Ablative Treatments for Small Renal Masses and Management of Recurrences: A Comprehensive Review

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Abstract: This review focuses on ablative techniques for small renal masses (SRMs), including radiofrequency ablation (RFA), cryoablation (CA), microwave ablation (MWA), and irreversible electroporation (IRE), and discusses recurrence management. Through an extensive literature review, we outline the procedures, outcomes, and follow-up strategies associated with each ablative method. The review provides a detailed examination of these techniques—RFA, CA, MWA, and IRE—elucidating their respective outcomes. Recurrence rates vary among them, with RFA and CA showing comparable rates, MWA demonstrating favorable short-term results, and IRE exhibiting promise in experimental stages. For managing recurrences, various strategies are considered, including active surveillance, re-ablation, or salvage surgery. Surveillance is preferred post-RFA and post-CA, due to slow SRM growth, while re-ablation, particularly with RFA and CA, is deemed feasible without additional complications. Salvage surgery emerges as a viable option for larger or resistant tumors. While ablative techniques offer short-term results comparable to surgery, further research is essential to understand their long-term effects fully. Decisions concerning recurrence management should consider individual and tumor-specific factors. Imaging, notably contrast-enhanced ultrasounds, plays a pivotal role in assessing treatment success, emphasizing the necessity of a multidisciplinary approach for optimal outcomes. The lack of randomized trials highlights the need for further research.

Keywords: RCC; small renal masses; ablative techniques; recurrence

1. Introduction

Renal cell carcinoma (RCC) is the 14th most prevalent malignancy worldwide, according to the Global Cancer Observatory [1]. Recently, developments in radiology have markedly increased the incidence of RCC. In particular, the spread of ultrasounds (US), computed tomography (CT) scans, and magnetic resonance imaging (MRI) increased detection rates of incidentalomas and small renal masses (SRMs), defined by dimensions inferior to 4 cm [2–5].

Various strategies are applicable for managing clinically localized SRMs with suspected RCC, including active surveillance, ablation therapy, and surgery (Figure 1) [6]. Current guidelines endorse nephron-sparing surgery (NSS), such as partial nephrectomy (PN), for managing SRMs when technically feasible [2,7]. However, it is widely recognized that SRMs usually are low-grade, slow-progressing tumors with limited metastatic potential [8,9]. To mitigate surgery-related morbidity and preserve renal function, ablative techniques have been developed as an alternative to PN in patients with SRMs [9–17]. Particularly, these techniques should be preferred in elderly patients with multiple comorbidities and pre-existing renal conditions, such as chronic kidney disease, hereditary and/or multiple tumors, and cases of solitary kidneys [18,19]. Ablative techniques can utilize either low-temperature methods, such as cryoablation, or high-temperature approaches, like radiofrequency ablation (RFA) and microwave ablation (MWA), along with a nonthermal modality known as irreversible electroporation (IRE) [20,21].
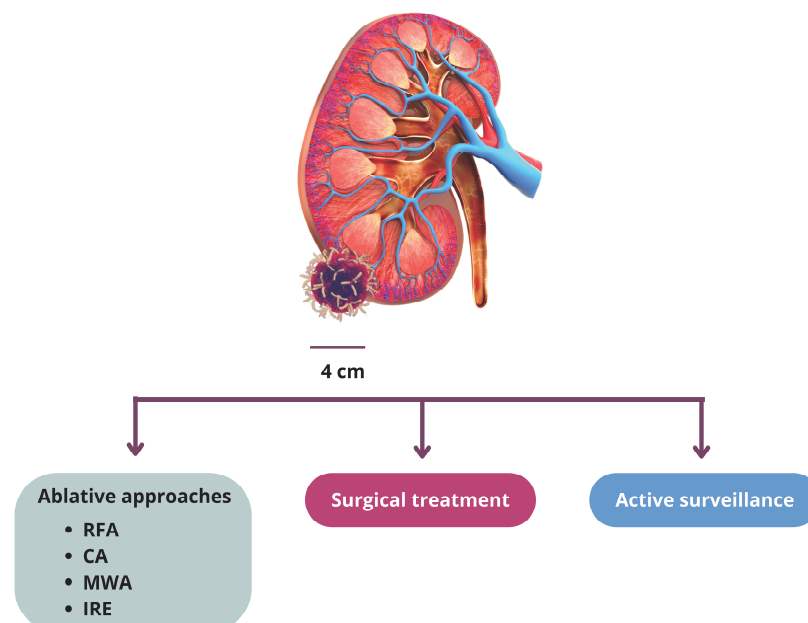
Figure 1. Treatment options for SRMs. SRMs, small renal masses; RFA, radiofrequency ablation; CA, cryoablation; MWA, microwave ablation; IRE, irreversible electroporation.

Since 2017, both the American Urological Association (AUA) and the European Association of Urology (EAU) guidelines have recommended ablative techniques as a valid alternative to surgery for pT1a renal masses (<4 cm), except for those located at the hilum or in proximity to the proximal ureter [2,22]. However, despite these recommendations, current literature still lacks randomized clinical trials comparing ablative techniques to NSS; indeed, only observational studies have been conducted for this purpose [9,23]. Nonetheless, on the one hand, previous studies suggest that the outcomes of ablative techniques are comparable to those of surgical resection, with a 5-year cancer-specific survival rate of 95%; on the other hand, it is crucial to note that the risk of local recurrence and metastasis tends to be more prevalent after focal ablations than after surgical approaches [24–27].

Consequently, the present manuscript aims to provide a narrative review of the scientific literature on (i) current methods adopted as ablative techniques for SRMs; (ii) short- and long-period outcomes after ablative management; (iii) imaging methods for detecting recurrences; and (iv) lastly, focalizing evidence regarding the management of these recurrences.

2. Materials and Methods

A comprehensive and narrative literature review was conducted by searching through databases such as PubMed, Embase, and the Cochrane Library, which encompassed publications up to February 2024.

2.1. Search Strategy and Data Extraction

The search was structured around key terms pertinent to the objectives of the review. The terms included "small renal masses", "ablation therapy", "recurrence", "radiofrequency ablation", "cryoablation", "microwave ablation", and "irreversible electroporation". These keywords were selected to ensure a broad and comprehensive retrieval of relevant literatures that cover various aspects of ablative treatments for SRMs, including procedure details, outcomes, and follow-up strategies.

Our review process aimed to include studies that provide detailed accounts of the procedures, outcomes, and follow-up strategies associated with each ablative technique. To ensure a thorough and unbiased selection, additional articles were identified through manual searches of reference lists from pertinent studies and review articles.

Data extraction was meticulously performed by two authors independently (AA and VI)), with a predefined strategy to resolve any discrepancies that arose. In instances of disagreement, a third author was consulted to reach a consensus (SDP). This collaborative approach ensured the accuracy and reliability of the data included in our review.

2.2. Data Synthesis

The gathered data were synthesized to construct a comprehensive overview of the current landscape of ablative techniques for the management of SRMs and the strategies employed in managing recurrences. This synthesis aims to present a narrative that encompasses the breadth of research in the field, highlighting procedural details, comparative outcomes, and advancements in follow-up strategies (Table 1).

Table 1. The search strategy summary.

Items	Specifications
Databases and other sources searched	PubMed, Embase, and Cochrane Library
Search terms used	small renal masses, ablation therapy, recurrence, radiofrequency ablation, cryoablation, microwave ablation, and irreversible electroporation.
Timeframe	1997–2024
Inclusion criteria	Articles written in English and those reporting outcomes of ablative treatments for SRMs.
Selection process	Two authors were responsible for data collection. Any discrepancies were resolved through discussion with a third author.

