TECHNOLOGY REVIEW (MINI-HTA)

MICROWAVE ABLATION FOR KIDNEY AND LIVER TUMOURS

Malaysian Health Technology Assessment Section (MaHTAS)
Medical Development Division
Ministry of Health Malaysia
001/2025

IPT Mark
INAHTA
Mini-HTA

DISCLAIMER

This technology review (mini-HTA) is prepared to assist health care decision-makers and health care professionals in making well-informed decisions related to the use of health technology in health care system, which draws on restricted review from analysis of best pertinent literature available at the time of development. This technology review has been subjected to an external review process. While effort has been made to do so, this document may not fully reflect all scientific research available. Other relevant scientific findings may have been reported since the completion of this technology review. MaHTAS is not responsible for any errors, injury, loss or damage arising or relating to the use (or misuse) of any information, statement or content of this document or any of the source materials.

Please contact htamalaysia@moh.gov.my if further information is required.

EVIDENCE INFORMED DELIBERATIVE PROCESS

This Technology Review underwent an evidence informed deliberative process during the Health Technology Assessment (HTA) Technical Advisory Committee meeting, chaired by the Director, Medical Development Division, MOH. Then it was endorsed in the HTA-CPG Council meeting chaired by the Director General of Health.

Published by:

Malaysian Health Technology Assessment Section (MaHTAS)
Medical Development Division, Ministry of Health Malaysia
Level 4, Block E1, Precinct 1, Government Office Complex, 62590, Putrajaya
Tel: 603 8883 1229
Available online via the official Ministry of Health Malaysia website: http://www.moh.gov.my

Cataloguing-in-Publication Data

Perpustakaan Negara Malaysia

A catalogue record for this book is available from the National Library of Malaysia

eISBN 978-967-2887-98-0

eISBN:978-967-2887-98-0

SUGGESTED CITATION: Fatin NM and Izzuna MMG. Microwave Ablation for Kidney and Liver Tumours. Technology Review. Ministry of Health Malaysia: Malaysian Health Technology Assessment Section (MaHTAS); 2025. 54 p. Report No.: 001/2025. eISBN: 978-967-2887-98-0

DISCLOSURE: The author of this report has no competing interest in this subject and the preparation of this report is entirely funded by the Ministry of Health Malaysia.

AUTHOR

Fatin Nabila Mokhtar
Research Officer
Senior Assistant Director
Malaysian Health Technology Assessment Section (MaHTAS)
Medical Development Division
Ministry of Health Malaysia

REVIEWER

Dr. Izzuna Mudla Mohamed Ghazali
Public Health Physician
Deputy Director
Malaysian Health Technology Assessment Section (MaHTAS)
Medical Development Division
Ministry of Health Malaysia

EXTERNAL REVIEWERS

Associate Professor Dr. Nur Yazmin Yaacob
Interventional Radiologist
Faculty of Medicine
Hospital Canselor Tuanku Mukhriz

Dr. Ridzuan Abdul Rahim
Interventional Radiologist
National Cancer Institute

EXECUTIVE SUMMARY

Background

Kidney and liver tumours are global health concerns with distinct epidemiological, clinical and therapeutic profiles. Kidney cancer, with over 431,000 new cases in 2020, is more prevalent in men and most common in North America and Europe. Renal cell carcinoma (RCC), particularly the clear cell subtype, is the dominant form influenced by risk factors like smoking and obesity. In Malaysia, kidney cancer is relatively rare, with a mortality rate of 1.8 per 100,000.

Liver cancer diagnosed in over 905,000 individuals globally in 2020, is more common in men and prevalent in East and Southeast Asia. Hepatocellular carcinoma (HCC) is the most common form. In Malaysia, liver cancer ranks among the top causes of cancer deaths, especially in older adults.

Treatment options for both tumour types include surgery, systemic therapies, ablation and radiation. Liver tumours have more established treatment guidelines, while kidney tumour guidance is still evolving. Challenges include drug resistance, limited treatment efficacy and adverse effects.

Microwave ablation is emerging as a promising, minimally invasive treatment. It offers precise tumour targeting with fewer complications but lacks long-term outcome data. Further research is essential to standardise microwave ablation protocols and integrate it into Malaysian clinical guidelines.

Objective/aim

The objective of this technology review was to assess the effectiveness, safety, economic implication and organisational issue of microwave ablation in treating kidney and liver tumours.

