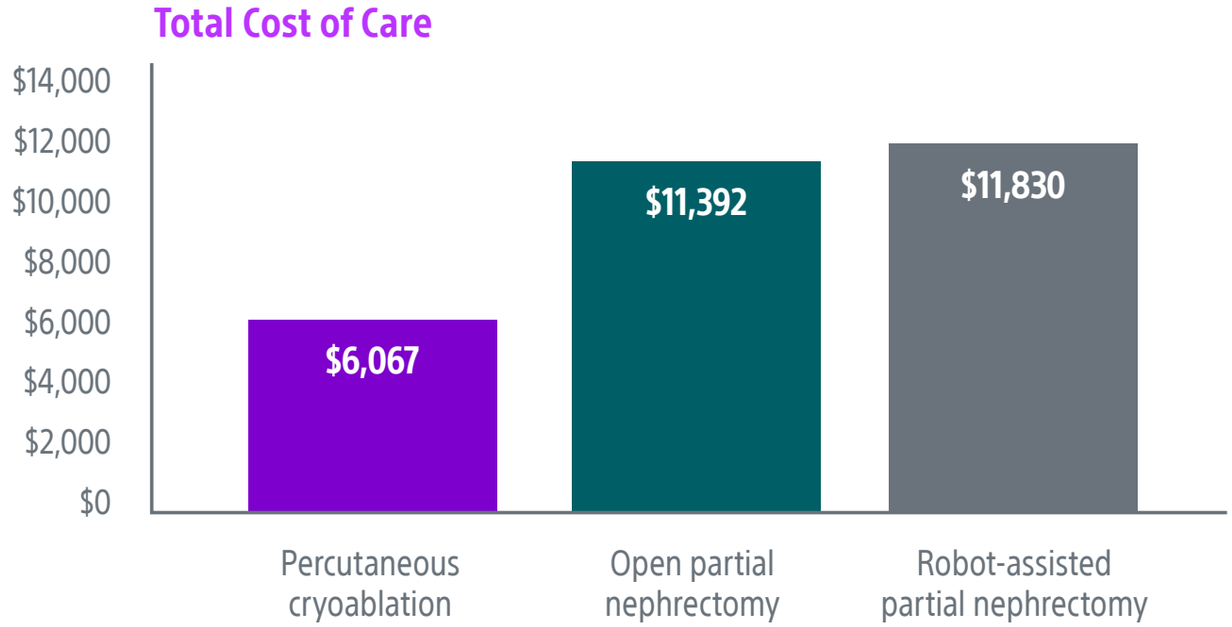
COST CONSIDERATIONS, REIMBURSEMENT, AND TRENDS

Chebab et al., 2016

Percutaneous Cryoablation vs Partial Nephrectomy: Cost Comparison of T1a Tumors

Purpose: To compare cost of percutaneous cryoablation vs open and robot-assisted partial nephrectomy of T1a renal masses from the hospital perspective. Chebab et al., retrospectively compared cost of 37 percutaneous cryoablations, 26 open partial nephrectomies, and 102 robot-assisted partial nephrectomies. Total cost was the sum of direct and indirect costs.

Cost data included procedure/operating room fees, supplies and devices, imaging, anesthesia fees, recovery room fees, room and board, ICU room and board, respiratory care, laboratory, and pathology fees.



COST CONSIDERATIONS, REIMBURSEMENT, AND TRENDS

Chebab et al., 2016

Percutaneous cryoablation is roughly half as costly as robot-assisted partial nephrectomy.