3. Ablative Techniques

Ablation procedures can be conducted using either laparoscopic or percutaneous approaches, with the latter being preferred due to its shorter operative time and the ability to perform under local anesthesia [28]. Various ablative techniques are available, including those employing low temperature (cryoablation), high temperature (RFA and

MWA), or nonthermal modalities, such as (IRE) (Table 2) [29,30]. Hereafter, we provide a brief panoramic of each technique and highlight strengths, limitations, and differences between them.

Table 2. Comparisons between currently available ablative techniques.

Ablative Method	Advantages	Disadvantages
CA	Real-time visualization Lesions >3 cm Less painful than RFA	Longer procedural time More bleeding risk
RFA	Shorter procedural time Less bleeding risk	No real-time visualization No lesions >3 cm More painful than CA "Heat-sink effect"
MWA	Shorter procedural time Lesions >3 cm No "heat sink effect" Simultaneous ablation	More painful No real-time visualization Bulkier than RFA Need for a cooling mechanism
IRE	Avoidance of change in temperature No "heat-sink effect" Less risk of vessel damage	Limited clinical experience

Abbreviations: CA: cryoablation; RFA: radiofrequency ablation; MWA: microwave ablation; IRE: irreversible electroporation.

3.1. Radiofrequency Ablation

RFA was the first ablation technique adopted for the treatment of RCC, as reported by Zlotta et al. in the year 1997 [31]. The procedure involves the placement of one or more radiofrequency electrodes into tumoral tissue as guided by US, CT scans, or MRI [32]. These electrodes induce ionic agitation by delivering electrical current, elevating the temperature above 60 °C, ultimately resulting in cell death through coagulative necrosis. The standard RFA protocol involves an initial electrical power of 30–40 W, increased at a rate of 10 W/min, with two breaks/roll-offs during ablation [33]. Studies have shown that RFA provides an excellent local control rate for T1a RCCs, ranging from 91 to 100%. The 5-year overall survival and cancer-specific survival rates among patients with T1 RCC are 97% and 96% to 97%, respectively.

Limitations of RFA are associated with the "heat-sink effect", wherein heat absorbed by flowing blood or air is carried away from the ablation area, leading to the dissipation of hyperthermia and a reduction in RFA efficacy [32]. Therefore, RFA is considered less effective for tumors larger than 3 cm, centrally located masses, and masses located in proximity to the ureteropelvic junction or large blood vessels [34].

3.2. Cryoablation

Cryoablation (CA) is a technique using argon-based cryoprobes to lower the tumor temperature below −40 °C, which will be subsequently thawed by using helium. The procedure involves double freeze–thaw cycles, comprising 15 min of freezing followed by 10 min of thawing [35]. Monitoring the cryoablation process involves real-time imaging of the created "ice ball" through US, CT, or MRI. The temperature on the tumor margin is actively controlled by real-time sensors [36].

As the RFA approach, renal mass CA can be carried out either percutaneously or laparoscopically. However, the current recommendation from the NCCN favors the percutaneous approach, due to its quicker execution and the avoidance of general anesthesia [37]. The laparoscopic approach may be warranted in specific instances, such as with periureteral or upper pole masses that cannot be effectively targeted percutaneously. Compared to RFA, this approach ensures better outcomes for lesions > 3 cm, and, due to the anesthetic properties of the cold, it is less painful for the patient [38]. However, CA is associated with

higher risks of bleeding, since blood arteries surrounding the mass cannot be cauterized as in RFA; moreover, the complete freezing of the renal mass, with the creation of an adequate "ice-ball", requires the insertion of multiple probes, increasing both procedure timing and risks of damaging surrounding tissues [39].

3.3. Microwave Ablation

MWA has been approved in the United States since 2008 [40].

Similar to RFA, MWA utilizes electromagnetic waves to generate heat and induce cell death through hyperthermic injury. A needle-like probe (antenna) is intratumorally placed, producing microwave energy that generates an electromagnetic field, resulting in frictional heating exceeding 100 °C [41]. Unlike RFA, MWA excels in heating larger tumor volumes because during RFA, the active heating zone is limited to a few millimeters around the electrode, whereas MWA can heat tissues up to 2 cm away from the antenna [42,43]. MWA also allows the use of multiple antennas to enhance the ablative effect, facilitating the simultaneous ablation of larger or multifocal tumors; this synergistic capability is not available with RFA [42]. However, MWA systems are bulkier than RFA systems and use larger cables, and the antenna may require cooling mechanisms because of potential overheating [44].

Lastly, Klapperich et al. highlighted that MWA, when compared to RFA and CA, may result in increased pain for the patient. However, the results of their study conducted on 96 patients undergoing MWA demonstrated that this technique had minimal impact on renal function and few ablation-related complications [45].

3.4. Irreversible Electroporation

IRE represents a novel nonthermal ablation technique that relies on electrical pulses transmitted between electrodes strategically placed in the tumor area, either through a percutaneous approach (under imaging guidance) or during open surgery [46]. The electric field generated induces changes in the electrochemical potential across the cell membrane, destabilizing the lipid bilayer and creating openings termed "nanopores" [47]. This modification alters the permeability of the cellular matrix, leading to cell death. The primary advantage of IRE over other thermal modalities lies in its avoidance of high-temperature-based mechanisms, thereby reducing the risk of collateral damage due to the heat-sink effect near vasculature. Consequently, IRE is considered the safest technique for tumors located in proximity to large vessels [48]. However, clinical experience with IRE is currently limited, contributing to its classification as an experimental method.

4. Imaging in Post-Ablative Techniques Follow-Up: Strategies and Timing

The most important point to evaluate after the use of an ablation technique is the completeness of lesion ablation to achieve an effective therapeutic response. Radiologists play a crucial role in distinguishing between complete ablation and local tumor progression (LTP) [49].

Currently, there is no consensus on the radiological technique and timing to be used in the follow-up after ablative techniques. Conventional techniques such as CT or MRI are frequently employed to evaluate the therapeutic efficacy of ablation [50]. However, the nephrotoxicity of contrast in CT and the high frequencies in poorly collaborating patients in MRI pose limitations for these procedures [51,52]. Furthermore, although exceedingly rare, the potential occurrence of nephrogenic systemic fibrosis associated with the use of gadolinium-based contrast agents has been observed in patients with chronic renal failure undergoing MRI [53].

In recent years, contrast-enhanced ultrasound (CEUS) emerged as a safe and well-tolerated imaging method with real-time multiplanar imaging using a non-toxic contrast agent [54]. It is a reproducible technique with high predictive values and specificity in evaluating the ablation effect. Compared to CT and MRI, CEUS may offer potential superiority in detecting LTP by providing real-time visualization of the ablation zone,

surrounding renal parenchyma, and renal vessels, despite being negatively influenced by intestinal gas and operator dependency, as in conventional ultrasounds [55].

Regardless of the type of instrumental investigation used, various imaging features enable radiologists to interpret follow-up images. Typically, most studies on post-ablation imaging features focus on tumor-enhancement characteristics and size measurement on follow-up CTs or magnetic resonance (MR) images [56,57].

Focal or curvilinear enhancement within or around the tumor often indicates LTP. However, while clear-cell RCCs demonstrate strong enhancement, non-clear-cell RCCs exhibit limited enhancement in case of LTP [58].

Distinguishing local recurrence from post-ablation inflammation is particularly crucial, especially in the case of endophytic tumors; it can be challenging to ascertain whether they are completely ablated or not. In this context, it is important to highlight that a persistent contrast enhancement can be detected up to 9 months after the cryoablation, although it may not necessarily indicate malignancy [59]. Indeed, a weak or moderate enhancement surrounding the residual ablated tumor, resembling a geographic lesion, imperatively indicates the need for a percutaneous biopsy to differentiate LTP from post-ablation inflammation. If this result is negative, the possibility of a false negative is considered, and further evaluation with a short-term follow-up is warranted [60,61]. When focal intra-lesion enhancement is present, LTP should be considered, even if the tumor is not growing. In such cases, a percutaneous biopsy targeting the affected area should be contemplated [49].