Results and conclusions

The initial search yielded 2,267 citations from electronic databases and 217 from Google Scholar, with 66 unique citations remaining after duplicate removal. Title screening identified 34 potentially relevant studies, and abstract review led to the retrieval of 31 full-text articles. After applying eligibility criteria, 20 studies were included: five systematic reviews and meta-analyses, one systematic review on study guidelines, six randomised controlled trials, seven retrospective cohort studies and one cost-effectiveness analysis. Most studies were conducted in the United States and China, followed by the United Kingdom, Germany, Saudi Arabia, Italy, Japan, Korea and Australia.

Effectiveness:

A substantial volume of retrievable data demonstrated that microwave ablation significantly enhanced clinical outcomes for kidney and liver tumours, particularly in terms of patient-reported outcomes, when compared to alternative treatment modalities. The findings indicated that:

a. Kidney tumour

- Disease-free survival
  - Higher in microwave group (94.0%) versus cryoablation group (89.0%) at 1-year and 5-year, 78.0% versus 77.0%.

- Overall survival
  - Higher in microwave group as compared to cyoablation group (p=0.001).

- Lower rates in microwave group for 1-, 3- and 5-year as compared to laparoscopic radical nephrectomy (p=0.0004).

- Recurrence (microwave versus partial nephrectomy)
  - During follow-up, two patients (4.2%) experienced local recurrences in microwave group.
  - Local recurrence rate was higher in microwave group (5.0% versus 1.4%).

b. Liver tumour

- Disease-free survival
  - Microwave group significantly improved as compared to radiofrequency group (p<0.01).

- Local tumour progression
  - Significant lower rates in microwave group at 2-year as compared to radiofrequency group (p=0.007).
  - Microwave group developed higher progression than croyoablation group (75.0 vs. 25.0%).

- Overall survival
  - Significant advantage for transcatheter arterial chemoembolisation plus microwave ablation (TACE + MWA) as compared to TACE alone (OR 4.64; 95% CI, 3.11 to 6.91).
  - Microwave group significantly improved (p=0.037) as compared to radiofrequency group.
  - Lowest overall survival (p=0.02) in TACE + MWA as compared to TACE alone and microwave group alone.
  - Higher in percutaneous microwave coagulation therapy (PMCT) as compared to percutaneous ethanol injection therapy (PEIT) in moderately/ poorly differentiated HCC (p=0.03).

- Recurrence
  - Local recurrence rates favoured TACE + MWA (OR 3.93; 95% CI, 2.64 to 5.87).
  - Lowest recurrence rates (p=0.0001) in TACE + MWA as compared to TACE alone and microwave group alone.
  - Higher patients in microwave group died as compared to surgical resection (43 vs. 40), primarily from cancer recurrence.
  - Overall recurrence rates were higher in microwave group (p=0.048) with significantly more early-stage recurrences and local recurrences compared to the surgical resection.

- Survival
  - Significant survival rates in TACE + MWA for tumours >5 cm at 1-, 2- and 3-year.

- Mortality
  - The mortality rate was higher in ultrasound-microwave group (18.8%; primarily due to tumour progression), as compared to cryoablation group (14.3%; mainly from local/ systemic HCC).

- Distant metastasis
    - Higher in microwave group as compared to cryoablation group (19.6 versus 17.8%).

Safety:
For kidney tumours, the findings indicated that microwave ablation demonstrated a relatively low complication rate compared to other treatment modalities, including cryoablation and partial nephrectomy. Major complications were infrequent, with most being periprocedural such as bleeding, pain and haematuria. Comparatively, microwave ablation showed a lower incidence of severe complications than cryoablation, and post-procedural renal function remained more stable than after partial nephrectomy. Additionally, no treatment-related mortalities were reported, and the incidence of major complications exhibited minimal heterogeneity across studies. These results suggested that microwave ablation is a safe and effective therapeutic option for kidney and liver tumours, with a favorable safety profile.

Meanwhile the evidence in liver tumours reported that, there was no significant differences in major complications or liver function changes post-treatment. Severe adverse events were rare, and no treatment-related deaths were reported. Minor complications, such as pain and fever, were generally well tolerated. One study noted a higher major complication rate for microwave ablation compared to cryoablation. Overall, microwave ablation remains a safe and effective treatment for liver tumours, though further research is needed to optimise its risk-benefit profile.