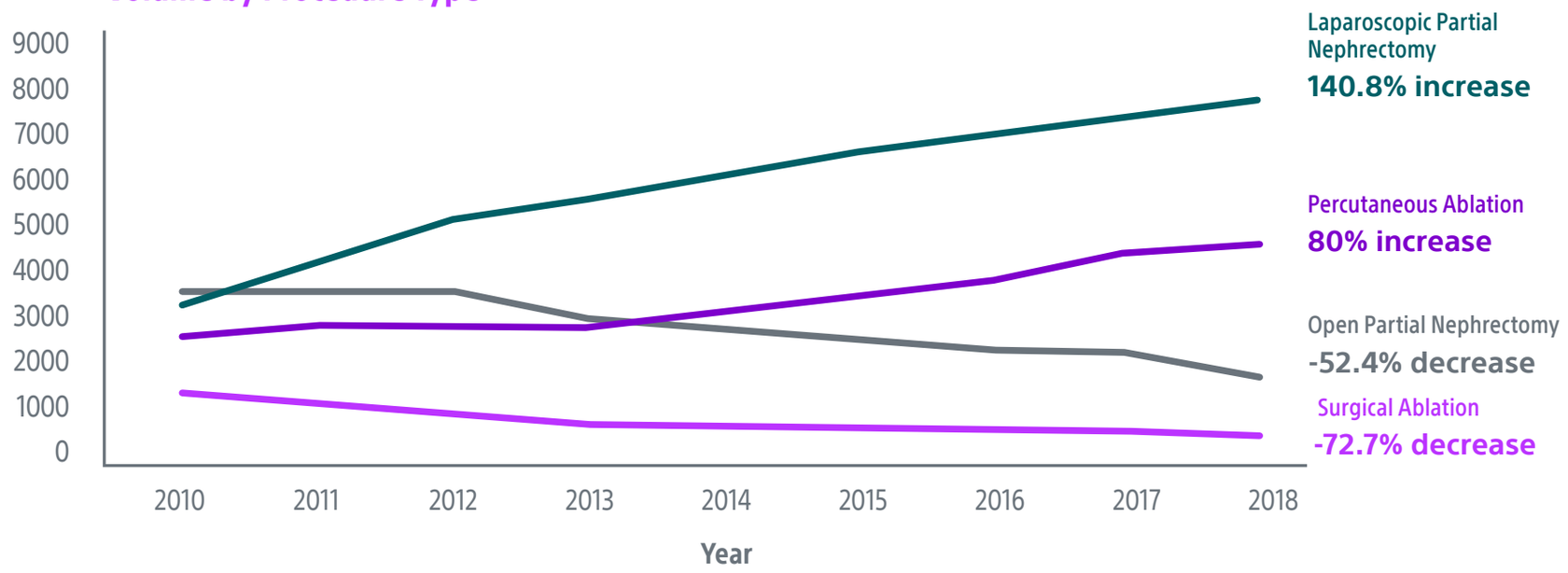
Variable	Median	Mean	Standard deviation	Statistics
Surgical supplies and devices				
Cryoablation	$2,596	$2,772	$550	Cryoablation vs open: p<0.0001
Open	$1,352	$1,445	$630	Cryoablation vs robot: p=0.002
Robot	$3,207	$3,288	$1,417	
Operating room				
Cryoablation	$1,516	$1,770	$1,864	Cryoablation vs open: p≤0.0001
Open	$3,272	$3,494	$700	Cryoablation vs robot: p<0.0001
Robot	$3,254	$3,280	$707	
Imaging				
Cryoablation	$0	$179	$366	Cryoablation vs open: p=0.861
Open	$76	$167	$189	Cryoablation vs robot: p=0.390
Robot	$103	$283	$700	
Recovery room				
Cryoablation	$291	$454	$337	Cryoablation vs open: p=0.331
Open	$410	$393	$139	Cryoablation vs robot: p=0.720
Robot	$356	$432	$227	
R&B—Routine				
Cryoablation	$0	$95	$278	Cryoablation vs open: p<0.0001
Open	$1,694	$1,907	$821	Cryoablation vs robot: p<0.0001
Robot	$869	$1,106	$674	
R&B—ICU				
Cryoablation	$0	$133	$814	Cryoablation vs open: p<0.730
Open	$0	$200	$699	Cryoablation vs robot: p<0.914
Robot	$0	$151	$853	
Anesthesia				
Cryoablation	$684	$653	$281	Cryoablation vs open: p<0.0001
Open	$1,223	$1,184	$375	Cryoablation vs robot: p<0.0001
Robot	$1,468	$1,678	$967	
Respiratory				
Cryoablation	$0	$8	$53	Cryoablation vs open: p=0.267
Open	$0	$47	$168	Cryoablation vs robot: p=0.325
Robot	$0	$57	$488	
Medications				
Cryoablation	$319	$365	$222	Cryoablation vs open: p=0.014
Open	$485	$572	$362	Cryoablation vs robot: p=0.936
Robot	$315	$368	$184	
Laboratory/Pathology				
Cryoablation	$80	$205	$299	Cryoablation vs open: p<0.0001
Open	$574	$804	$540	Cryoablation vs robot: p<0.0001
Robot	$485	$720	$656	
Other				
Cryoablation	$0	$164	$815	Cryoablation vs open: p=0.573
Open	$0	$84	$213	Cryoablation vs robot: p=0.457
Robot	$0	$61	$295	
Total				
Cryoablation	$6,067	$6,803	$4,459	Cryoablation vs open: p<0.0001
Open	$11,392	$11,803	$3,190	Cryoablation vs robot: p<0.0001
Robot	$11,830	$13,242	$4,371	