Furthermore, changes in the dimensions of an SRM during thermal ablation also contribute to predicting the likelihood of LTP [13,62]. As the RCC shrinks, there is a reduction in the probability of local recurrence, owing to the decreased number of viable tumor cells. This phenomenon is more pronounced in cases of RFA and MWA, compared to cryoablation [63].

Establishing the optimal timing for imaging to assess therapeutic efficacy following ablation techniques constitutes another pivotal point in enhancing diagnostic capabilities and improving the tumor-free survival rate. Currently, there is no consensus on the surveillance intervals for repeating imaging; the choice should be based on the characteristics of the lesion and the patient, adjusting it according to the suspicion of LTP [64]. Some authors suggest an initial radiological assessment after 6 weeks, while others delay the first follow-up to 3 months [65,66]. Hoeffel et al. advocate for obtaining the initial imaging evaluation within 24 h from treatment to exclude early complications and for obtaining the second assessment after 6 weeks [67]. Following these early evaluations, most authors agree on a follow-up at 6 or 9 months after the procedure. Moreover, AUA guidelines recommend an assessment every 12 months for approximately 5 years [22].

5. Recurrence Rates Following Ablative Techniques

According to the treatment employed, local recurrence (LR) rates range from 1% to 9% [68]. Specifically, LR rates after the aforementioned ablative techniques are higher than those after surgery (2–10% vs. 1–2%) [69]. However, even though PN is superior to ablation in terms of overall survival (OS) and LR, ablative techniques result in lower complication rates [70]. In general, regardless of the technique used (PN vs. Ablation), most recurrences occur within 5 years and rarely decades after primary treatment [71]. Furthermore, LR mostly occurs at the site of the primary treatment within the kidney, while extrarenal local recurrences are uncommon [72].

Regarding CA, Zargar et al. analyzed data from 139 patients undergoing CA with a median follow-up of 24 months. The authors observed LTP in 10 (7.2%) patients and reported that for each increase of 1 cm in tumor size, patients were 1.5 times more likely to have a tumor recurrence [73]. Similarly, Breen et al. analyzed outcomes from ablative CA performed on 171 tumors in 147 patients, reporting an initial incomplete treatment rate of 7.6%, which improved to 2.4% with CA retreatment [74]. Overall, RFA and CA present comparable recurrence rates, which are higher than those associated with PN,

yet they exhibit fewer complications than PN, probably due to their minimally invasive nature (RR: 0.72, 95%CI 0.55–0.94, *p* = 0.004) [44]. Typical complications following ablation comprise procedural bleeding, perirenal hematoma, temporary hematuria, and visceral injury. Among these, bleeding stands out as the most frequent complication [75].

In the specific case of RFA, Psutka et al. conducted a retrospective analysis of long-term oncologic outcomes of 185 patients with T1 RCC with an average tumor size of 3 cm. Of them, 143 (77%) presented with T1a tumors and 42 (23%) with T1b tumors. Overall, 12 (6.5%) experienced LR, with 6 out of 143 (4.2%) in T1a patients and 6 out of 42 (14.3%) in T1b patients. Therefore, tumor stage is a significant predictor of the higher risk of recurrence (stage T1b vs. T1a: univariate HR 3.38, *p* = 0.0072; multivariate HR 4.3, *p* = 0.0085) [34]. Similar findings were reported by Lam CJ et al. in a retrospective-fashioned study conducted between October 2011 and May 2019 involving 141 patients. The mean ± standard deviation (SD) tumor size was 2.6 ± 0.8 cm, and the mean follow-up was 67 (81–161) months. After RFA, the authors reported recurrence rates of 6.4% [76].

Similar LR rates have been reported for MWA. Indeed, McClure et al. conducted a meta-analysis to compare outcomes in terms of LR between MWA and more traditional ablative techniques, such as CA. The authors found low rates of LR for MWA, compared to traditional ablative techniques; in particular, these rates ranged from 2% to 5% at 1 year and 5 years, respectively, for MWA, while rates stood at 6% at both times for CA. Consequently, the one-year local recurrence was significantly improved with MWA compared to CA, while at five years, the rates of local recurrence were similar. This short-term lower recurrence rate is probably attributed to the higher intertumoral temperature and larger ablation zone achieved with MWA. Regarding other outcomes, such as overall survival, disease-free survival, overall/major complications, procedure/ablation time, 1- to 3-month primary technique efficacy, and technical success, the authors reported no significant differences between MWA and other techniques [77].

The most recently developed ablation technique is the IRE, which is still considered an experimental technique; indeed, the majority of available studies involve 10 or fewer patients. Additionally, the limited available follow-up times pose a challenge in establishing reliable oncological outcomes, as most studies had a follow-up duration of less than a year, which we consider the minimum necessary duration. The largest study reported in the current literature is by Canvasser et al., in which 41 patients, with a median tumor size of 2 cm, underwent IRE. With a mean follow-up of 22 months, the 2-year local recurrence-free survival (LRFS) was 83%. Therefore, although IRE has low morbidity, according to the available preliminary studies, this technique has suboptimal short-term local disease control when compared with conventional thermal ablation techniques [78]. A Larger series and longer follow-up studies will need to be conducted to determine long-term outcomes [79].

6. How to Address SRMs Following Unsuccessful Ablative Therapy?

When SRMs are selected for ablative techniques, the rates of persistence or recurrence are very low. Consequently, there is limited information regarding management strategies on how to address residual tumors following unsuccessful ablative therapy. As discussed by Breda et al. in their review, surgeons have three options at their disposal: active surveillance, repeated ablation, or salvage surgery, typically involving salvage nephrectomy [26].

As mentioned earlier, contrast enhancement after renal ablation does not exclusively indicate a recurrence; on the contrary, it may be an expression of inflammation or volume-averaging discrepancies in imaging [80]. Active surveillance, especially in the case of RFA and CA, appears to be the most appropriate option, considering that even untreated SRMs show growth rates of 0.2 cm per year [81]. Moreover, in case of recurrence after one year, it does not seem to limit or alter future treatment options [82].

Approximately 66% to 73% of patients undergoing initial ablative treatment and experiencing LTR are estimated to undergo repeated ablation [81]. Indeed, approximately 7.4% to 8.5% of all RFA-treated lesions and 0.9% to 1.3% of CA-treated lesions are managed by

repeating ablations [83]. The higher rates of re-ablation after RFA may be explained by the type of procedure used for the initial treatment, typically employing a percutaneous approach compared to CA, which is primarily performed using a laparoscopic technique [84]. Firstly, the laparoscopic technique allows for the better placement of the probe under direct vision; secondly, the percutaneous approach presents lower morbidity and risk than repeated laparoscopic procedures. Therefore, physicians are more inclined to repeat the percutaneous procedure than the laparoscopic one [83].

Contrary to expectations, performing a repeated ablation poses no additional technical challenges when compared to the primary ablation procedure [85]. In this regard, Okhunov et al. have reported outstanding outcomes in salvage CA for T1a SMRs, emphasizing that salvage CA is simpler than the primary treatment, due to the presence of identifiable landmarks resulting from the post-ablation tissue reaction, which aids in targeting the tumor more effectively. In their smaller multicentered report, they also demonstrated a 100% cancer-specific survival rate [86]. Similarly, Matin et al. reported a notably low incidence of therapeutic shortcomings, standing at 4.2% among individuals subjected to salvage ablative interventions. Within the subgroup manifesting recurrent pathology, the research revealed an overarching survival rate of 82.5% and a metastasis-free survival rate of 97.4% over a span of two years for patients harboring localized, unilateral tumors [87].