Economic implication:
Microwave ablation was found to be a cost-effective treatment for early-stage RCC compared to robotic-assisted partial nephrectomy (RA-PN), with lower recurrence and metastasis rates, increased life-years and reduced costs. Sensitivity analyses confirmed the robustness of these findings, with microwave ablation being the dominant strategy in 98.3% of simulations. Cost-adaptation analysis across eight high-income countries consistently showed lower costs for ablation, reinforcing its economic advantage. However, no studies were identified evaluating its cost-effectiveness for liver tumours.

Organisational issues:
Several guidelines address the use of microwave ablation for treating liver and kidney tumors. For HCC and colorectal liver metastases under 5 cm, ablation is considered safe and feasible in selected patients unsuitable for first-line therapy, though evidence quality is very low and biological tumour differences warrant caution. The guideline outlines best practices for thermal liver ablation, emphasising coagulation parameters, fasting, antibiotic prophylaxis and safety measures. In addition, the guideline on small RCC highlights microwave ablation risks, particularly pelvicalyceal injury in cT1a tumors and recommends contrast-enhanced imaging for planning, general anesthesia and adjunctive techniques such as fluid/ carbon dioxide dissection, ureteric stenting and transarterial embolisation to protect adjacent organs and improve outcomes.

Conclusion:
There was high certainty evidence supporting the use of microwave ablation, either as a standalone treatment or in combination with existing therapies, for managing kidney and liver tumours. In kidney tumours, microwave ablation is associated with low local recurrence rates, high overall survival, shorter ablation times and reduced 1-year recurrence rates. For liver tumours, evidence indicates that microwave ablation results in lower local tumour progression, larger ablation volumes and improved disease-free survival, particularly among patients with larger tumours or those in earlier cancer stages. When combined with TACE, microwave ablation significantly improves both overall and progression-free survival, with notable benefits in tumour response and recurrence reduction. In terms of safety, microwave ablation is

associated with fewer complications compared to surgical interventions. Additionally, one study on kidney tumours found microwave ablation to be a cost-effective option, with lower costs than RA-PN.

Methods

A systematic review was conducted to evaluate microwave ablation for kidney and liver tumours. The review protocol, search strategy, and literature search were developed by the primary investigator. The Ovid interface was used to search MEDLINE® All <1946 to January 3, 2025>, with additional searches performed in EMBASE, Cochrane Library, US FDA and INAHTA databases. Bibliographies of retrieved articles were also reviewed for relevant studies. Only human studies were included, with no language restrictions. The latest search was completed on 15th January 2025.

TABLE OF CONTENTS

ABBREVIATIONS

AHPBA	Americas Hepato-Pancreato-Biliary Association
CASP	Critical Appraisal Skills Programme
CIRSE	Cardiovascular and Interventional Radiological Society of Europe
CI	Confidence interval
CT	Computed tomography
HCC	Hepatocellular carcinoma
HR	Hazard ratio
ICC	Intrahepatic cholangiocarcinoma
ICER	Incremental cost-effectiveness ratio
IQR	Interquartile range
MRI	Magnetic resonance imaging
OR	Odds ratio
PEIT	Percutaneous ethanol injection therapy
PMCT	Percutaneous microwave coagulation therapy
QALY	Quality-adjusted life-years
RA-PN	Robotic-assisted partial nephrectomy
RCC	Renal cell carcinoma
ROB	Risk of bias
RR	Relative risk
SAGES	Society of American Gastrointestinal and Endoscopic Surgeons
TACE + MWA	Transcatheter arterial chemoembolisation plus microwave ablation
TACE + RFA	Transcatheter arterial chemoembolisation plus radiofrequency ablation
US FDA	United States of Food and Administration
WTP	Willingness-to-pay

1.0 BACKGROUND

Kidney and liver tumours are significant health concerns worldwide, with varying prevalence rates across different regions and populations. In 2020, approximately 431,288 new cases of kidney cancer were reported globally, accounting for about 2.2% of all cancer diagnoses. Men are more commonly affected than women, with an estimated 254,500 cases in men and 148,800 in women, reflecting a relative risk of about 1.7 for men compared to women. The highest incidence rates are observed in North America and Europe, while the lowest rates are in Asia and Africa.[1,2]