COST CONSIDERATIONS, REIMBURSEMENT, AND TRENDS

Patel et al., 2021

Percutaneous ablation of renal tumors versus surgical ablation and partial nephrectomy: Medicare trends and reimbursement cost comparison from 2010 to 2018

The purpose of this study is to analyze trends in Medicare volume and reimbursement for percutaneous and surgical ablation as well as laparoscopic and open partial nephrectomy for treatment of small renal tumors from 2010 to 2018. **Minimally invasive procedures are trending up:** Since 2010, minimally invasive procedures have become more popular among Medicare patients. Both laparoscopic partial nephrectomy and percutaneous ablation have increased, while open partial nephrectomy and surgical ablation have decreased.

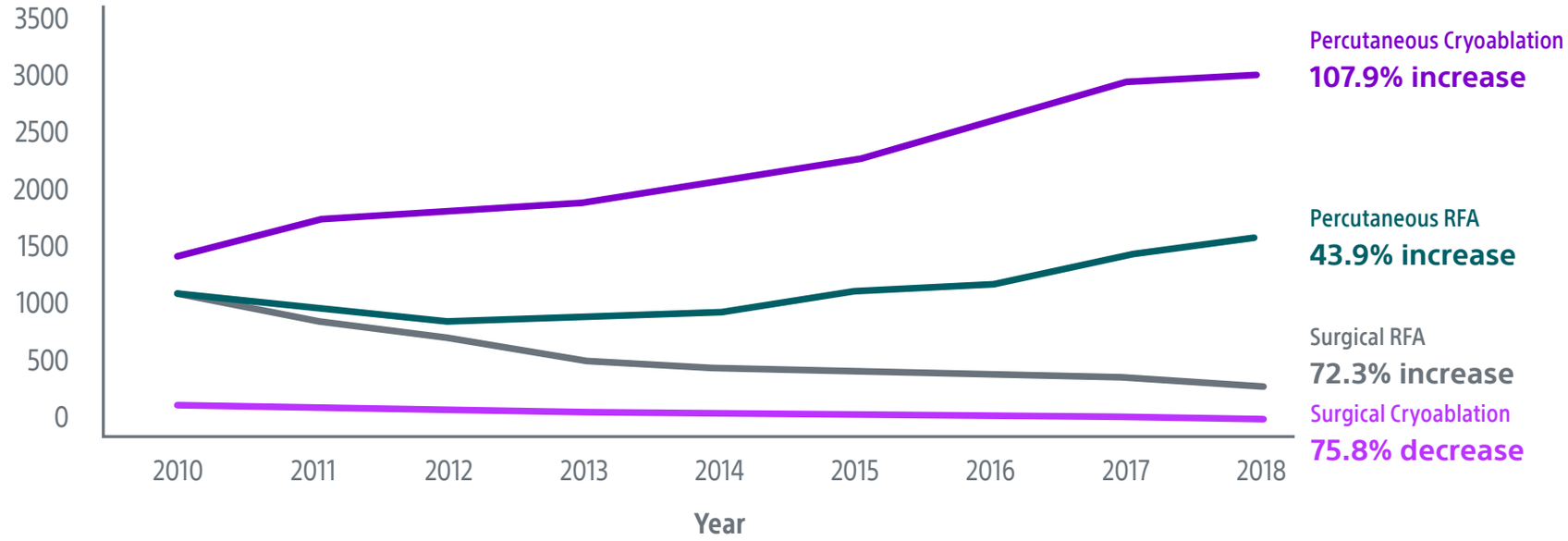


COST CONSIDERATIONS, REIMBURSEMENT, AND TRENDS

Patel et al., 2021

Percutaneous cryoablation is the most popular modality for kidney lesions:
Among ablation modalities, percutaneous cryoablation has increased most dramatically. The marked increase in volume of percutaneous ablations, likely due to its demonstrated safety when performed close to the renal collecting system and visibility of the iceball.

Volume by Ablation Modality



COST CONSIDERATIONS, REIMBURSEMENT, AND TRENDS

Patel et al., 2021

Reimbursement breakdown

Comparing percutaneous radiofrequency ablation, percutaneous cryoablation, surgical radiofrequency ablation, surgical cryoablation, open partial nephrectomy, and laparoscopic partial nephrectomy. Percutaneous approaches reimburse at a lower rate, but also have lower associated costs.

Procedure	2010				2018			
	Reimbursement per procedure	Work RVU	Practice expense RVU	Malpractice RVU	Reimbursement perprocedure	Work RVU	Practice expense RVU	Malpractice RVU
Percutaneous radiofrequency ablation of renal tumor(s)*	$374.86	6.80	2.59	0.47	$358.56	6.55	2.84	0.57
Percutaneous cryoablation of renal tumor(s)	$482.74	9.13	3.50	0.63	$481.32	8.88	3.71	0.78
Surgical radiofrequency ablation of renal tumor(s)*	$1211.18	21.36	9.21	1.54	$1216.43	21.36	10.09	2.34