It is crucial to communicate to the patient that ablative salvage procedures generally have the potential for lower success rates. In this context, Loloi et al. documented failure rates of approximately 6% for primary ablation, around 25% for secondary ablation, and approximately 50% for tertiary ablation [88]. Hence, considering on the one hand the rarity of LR and on the other hand the absence of level I recommendations from international guidelines, the decision on the most appropriate approach is still challenging for both clinicians and patients. Generally, surgery is the most suitable therapeutic option in case of large tumor size or disease progression after an initial failed ablative treatment. The choice between PN and radical nephrectomy (RN) depends not only on the type of lesion but also on the patient and, most importantly, on the surgeon's experience. Accordingly, the fibrosis surrounding the residual tumor resulting from the ablative procedure undoubtedly influences the choice of salvage surgery [89]. This was highlighted in a study provided by Nguyen et al., where in half of the patients initially considered for PN, the procedure was converted to RN due to extensive scarring and fibrosis [90].

In contrast, Kowalczyk et al. stated that open PN could be considered a safe approach in these patients. Indeed, none of the 16 patients operated on were converted; however, PN after radio-frequency ablation had a higher reintervention rate compared to other series of primary or repeated PN [89].

In 2010, Breda et al. suggested that PN should be recommended in selected patients after unsuccessful ablative therapy, preferably opting for an open approach. Moreover, in the case of RN, they proposed a laparoscopic approach, considering it equally safe [26].

Additionally, Karam et al. reported oncological outcomes in 14 patients, of whom 11 underwent PN and 3 underwent RN. Most surgeries were performed using an open approach, with one laparoscopic and one robotic-assisted surgery. Over a median follow-up of 26.5 months, no deaths were observed. However, a high rate of overall perioperative complications was recorded, in particular an intra-operative complication in one patient (a pleurotomy) and postoperative complications in nine patients (64%), with four complications being Clavien grade III [91].

Similar rates of complications were observed by Jimenez et al. in 27 patients who underwent salvage surgery. Six patients (22%) experienced major complications (Clavien grade III-IVb), including four with hemorrhagic complications, while minor complications (Clavien grade II) were reported in four patients (15%). They emphasized that salvage surgery is complex but feasible, with adequate preservation of renal function, even in patients with a solitary kidney, severe chronic kidney disease (CKD), or high-complexity tumors [92].

Additional investigations are necessary to assess the long-term effectiveness of salvage techniques, especially concerning robotic surgery. The largest caseload of salvage robotic renal surgery after failed tumor ablation was conducted by Martini et al. They assessed the role of salvage robotic surgery, based on a multi-institutional collaborative dataset promoted by the Junior ERUS/YAU robot-assisted surgery working group of the European Association of Urology. They recorded an intraoperative complication rate of 6% and a postoperative complication rate of 20%. Furthermore, it was revealed that the prior ablative technique did not negatively impact the pathologist's ability to detect tumor cells in the samples [93]. In conclusion, robotic-assisted surgery proves to be a valuable tool in salvage surgery after ablative treatment when performed by experienced surgeons in high-volume centers [94].

7. Limitations

This review has several limitations that warrant attention. Firstly, the non-systematic nature of data collection and analysis limits the ability to perform direct comparisons among the various ablative techniques discussed. Secondly, variations in the methodologies of included studies, including study designs, sample sizes, and follow-up durations, may compromise the uniformity of presented results. Thirdly, most studies rely on retrospective data, which can be subject to selection bias. Lastly, the absence of randomized controlled trials further limits the strength of the conclusions that can be drawn regarding the comparative efficacy and safety of ablative techniques in managing SRMs and in the management of recurrences. Therefore, the findings of this review should be interpreted with caution and considered as a starting point for more in-depth and systematic future research on the topic.

8. Conclusions

Ablative techniques offer viable alternatives to surgery, with each presenting unique benefits and considerations. While short-term outcomes demonstrate comparable efficacy between ablative techniques and surgical interventions, the long-term implications, especially regarding local recurrence and metastasis, warrant further investigation. The absence of randomized clinical trials comparing ablative methods to surgery underscores the need for further research to support evidence-based decision-making. The management of residual SRMs following ablative treatment necessitates a discerning approach considering individual patient factors, lesion characteristics, and evolving technological advancements. As the field continues to evolve, a personalized and multidisciplinary approach remains crucial in optimizing outcomes and minimizing the impact of recurrent SRMs.