A kidney tumour refers to a neoplasm originating in the kidney, which can be benign or malignant, with renal cell carcinoma (RCC) being the most common malignant type. Clear cell renal cell carcinoma is the most prevalent subtype of RCC, accounting for about 65.0% of renal tumours and is often associated with mutations in the Von Hippel-Lindau gene. Other RCC subtypes include papillary RCC, chromophobe RCC and collecting duct carcinoma, each with distinct genetic and morphological characteristics. Risk factors for RCC include cigarette smoking, obesity, hypertension and chronic kidney disease.[3,4] Renal tumours in neonates and children are less common, with different types including congenital mesoblastic nephroma and Wilms tumour, which have specific clinical presentations and management strategies.[5]

Meanwhile, liver tumours encompass a variety of primary malignancies such as hepatocellular carcinoma (HCC), intrahepatic cholangiocarcinoma (ICC) and other less common types like fibrolamellar carcinoma and hepatoblastoma, as well as metastatic cancers.[6-8] Hepatoblastoma is a primary liver cancer seen in paediatric populations, particularly in infants and toddlers, and is usually chemosensitive with a favourable prognosis following surgical resection.[8-10] Treatment options for liver tumours vary based on the type and stage of the tumour, with surgical resection and transplantation being potential curative approaches for localised disease.[7]

In the meantime, an estimated 905,677 persons were diagnosed with liver cancer globally in 2020, with an age-standardised incidence rate of 9.5 per 100,000 people. Liver cancer is more prevalent in men, with an incidence rate of 14.1 per 100,000, compared to 5.2 per 100,000 in women. East Asia, Southeast Asia, Northern and Western Africa have the greatest occurrence rates, whereas Northern Europe and South-Central Asia have the lowest.[11,12]

The incidence of kidney cancer in Malaysia is relatively low, with approximately 1.9 cases per 100,000 individuals.[13] In the meantime, liver cancer ranks as the fifth most common cancer among both genders in Malaysia. It is the fourth most prevalent cancer among men between 2017 and 2021. Similar to 2012 to 2016, incidence is highest in the 70 to 74 age group, followed by the 65 to 69 age group. Most age groups are expected to have a rise in rates between 2017 and 2021, particularly those over the age of 40.[14] In 2022, the number of deaths attributed to liver cancer in Malaysia was 2,298, ranking it as the fourth leading cause of cancer deaths. Meanwhile, the number of deaths for kidney cancer was 670, ranking it 14th. Looking at the age-standardised mortality rates, liver cancer had a rate of 6.3 per 100,000, while kidney cancer had a rate of 1.8 per 100,000. The risk of dying from liver cancer before the age of 75 was 0.71%, and for kidney cancer, it was 0.15%. Moreover, liver cancer was among the top three leading cancers ranked by deaths for both sexes.[15]

Current treatments for kidney tumours include surgical resection, systemic therapies such as kinase inhibitors and immunotherapies, and radiation therapy for specific cases. For liver tumours, treatments include surgical resection, systemic therapies like sorafenib and the combination of atezolizumab with bevacizumab, and radiation therapy in certain contexts.[16,17]

According to the National Institute for Health and Care Excellence (NICE), multiple evidence-based guidelines have been established regarding therapeutic interventions for the management of liver tumours, including:[18]

- Selective internal radiation therapy with QuiremSpheres for treating unresectable advanced HCC (2024)
- Selective internal radiation therapies for treating HCC (2024)
- Image-guided percutaneous laser ablation for primary and secondary liver tumours (2024)
- Selective internal radiation therapy for neuroendocrine tumours that have metastasised to the liver (2024)
- Cabozantinib for previously treated advanced HCC (2022)
- Melphalan chemosaturation with percutaneous hepatic artery perfusion and hepatic vein isolation for primary or metastatic cancer in the liver (2021)
- Atezolizumab with bevacizumab for treating advanced or unresectable HCC (2020)
- Irreversible electroporation for primary liver cancer (2019)
- Regorafenib for previously treated advanced HCC (2019)
- Lenvatinib for untreated advanced HCC (2018)
- Sorafenib for treating advanced HCC (2017)
- Microwave ablation for treating liver metastases (2016)
- Living-donor liver transplantation (2015)
- SonoVue (sulphur hexafluoride microbubbles) – contrast agent for contrast-enhanced ultrasound imaging of the liver (2012)

However, the formulation of clinical guidance for kidney tumours remains under development.