Surgical cryoablation of renal tumor(s)	$1269.62	22.22	9.72	1.60	$1269.35	22.22	10.60	2.44
Open partial nephrectomy	$1371.37	24.21	10.41	1.78	$1381.67	24.21	11.44	2.73
Laparoscopic partial nephrectomy	$1545.99	27.41	11.61	2.00	$1552.66	27.41	12.71	3.01

Conclusion: There has been a trend toward minimally invasive techniques for treatment of small renal tumors among Medicare patients. Laparoscopic partial nephrectomy has become the dominant treatment. In the setting of evidence showing comparable outcomes with surgery as well as lower costs to insurers, the volume of percutaneous ablation has also markedly increased.

CRYOABLATION AND IMMUNOTHERAPY

In addition to killing cancer cells, ablation treatment may stimulate an immune response in patients against those cancer cells (**Yakkala** and **Kim**). Because of this, there is a growing interest in combining cryoablation with immunotherapies.

Wah et al., 2021

An Exploratory Analysis of Changes in Circulating Plasma Protein Profiles Following Image-Guided Ablation of Renal Tumours Provides Evidence for Effects on Multiple Biological Processes

Wah and colleagues conducted a pilot exploratory study evaluating circulating plasma protein profiles after image guided ablation of small renal masses to provide insights on impact to the immune system. Patients underwent cryoablation, radiofrequency ablation, or microwave ablation. Key findings:

- Cryoablation induced the most marked change in protein profiles compared to microwave and radiofrequency. This confirms previous findings by **Erinjeri**, **Ahmad** and more.
- The most marked changes were 24 hours after cryoablation, with 29 proteins increasing and 18 decreasing significantly. Principally, these changes occurred in cytokines and proteins involved in regulating inflammation, danger-associated molecular patterns, cell-proliferation, hypoxic response, apoptosis, and migration.
- Increases in IL-8, IL-6, and CCL23 specifically correlated with number of cryoprobes.

ENDNOTES

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