References

1. Bukavina, L.; Bensalah, K.; Bray, F.; Carlo, M.; Challacombe, B.; Karam, J.A.; Kassouf, W.; Mitchell, T.; Montironi, R.; O'Brien, T.; et al. Epidemiology of Renal Cell Carcinoma: 2022 Update. *Eur. Urol.* **2022**, *82*, 529–542. [CrossRef] [PubMed]
2. Ljungberg, B.; Albiges, L.; Abu-Ghanem, Y.; Bedke, J.; Capitanio, U.; Dabestani, S.; Fernández-Pello, S.; Giles, R.H.; Hofmann, F.; Hora, M.; et al. European Association of Urology Guidelines on Renal Cell Carcinoma: The 2022 Update. *Eur. Urol.* **2022**, *82*, 399–410. [CrossRef]
3. Calace, F.P.; Napolitano, L.; Arcaniolo, D.; Stizzo, M.; Barone, B.; Crocetto, F.; Olivetta, M.; Amicuzi, U.; Cirillo, L.; Rubinacci, A.; et al. Micro-Ultrasound in the Diagnosis and Staging of Prostate and Bladder Cancer: A Comprehensive Review. *Medicina* **2022**, *58*, 1624. [CrossRef] [PubMed]
4. Lasorsa, F.; Rutigliano, M.; Milella, M.; Ferro, M.; Pandolfo, S.D.; Crocetto, F.; Autorino, R.; Battaglia, M.; Ditonno, P.; Lucarelli, G. Cancer Stem Cells in Renal Cell Carcinoma: Origins and Biomarkers. *Int. J. Mol. Sci.* **2023**, *24*, 13179. [CrossRef] [PubMed]
5. Lasorsa, F.; Rutigliano, M.; Milella, M.; Ferro, M.; Pandolfo, S.D.; Crocetto, F.; Simone, S.; Gesualdo, L.; Battaglia, M.; Ditonno, P.; et al. Complement System and the Kidney: Its Role in Renal Diseases, Kidney Transplantation and Renal Cell Carcinoma. *Int. J. Mol. Sci.* **2023**, *24*, 16515. [CrossRef] [PubMed]
6. Pierorazio, P.M.; Johnson, M.H.; Patel, H.D.; Sozio, S.M.; Sharma, R.; Iyoha, E.; Bass, E.B.; Allaf, M.E. Management of Renal Masses and Localized Renal Cancer: Systematic Review and Meta-Analysis. *J. Urol.* **2016**, *196*, 989–999. [CrossRef] [PubMed]
7. Pandolfo, S.D.; Cerrato, C.; Wu, Z.; Franco, A.; Del Giudice, F.; Sciarra, A.; Verze, P.; Lucarelli, G.; Imbimbo, C.; Perdonà, S.; et al. A systematic review of robotic partial nephrectomy outcomes for advanced indications: Large (cT2-T3), solitary kidney, completely endophytic, hilar, recurrent, and multiple renal tumors. *Asian J. Urol.* **2023**, *61*, 101837. [CrossRef]
8. Sánchez-Martín, F.M.; Millán-Rodríguez, F.; Urdaneta-Pignalosa, G.; Rubio-Briones, J.; Villavicencio-Mavrich, H. Small Renal Masses: Incidental Diagnosis, Clinical Symptoms, and Prognostic Factors. *Adv. Urol.* **2008**, *2008*, 310694. [CrossRef] [PubMed]
9. Pandolfo, S.D.; Carbonara, U.; Beksac, A.T.; Derweesh, I.; Celia, A.; Schiavina, R.; Elbich, J.; Basile, G.; Hampton, L.J.; Cerrato, C.; et al. Microwave versus cryoablation and radiofrequency ablation for small renal mass: A multicenter comparative analysis. *Minerva Urol. Nephrol.* **2023**, *75*, 66–72. [CrossRef]
10. Hu, X.; Shao, Y.-X.; Wang, Y.; Yang, Z.-Q.; Yang, W.-X.; Li, X. Partial nephrectomy versus ablative therapies for cT1a renal masses: A Systematic Review and meta-analysis. *Eur. J. Surg. Oncol.* **2019**, *45*, 1527–1535. [CrossRef]
11. Pandolfo, S.D.; Loizzo, D.; Beksac, A.T.; Derweesh, I.; Celia, A.; Bianchi, L.; Elbich, J.; Costa, G.; Carbonara, U.; Lucarelli, G.; et al. Percutaneous thermal ablation for cT1 renal mass in solitary kidney: A multicenter trifecta comparative analysis versus robot-assisted partial nephrectomy. *Eur. J. Surg. Oncol.* **2023**, *49*, 486–490. [CrossRef] [PubMed]
12. Pandolfo, S.D.; Beksac, A.; Derweesh, I.H.; Celia, A.; Schiavina, R.; Bianchi, L.; Costa, G.; Carbonara, U.; Loizzo, D.; Lucarelli, G.; et al. Percutaneous Ablation versus Robot-Assisted Partial Nephrectomy for Completely Endophytic Renal Masses: A Multicenter Trifecta Analysis with a Minimum 3-year Follow-up. *J. Endourol.* **2022**, *37*, 279–285. [CrossRef] [PubMed]
13. Cerrato, C.; Meagher, M.F.; Autorino, R.; Simone, G.; Yang, B.; Uzzo, R.G.; Kutikov, A.; Porpiglia, F.; Capitanio, U.; Montorsi, F.; et al. Partial versus radical nephrectomy for complex renal mass: Multicenter comparative analysis of functional outcomes (Rosula collaborative group). *Minerva Urol. Nephrol.* **2023**, *75*, 425–433. [CrossRef] [PubMed]
14. Cerrato, C.; Patel, D.; Autorino, R.; Simone, G.; Yang, B.; Uzzo, R.; Porpiglia, F.; Capitanio, U.; Porter, J.; Beksac, A.T.; et al. Partial or radical nephrectomy for complex renal mass: A comparative analysis of oncological outcomes and complications from the ROSULA (Robotic Surgery for Large Renal Mass) Collaborative Group. *World J. Urol.* **2023**, *41*, 747–755. [CrossRef] [PubMed]
15. Wu, Z.; Chen, H.; Chen, Q.; Ge, S.; Yu, N.; Campi, R.; Gómez Rivas, J.; Autorino, R.; Rouprêt, M.; Psutka, S.P.; et al. Prognostic Significance of Grade Discrepancy Between Primary Tumor and Venous Thrombus in Nonmetastatic Clear-cell Renal Cell Carcinoma: Analysis of the REMEMBER Registry and Implications for Adjuvant Therapy. *Eur. Urol. Oncol.* **2023**, *7*, 112–121. [CrossRef] [PubMed]
16. Saitta, C.; Afari, J.A.; Autorino, R.; Capitanio, U.; Porpiglia, F.; Amparore, D.; Piramide, F.; Cerrato, C.; Meagher, M.F.; Noyes, S.L.; et al. Development of a novel score (RENSAFE) to determine probability of acute kidney injury and renal functional decline post surgery: A multicenter analysis. *Urol. Oncol.* **2023**, *41*, 487.e15–487.e23. [CrossRef]
17. Flammia, R.S.; Anceschi, U.; Tuderti, G.; Di Maida, F.; Grosso, A.A.; Lambertini, L.; Mari, A.; Mastroianni, R.; Bove, A.; Capitanio, U.; et al. Development and internal validation of a nomogram predicting 3-year chronic kidney disease upstaging following robot-assisted partial nephrectomy. *Int. Urol. Nephrol.* **2023**, *56*, 913–921. [CrossRef]
18. Ziglioli, F.; De Filippo, M.; Cavalieri, D.M.; Pagnini, F.; Campobasso, D.; Guarino, G.; Maestroni, U. Percutaneous Radiofrequency Ablation (RFA) in renal cancer. How to manage challenging masses. A narrative review. *Acta Biomed.* **2022**, *93*, e2022220. [CrossRef]
19. Crocerossa, F.; Fiori, C.; Capitanio, U.; Minervini, A.; Carbonara, U.; Pandolfo, S.D.; Loizzo, D.; Eun, D.D.; Larcher, A.; Mari, A.; et al. Estimated Glomerular Filtration Rate Decline at 1 Year After Minimally Invasive Partial Nephrectomy: A Multimodel Comparison of Predictors. *Eur. Urol. Open Sci.* **2022**, *38*, 52–59. [CrossRef]
20. Ahmed, M.; Brace, C.L.; Lee, F.T.; Goldberg, S.N. Principles of and Advances in Percutaneous Ablation. *Radiology* **2011**, *258*, 351–369. [CrossRef]
21. Woldrich, J.M.; Palazzi, K.; Stroup, S.P.; Sur, R.L.; Parsons, J.K.; Chang, D.; Derweesh, I.H. Trends in the surgical management of localized renal masses: Thermal ablation, partial and radical nephrectomy in the USA, 1998–2008. *BJU Int.* **2013**, *111*, 1261–1268. [CrossRef] [PubMed]

22. Campbell, S.; Uzzo, R.G.; Allaf, M.E.; Bass, E.B.; Cadeddu, J.A.; Chang, A.; Clark, P.E.; Davis, B.J.; Derweesh, I.H.; Giambarresi, L.; et al. Renal Mass and Localized Renal Cancer: AUA Guideline. *J. Urol.* **2017**, *198*, 520–529. [CrossRef] [PubMed]

23. Neves, J.B.; Cullen, D.; Grant, L.; Walkden, M.; Bandula, S.; Patki, P.; Barod, R.; Mumtaz, F.; Aitchison, M.; Pizzo, E.; et al. Protocol for a feasibility study of a cohort embedded randomised controlled trial comparing Nephron Sparing Treatment (NEST) for small renal masses. *BMJ Open* **2019**, *9*, e030965. [CrossRef] [PubMed]

24. Gill, I.S.; Remer, E.M.; Hasan, W.A.; Strzempkowski, B.; Spaliviero, M.; Steinberg, A.P.; Kaouk, J.H.; Desai, M.M.; Novick, A.C. RENAL CRYOABLATION: OUTCOME AT 3 YEARS. *J. Urol.* **2005**, *173*, 1903–1907. [CrossRef] [PubMed]

25. Stern, J.M.; Svatek, R.; Park, S.; Hermann, M.; Lotan, Y.; Sagalowsky, A.I.; Cadeddu, J.A. Intermediate comparison of partial nephrectomy and radiofrequency ablation for clinical T1a renal tumours. *BJU Int.* **2007**, *100*, 287–290. [CrossRef] [PubMed]

26. Breda, A.; Anterasian, C.; Belldegrun, A. Management and outcomes of tumor recurrence after focal ablation renal therapy. *J. Endourol.* **2010**, *24*, 749–752. [CrossRef] [PubMed]

27. Pandolfo, S.D.; Wu, Z.; Campi, R.; Bertolo, R.; Amparore, D.; Mari, A.; Verze, P.; Manfredi, C.; Franco, A.; Ditonno, F.; et al. Outcomes and Techniques of Robotic-Assisted Partial Nephrectomy (RAPN) for Renal Hilar Masses: A Comprehensive Systematic Review. *Cancers* **2024**, *16*, 693. [CrossRef] [PubMed]

28. Gunn, A.J.; Gervais, D.A. Percutaneous ablation of the small renal mass-techniques and outcomes. *Semin. Interv. Radiol.* **2014**, *31*, 33–41. [CrossRef] [PubMed]