Table 1 presents a comprehensive overview of various current therapeutic interventions employed in the treatment of kidney and liver tumours.

Table 1: Current interventions in treating kidney and liver tumours.[19,20]

Treatment	Remarks
Surgical	• Partial nephrectomy/ hepatectomy: Removal of the tumour and a small margin of healthy tissue, preserving most of the kidney/ liver. • Radical nephrectomy: Complete removal of the affected kidney, often including surrounding tissues and lymph nodes. • Liver transplant: Replacing the diseased liver with a healthy donor organ.
Ablation techniques	• Cryoablation: Utilises extreme cold to destroy cancer cells. • Radiofrequency ablation: Employs electrical currents to generate heat, targeting and eliminating cancer cells.
Targeted therapy	• Drugs designed to interfere with specific molecules necessary for cancer cell growth and survival.
Immunotherapy	• Treatments that enhance the body's natural defenses to combat cancer.
Radiation therapy	• Uses high-energy beams to target and kill cancer cells, often employed when surgery is not viable.

Challenges in the current treatment for kidney and liver tumours include drug resistance, limited efficacy of available therapies, and adverse effects associated with treatment. For RCC, resistance to immunotherapies and targeted therapies remains a significant challenge. Despite advancements, intrinsic and acquired resistance to treatments like anti-PD-1 antibodies and tyrosine kinase inhibitors limits their effectiveness.[1,21] Liver tumours,

particularly HCC, are often diagnosed at advanced stages, limiting treatment options. The chemoresistance of HCC complicates chemotherapy effectiveness, and underlying liver dysfunction often restricts the use of systemic therapies.[5,22] The safety profile of treatments such as sorafenib, a standard therapy for HCC, includes severe side effects like hand-foot skin reactions, diarrhea, and hypertension, which can lead to treatment discontinuation.[5] Moreover in kidney tumours, the toxicity of radiation therapy and systemic treatments can significantly impact patient quality of life and limit the feasibility of aggressive treatment approaches.[17] Emerging therapies like antibody-based therapeutics for RCC and combination therapies for HCC show promise but are still under investigation for long-term efficacy and safety.[5,21]

As the demand for minimally invasive cancer treatments grows, innovative thermal ablation techniques have gained prominence. Microwave ablation as shown in **Figure 1** represents an advanced therapeutic modality for the treatment of kidney and liver tumours, offering a precise and effective solution by utilising high-frequency electromagnetic waves to induce localised tumour necrosis. This technique does not require grounding pads and is less influenced by tissue impedance and perfusion, which can lead to more uniform and efficient ablation zones.[23-25] It is important to note that rapid delivery of high power microwave ablation can lead to surrounding overheating, potentially causing neural injuries when applied to spinal lesions.[23,26]

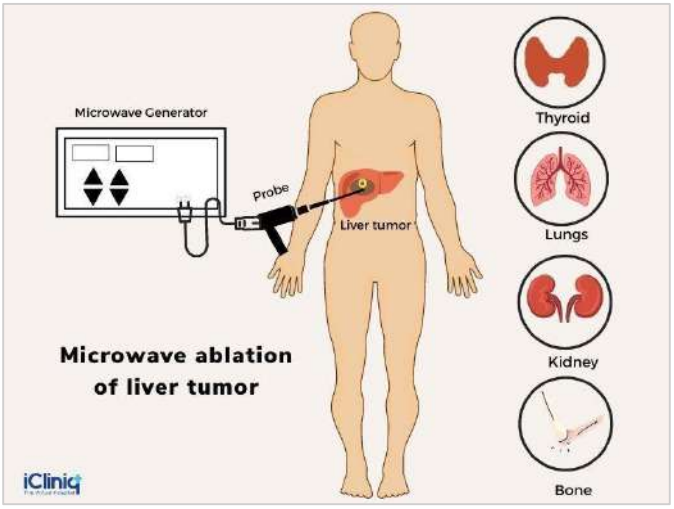


Figure 1: Microwave ablation of liver tumour. It can be applied to the treatment of various diseases beyond kidney and liver tumours.[27]

Despite its growing clinical adoption, microwave ablation remains inadequately characterised in terms of long-term efficacy and comparative outcomes against established treatment modalities for kidney and liver tumours. The heterogeneity of patient responses and variability in tumour characteristics necessitate further investigation to optimise microwave ablation protocols and improve treatment standardisation. A robust evaluation framework is required to assess the efficacy and safety of microwave ablation, ensuring its integration into evidence-based clinical practice guidelines for the treatment of kidney or liver tumours in Malaysia.