29. Kwan, K.G.; Matsumoto, E.D. Radiofrequency Ablation and Cryoablation of Renal Tumours. *Curr. Oncol.* **2007**, *14*, 34–38. [CrossRef]

30. Gervais, D.A.; McGovern, F.J.; Arellano, R.S.; McDougal, W.S.; Mueller, P.R. Radiofrequency Ablation of Renal Cell Carcinoma: Part 1, Indications, Results, and Role in Patient Management over a 6-Year Period and Ablation of 100 Tumors. *Am. J. Roentgenol.* **2005**, *185*, 64–71. [CrossRef]

31. Zlotta, A.R.; Wildschutz, T.; Raviv, G.; Peny, M.O.; van Gansbeke, D.; Noel, J.C.; Schulman, C.C. Radiofrequency interstitial tumor ablation (RITA) is a possible new modality for treatment of renal cancer: Ex vivo and in vivo experience. *J. Endourol.* **1997**, *11*, 251–258. [CrossRef]

32. Chu, K.F.; Dupuy, D.E. Thermal ablation of tumours: Biological mechanisms and advances in therapy. *Nat. Rev. Cancer* **2014**, *14*, 199–208. [CrossRef] [PubMed]

33. Iannuccilli, J.D.; Dupuy, D.E.; Beland, M.D.; Machan, J.T.; Golijanin, D.J.; Mayo-Smith, W.W. Effectiveness and safety of computed tomography-guided radiofrequency ablation of renal cancer: A 14-year single institution experience in 203 patients. *Eur. Radiol.* **2016**, *26*, 1656–1664. [CrossRef] [PubMed]

34. Mauri, G.; Mistretta, F.A.; Bonomo, G.; Camisassi, N.; Conti, A.; Della Vigna, P.; Ferro, M.; Luzzago, S.; Maiettini, D.; Musi, G.; et al. Long-Term Follow-Up Outcomes after Percutaneous US/CT-Guided Radiofrequency Ablation for cT1a-b Renal Masses: Experience from Single High-Volume Referral Center. *Cancers* **2020**, *12*, 1183. [CrossRef] [PubMed]

35. Woolley, M.L.; Schulsinger, D.A.; Durand, D.B.; Zeltser, I.S.; Waltzer, W.C. Effect of Freezing Parameters (Freeze Cycle and Thaw Process) on Tissue Destruction Following Renal Cryoablation. *J. Endourol.* **2002**, *16*, 519–522. [CrossRef] [PubMed]

36. Zondervan, P.J.; Buijs, M.; De La Rosette, J.J.; Van Delden, O.; Van Lienden, K.; Laguna, M.P. Cryoablation of small kidney tumors. *Int. J. Surg.* **2016**, *36*, 533–540. [CrossRef] [PubMed]

37. Motzer, R.J.; Jonasch, E.; Agarwal, N.; Alva, A.; Baine, M.; Beckermann, K.; Carlo, M.I.; Choueiri, T.K.; Costello, B.A.; Derweesh, I.H.; et al. Kidney Cancer, Version 3.2022, NCCN Clinical Practice Guidelines in Oncology. *J. Natl. Compr. Canc Netw.* **2022**, *20*, 71–90. [CrossRef]

38. Schmit, G.D.; Atwell, T.D.; Callstrom, M.R.; Farrell, M.A.; Leibovich, B.C.; Patterson, D.E.; Chow, G.K.; Blute, M.L.; Charboneau, J.W. Percutaneous cryoablation of renal masses >or=3 cm: Efficacy and safety in treatment of 108 patients. *J. Endourol.* **2010**, *24*, 1255–1262. [CrossRef]

39. Krokidis, M.E.; Kitrou, P.; Spiliopoulos, S.; Karnabatidis, D.; Katsanos, K. Image-guided minimally invasive treatment for small renal cell carcinoma. *Insights Imaging* **2018**, *9*, 385–390. [CrossRef]

40. Shakeri, S.; Raman, S.S. Trends in Percutaneous Thermal Ablation Therapies in the Treatment of T1a Renal Cell Carcinomas Rather than Partial Nephrectomy/Radical Nephrectomy. *Semin. Interv. Radiol.* **2019**, *36*, 183–193. [CrossRef]

41. Lubner, M.G.; Brace, C.L.; Hinshaw, J.L.; Lee, F.T. Microwave tumor ablation: Mechanism of action, clinical results, and devices. *J. Vasc. Interv. Radiol.* **2010**, *21*, S192–S203. [CrossRef] [PubMed]

42. Wright, A.S.; Lee, F.T.; Mahvi, D.M. Hepatic Microwave Ablation With Multiple Antennae Results in Synergistically Larger Zones of Coagulation Necrosis. *Ann. Surg. Oncol.* **2003**, *10*, 275–283. [CrossRef] [PubMed]

43. Sun, Y.; Wang, Y.; Ni, X.; Gao, Y.; Shao, Q.; Liu, L.; Liang, P. Comparison of Ablation Zone Between 915- and 2450-MHz Cooled-Shaft Microwave Antenna: Results in In Vivo Porcine Livers. *Am. J. Roentgenol.* **2009**, *192*, 511–514. [CrossRef]

44. Vita, E.D.; Presti, D.L.; Massaroni, C.; Iadicicco, A.; Schena, E.; Campopiano, S. A review on radiofrequency, laser, and microwave ablations and their thermal monitoring through fiber Bragg gratings. *iScience* **2023**, *26*, 108260. [CrossRef] [PubMed]

45. Klapperich, M.E.; Abel, E.J.; Ziemlewicz, T.J.; Best, S.; Lubner, M.G.; Nakada, S.Y.; Hinshaw, J.L.; Brace, C.L.; Lee, F.T.; Wells, S.A. Effect of Tumor Complexity and Technique on Efficacy and Complications after Percutaneous Microwave Ablation of Stage T1a Renal Cell Carcinoma: A Single-Center, Retrospective Study. *Radiology* **2017**, *284*, 272–280. [CrossRef] [PubMed]

46. Wagstaff, P.G.; Buijs, M.; van den Bos, W.; de Bruin, D.M.; Zondervan, P.J.; de la Rosette, J.J.; Laguna Pes, M.P. Irreversible electroporation: State of the art. *Onco Targets Ther.* **2016**, *9*, 2437–2446. [CrossRef] [PubMed]

47. Davalos, R.V.; Mir, L.M.; Rubinsky, B. Tissue Ablation with Irreversible Electroporation. *Ann. Biomed. Eng.* **2005**, *33*, 223–231. [CrossRef] [PubMed]

48. Srimathveeravalli, G.; Wimmer, T.; Monette, S.; Gutta, N.B.; Ezell, P.C.; Maybody, M.; Weiser, M.R.; Solomon, S.B. Evaluation of an Endorectal Electrode for Performing Focused Irreversible Electroporation Ablations in the Swine Rectum. *J. Vasc. Interv. Radiol.* **2013**, *24*, 1249–1256. [CrossRef]

49. Park, B.K. Assessment of Local Tumor Progression After Image-Guided Thermal Ablation for Renal Cell Carcinoma. *Korean J. Radiol.* **2024**, *25*, 33. [CrossRef]

50. Frieser, M.; Kiesel, J.; Lindner, A.; Bernatik, T.; Haensler, J.; Janka, R.; Hahn, E.; Strobel, D. Efficacy of Contrast-Enhanced US versus CT or MRI for the Therapeutic Control of Percutaneous Radiofrequency Ablation in the Case of Hepatic Malignancies. *Ultraschall Med.* **2011**, *32*, 148–153. [CrossRef]

51. Thomsen, H.S.; Morcos, S.K.; Barrett, B.J. Contrast-induced nephropathy: The wheel has turned 360 degrees. *Acta Radiol.* **2008**, *49*, 646–657. [CrossRef] [PubMed]

52. Syvanthong, C.; Wile, G.E.; Zagoria, R.J. Effect of Radiofrequency Ablation of Renal Tumors on Renal Function in Patients with a Solitary Kidney. *Am. J. Roentgenol.* **2007**, *188*, 1619–1621. [CrossRef] [PubMed]

53. Lange, S.; Mędrzycka-Dąbrowska, W.; Zorena, K.; Dąbrowski, S.; Ślęzak, D.; Malecka-Dubiela, A.; Rutkowski, P. Nephrogenic Systemic Fibrosis as a Complication after Gadolinium-Containing Contrast Agents: A Rapid Review. *Int. J. Environ. Res. Public Health* **2021**, *18*, 3000. [CrossRef] [PubMed]

54. Barwari, K.; Wijkstra, H.; Van Delden, O.M.; De La Rosette, J.J.; Laguna, M.P. Contrast-Enhanced Ultrasound for the Evaluation of the Cryolesion After Laparoscopic Renal Cryoablation: An Initial Report. *J. Endourol.* **2013**, *27*, 402–407. [CrossRef] [PubMed]

55. Li, X.; Liang, P.; Yu, J.; Yu, X.-L.; Liu, F.-Y.; Cheng, Z.-G.; Han, Z.-Y. Role of contrast-enhanced ultrasound in evaluating the efficiency of ultrasound guided percutaneous microwave ablation in patients with renal cell carcinoma. *Radiol. Oncol.* **2013**, *47*, 398–404. [CrossRef] [PubMed]

56. Eiken, P.W.; Atwell, T.D.; Kurup, A.N.; Boorjian, S.A.; Thompson, R.H.; Schmit, G.D. Imaging following renal ablation: What can we learn from recurrent tumors? *Abdom. Radiol.* **2018**, *43*, 2750–2755. [CrossRef] [PubMed]

57. Lum, M.A.; Shah, S.B.; Durack, J.C.; Nikolovski, I. Imaging of Small Renal Masses before and after Thermal Ablation. *RadioGraphics* **2019**, *39*, 2134–2145. [CrossRef] [PubMed]

58. Wile, G.E.; Leyendecker, J.R.; Krehbiel, K.A.; Dyer, R.B.; Zagoria, R.J. CT and MR Imaging after Imaging-guided Thermal Ablation of Renal Neoplasms. *RadioGraphics* **2007**, *27*, 325–339. [CrossRef] [PubMed]

59. Stein, A.J.; Mayes, J.M.; Mouraviev, V.; Chen, V.H.; Nelson, R.C.; Polascik, T.J. Persistent Contrast Enhancement Several Months after Laparoscopic Cryoablation of the Small Renal Mass May Not Indicate Recurrent Tumor. *J. Endourol.* **2008**, *22*, 2433–2440. [CrossRef]

60. Burns, J.A.; Weiner, A.B.; Catalona, W.J.; Li, E.V.; Schaeffer, E.M.; Hanauer, S.B.; Strong, S.; Burns, J.; Hussain, M.H.A.; Kundu, S.D. Inflammatory Bowel Disease and the Risk of Prostate Cancer. *Eur. Urol.* **2019**, *75*, 846–852. [CrossRef]

61. Lokken, R.P.; Gervais, D.A.; Arellano, R.S.; Tuncali, K.; Morrison, P.R.; Tatli, S.; Mueller, P.R.; Silverman, S.G. Inflammatory Nodules Mimic Applicator Track Seeding After Percutaneous Ablation of Renal Tumors. *Am. J. Roentgenol.* **2007**, *189*, 845–848. [CrossRef]

62. Napolitano, L.; Manfredi, C.; Cirillo, L.; Fusco, G.M.; Passaro, F.; Abate, M.; La Rocca, R.; Mastrangelo, F.; Spirito, L.; Pandolfo, S.D.; et al. Cytoreductive Nephrectomy and Metastatic Renal Cell Carcinoma: State of the Art and Future Perspectives. *Medicina* **2023**, *59*, 767. [CrossRef] [PubMed]

63. Maccini, M.; Sehrt, D.; Pompeo, A.; Chicoli, F.A.; Molina, W.R.; Kim, F.J. Biophysiologic considerations in cryoablation: A practical mechanistic molecular review. *Int. Braz. J. Urol.* **2011**, *37*, 693–696. [CrossRef] [PubMed]

64. Pecoraro, A.; Campi, R.; Marchioni, M. Techniques and outcomes of percutaneous tumour ablation for small renal masses. *Curr. Opin. Urol.* **2023**, *33*, 360–366. [CrossRef] [PubMed]

65. Meloni, M.F.; Bertolotto, M.; Alberzoni, C.; Lazzaroni, S.; Filice, C.; Livraghi, T.; Ferraioli, G. Follow-Up After Percutaneous Radiofrequency Ablation of Renal Cell Carcinoma: Contrast-Enhanced Sonography Versus Contrast-Enhanced CT or MRI. *Am. J. Roentgenol.* **2008**, *191*, 1233–1238. [CrossRef]

66. Kawamoto, S.; Permpongkosol, S.; Bluemke, D.A.; Fishman, E.K.; Solomon, S.B. Sequential Changes after Radiofrequency Ablation and Cryoablation of Renal Neoplasms: Role of CT and MR Imaging. *RadioGraphics* **2007**, *27*, 343–355. [CrossRef] [PubMed]

67. Hoeffel, C.; Pousset, M.; Timsit, M.-O.; Elie, C.; Méjean, A.; Merran, S.; Tranquart, F.; Khairoune, A.; Joly, D.; Richard, S.; et al. Radiofrequency ablation of renal tumours: Diagnostic accuracy of contrast-enhanced ultrasound for early detection of residual tumour. *Eur. Radiol.* **2010**, *20*, 1812–1821. [CrossRef] [PubMed]

68. Kriegmair, M.C.; Bertolo, R.; Karakiewicz, P.I.; Leibovich, B.C.; Ljungberg, B.; Mir, M.C.; Ouzaid, I.; Salagierski, M.; Staehler, M.; van Poppel, H.; et al. Systematic Review of the Management of Local Kidney Cancer Relapse. *Eur. Urol. Oncol.* **2018**, *1*, 512–523. [CrossRef]

69. Hafez, K.S.; Novick, A.C.; Campbell, S.C. Patterns of tumor recurrence and guidelines for followup after nephron sparing surgery for sporadic renal cell carcinoma. *J. Urol.* **1997**, *157*, 2067–2070. [CrossRef]

70. Uhlig, J.; Strauss, A.; Rücker, G.; Seif Amir Hosseini, A.; Lotz, J.; Trojan, L.; Kim, H.S.; Uhlig, A. Partial nephrectomy versus ablative techniques for small renal masses: A systematic review and network meta-analysis. *Eur. Radiol.* **2019**, *29*, 1293–1307. [CrossRef]

71. Adamy, A.; Chong, K.T.; Chade, D.; Costaras, J.; Russo, G.; Kaag, M.G.; Bernstein, M.; Motzer, R.J.; Russo, P. Clinical Characteristics and Outcomes of Patients With Recurrence 5 Years After Nephrectomy for Localized Renal Cell Carcinoma. *J. Urol.* **2011**, *185*, 433–438. [CrossRef] [PubMed]

72. Du, Y.; Grüllich, C.; Hadaschik, B.; Hatiboglu, G.; Hohenfellner, M.; Pahernik, S. Local Recurrence After Curative Surgical Treatment of Renal Cell Cancer: A Study of 91 Patients. *Clin. Genitourin. Cancer* **2016**, *14*, e379–e385. [CrossRef] [PubMed]