2.0 OBJECTIVE/ AIM

The objective of this technology review was to assess the effectiveness, safety, economic implication and organisational issue of microwave ablation in treating kidney and liver tumours.

3.0 TECHNICAL FEATURES

Microwave ablation utilises dielectric hysteresis to generate heat. Electromagnetic fields at 900 to 2,500 MHz can cause tissue damage by heating it to deadly levels. The fluctuating electric field forces polar molecules in tissue, such as H_2O, to realign, increasing their kinetic energy and hence temperature **(see Figure 2)**. Tissues with significant water content, such as solid organs and tumours, are best suited for this form of heating.[28] The interstitial antenna transmits microwave radiation from the generator to the tissue. The antenna's radiation causes immediate heating in the surrounding tissue. This method of heating varies from radiofrequency ablation, which generates heat by resistive heating when an electrical current travels through the ionic tissue medium. Radiofrequency heating requires an electrically conductive channel, is limited in locations with low electrical conductivity and only heats tissues near the electrode. Microwaves may travel through and successfully heat a variety of tissues, including those with low electrical conductivity, high impedance or low thermal conductivity. For example, bone and lung are two tissue types that have been linked with inferior results or local progression with radiofrequency ablation due to high baseline impedance.[29]

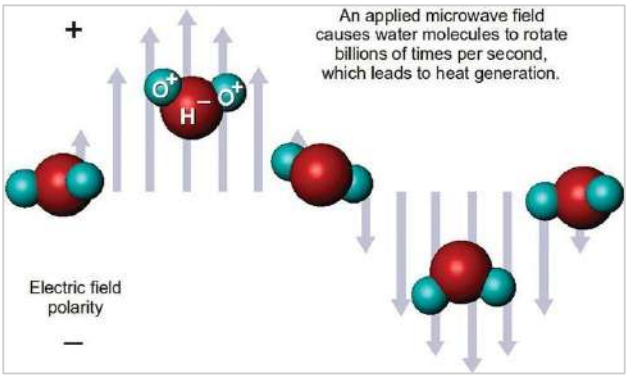


Figure 2: Microwave heating physics - schematic demonstrates how an alternating electromagnetic field causes polar molecules to continuously realign, producing kinetic energy and, in turn, heat.[28]

Multiple microwave antennas can be energised concurrently to provide thermal synergy whether positioned near together or far apart to target multiple tumours at once. Although different power sources may be used for multiapplicator ablation, microwave technology allows for continuous power without switching between electrodes during activation, unlike radiofrequency. Microwave ablation is unique in its capability to position and phase antennas to optimise electromagnetic field overlap.[30]

The microwave system has three components: a generator, a power distribution system and an antenna. Power is created using magnetrons or solid-state sources. Microwave ablation does not experience impedance spikes or decreased power output, unlike radiofrequency ablation in high-impedance tissues.[27] Microwave antennas play a crucial role in transferring energy to tissue. Geometry determines an antenna's active heating zone and power coupling efficiency. Typical microwave ablation antenna designs are straight and needle-like. Common designs include monopole, dipole, triaxial, choked or slotted antennas. Microwave antenna design involves balancing power efficiency, tissue heating pattern and antenna diameter, with appropriate compromises to achieve desired results. Smaller antennas often made of coaxial cable, may struggle to handle greater power levels without causing heat injury to tissues around the antenna shaft **(Figure 3)**. During the ablation procedure, the surgeon inserts a tiny laparoscopic port or open incision to approach the tumour. A computer tomography scan or ultrasonic guidance is utilised to determine the precise position of the tumour. A tiny microwave-emitting antenna is then introduced into the tumour.[31]