73. Zargar, H.; Atwell, T.D.; Cadeddu, J.A.; De La Rosette, J.J.; Janetschek, G.; Kaouk, J.H.; Matin, S.F.; Polascik, T.J.; Zargar-Shoshtari, K.; Thompson, R.H. Cryoablation for Small Renal Masses: Selection Criteria, Complications, and Functional and Oncologic Results. *Eur. Urol.* **2016**, *69*, 116–128. [CrossRef] [PubMed]

74. Breen, D.J.; Bryant, T.J.; Abbas, A.; Shepherd, B.; McGill, N.; Anderson, J.A.; Lockyer, R.C.; Hayes, M.C.; George, S.L. Percutaneous cryoablation of renal tumours: Outcomes from 171 tumours in 147 patients. *BJU Int.* **2013**, *112*, 758–765. [CrossRef] [PubMed]

75. Shi, H.; Li, J.; Fan, Z.; Yang, J.; Fu, S.; Wang, H.; Wang, J.; Zhang, J. Comparison of Radiofrequency Ablation Versus Cryoablation For T1 Renal Tumors: An Evidence-Based Analysis of Comparative Outcomes. *Front. Oncol.* **2022**, *12*, 802437. [CrossRef] [PubMed]

76. Lam, C.J.; Wong, N.C.; Voss, M.; Mironov, O.; Connolly, M.; Matsumoto, E.D.; Kapoor, A. Surveillance post-radiofrequency ablation for small renal masses: Recurrence and followup. *Can. Urol. Assoc. J.* **2020**, *14*, 398–403. [CrossRef] [PubMed]

77. McClure, T.; Lansing, A.; Ferko, N.; Wright, G.; Ghosh, S.K.; Raza, S.; Kalsekar, I.; Clarke, K.; Talenfeld, A. A Comparison of Microwave Ablation and Cryoablation for the Treatment of Renal Cell Carcinoma: A Systematic Literature Review and Meta-analysis. *Urology* **2023**, *180*, 1–8. [CrossRef]

78. Canvasser, N.E.; Sorokin, I.; Lay, A.H.; Morgan, M.S.C.; Ozayar, A.; Trimmer, C.; Cadeddu, J.A. Irreversible electroporation of small renal masses: Suboptimal oncologic efficacy in an early series. *World J. Urol.* **2017**, *35*, 1549–1555. [CrossRef]

79. Dai, J.C.; Morgan, T.N.; Steinberg, R.L.; Johnson, B.A.; Garbens, A.; Cadeddu, J.A. Irreversible Electroporation for the Treatment of Small Renal Masses: 5-Year Outcomes. *J. Endourol.* **2021**, *35*, 1586–1592. [CrossRef]

80. Polascik, T.J.; Mouraviev, V. The Rise of Ablative Technologies for Treating the Small Renal Mass. *Eur. Urol.* **2007**, *52*, 636–638. [CrossRef]

81. Kunkle, D.A.; Uzzo, R.G. Cryoablation or radiofrequency ablation of the small renal mass: A meta-analysis. *Cancer* **2008**, *113*, 2671–2680. [CrossRef] [PubMed]

82. Benway, B.M.; Bhayani, S.B. Approach to the small renal mass: Weighing treatment options. *Curr. Urol. Rep.* **2009**, *10*, 11–16. [CrossRef] [PubMed]

83. Long, L.; Park, S. Differences in Patterns of Care: Reablation and Nephrectomy Rates After Needle Ablative Therapy for Renal Masses Stratified by Medical Specialty. *J. Endourol.* **2009**, *23*, 421–426. [CrossRef] [PubMed]

84. Park, S.; Cadeddu, J.A.; Shingleton, W.B. Oncologic outcomes for ablative therapy of kidney cancer. *Curr. Urol. Rep.* **2007**, *8*, 31–37. [CrossRef] [PubMed]

85. Hegg, R.M.; Schmit, G.D.; Boorjian, S.A.; McDonald, R.J.; Kurup, A.N.; Weisbrod, A.J.; Callstrom, M.R.; Atwell, T.D.; Thompson, R.H. Percutaneous Renal Cryoablation After Partial Nephrectomy: Technical Feasibility, Complications and Outcomes. *J. Urol.* **2013**, *189*, 1243–1248. [CrossRef] [PubMed]

86. Okhunov, Z.; Chamberlin, J.; Moreira, D.M.; George, A.; Babaian, K.; Shah, P.; Youssef, R.; Kaler, K.S.; Lobko, I.I.; Kavoussi, L.; et al. Salvage Percutaneous Cryoablation for Locally Recurrent Renal-Cell Carcinoma After Primary Cryoablation. *J. Endourol.* **2016**, *30*, 632–637. [CrossRef] [PubMed]

87. Matin, S.F.; Ahrar, K.; Cadeddu, J.A.; Gervais, D.A.; McGovern, F.J.; Zagoria, R.A.; Uzzo, R.G.; Haaga, J.; Resnick, M.I.; Kaouk, J.; et al. Residual and Recurrent Disease Following Renal Energy Ablative Therapy: A Multi-Institutional Study. *J. Urol.* **2006**, *176*, 1973–1977. [CrossRef] [PubMed]

88. Loloi, J.; Shingleton, W.B.; Nakada, S.Y.; Zagoria, R.J.; Landman, J.; Lee, B.R.; Matin, S.F.; Ahrar, K.; Leveillee, R.J.; Cadeddu, J.A.; et al. Management of Residual or Recurrent Disease Following Thermal Ablation of Renal Cortical Tumors. *jkcvhl* **2020**, *7*, 1–5. [CrossRef] [PubMed]

89. Kowalczyk, K.J.; Hooper, H.B.; Linehan, W.M.; Pinto, P.A.; Wood, B.J.; Bratslavsky, G. Partial Nephrectomy After Previous Radio Frequency Ablation: The National Cancer Institute Experience. *J. Urol.* **2009**, *182*, 2158–2163. [CrossRef]

90. Nguyen, C.T.; Lane, B.R.; Kaouk, J.H.; Hegarty, N.; Gill, I.S.; Novick, A.C.; Campbell, S.C. Surgical Salvage of Renal Cell Carcinoma Recurrence After Thermal Ablative Therapy. *J. Urol.* **2008**, *180*, 104–109. [CrossRef]

91. Karam, J.A.; Wood, C.G.; Compton, Z.R.; Rao, P.; Vikram, R.; Ahrar, K.; Matin, S.F. Salvage surgery after energy ablation for renal masses: Salvage surgery after renal mass ablation. *BJU Int.* **2015**, *115*, 74–80. [CrossRef] [PubMed]

92. Jiménez, J.A.; Zhang, Z.; Zhao, J.; Abouassaly, R.; Fergany, A.; Gong, M.; Kaouk, J.; Krishnamurthi, V.; Stein, R.; Stephenson, A.; et al. Surgical Salvage of Thermal Ablation Failures for Renal Cell Carcinoma. *J. Urol.* **2016**, *195*, 594–600. [CrossRef] [PubMed]

93. Martini, A.; Turri, F.; Barod, R.; Rocco, B.; Capitanio, U.; Briganti, A.; Montorsi, F.; Mottrie, A.; Challacombe, B.; Lagerveld, B.W.; et al. Salvage Robot-assisted Renal Surgery for Local Recurrence After Surgical Resection or Renal Mass Ablation: Classification, Techniques, and Clinical Outcomes. *Eur. Urol.* **2021**, *80*, 730–737. [CrossRef] [PubMed]
94. Larcher, A.; Muttin, F.; Peyronnet, B.; De Naeyer, G.; Khene, Z.-E.; Dell'Oglio, P.; Ferreiro, C.; Schatteman, P.; Capitanio, U.; D'Hondt, F.; et al. The Learning Curve for Robot-assisted Partial Nephrectomy: Impact of Surgical Experience on Perioperative Outcomes. *Eur. Urol.* **2019**, *75*, 253–256. [CrossRef] [PubMed]