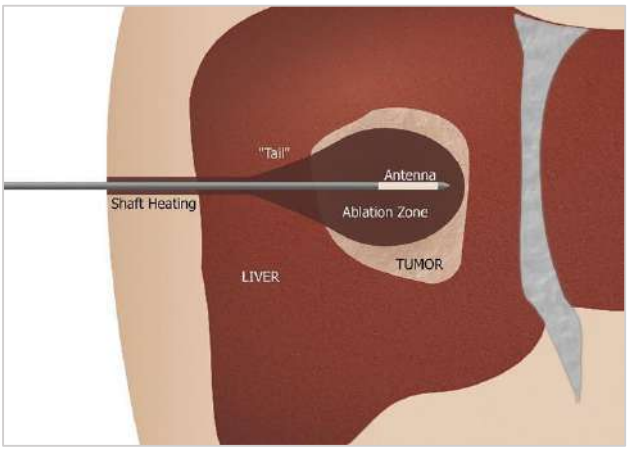


Figure 3: Shaft heating - because of the significant shaft heating that can occur with microwaves, a robust shaft cooling mechanism is required to minimise thermal damage to the subcutaneous tissues and the skin, especially with the development of higher power systems.[31] For a more comprehensive understanding, **Figure 4** provides a clearer comparison of the differences among various thermal ablation techniques.

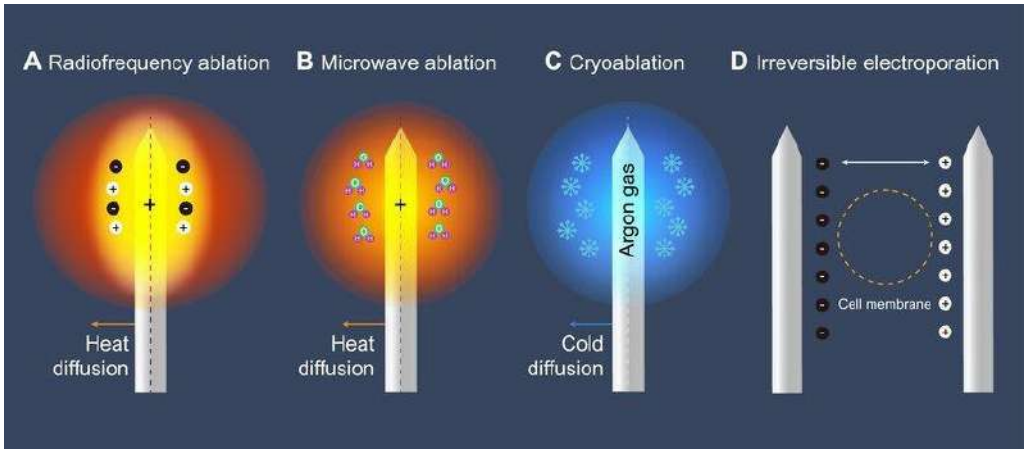


Figure 4: Various ablation technologies and their principles – a) Radiofrequency ablation; utilises oscillating electrical currents to generate resistive heating around an electrode, leading to tissue hyperthermia, b) microwave ablation; employs a propagating microwave electromagnetic field to induce tissue hyperthermia through dielectric hysteresis, c) cryoablation; relies on gas pressure changes to cool a cryoprobe, which, in direct thermal contact with the tumour, causes ice crystal formation and osmotic shock and d) irreversible electroporation; alters transmembrane potentials, causing irreversible disruption of cell membrane integrity.[32]

Microwave ablation has seen significant advancements in recent years, enhancing its efficacy and expanding its applications in tumour treatment. Clinical trials are exploring the synergistic effects of combining microwave ablation with immunotherapies and chemotherapy to enhance overall treatment efficacy. Furthermore, the incorporation of artificial intelligence algorithms is being investigated to assist in treatment planning and real-time adjustments during microwave ablation procedures, aiming to improve precision and outcomes. These advancements underscore microwave ablation's evolving role in oncology, offering patients effective and less invasive treatment options.

4.0 METHODS

4.1 Searching

A systematic review was conducted. Search strategy was developed by the main author and reviewed by the co-author.

4.1 Searching

The following electronic databases were searched through the Ovid interface:

- Ovid MEDLINE® All <1946 to 3rd January 2025>

Other databases: EMBASE, Cochrane Library, US FDA, INAHTA

The specific search strategy employed are presented in **Appendix 1**. Additional articles were retrieved from reviewing the bibliographies of retrieved articles. The search was limited to articles on human. There was no language limitation in the search and the last search was conducted on 15th January 2025.

4.2 Selection

A reviewer screened the titles and abstracts against the inclusion and exclusion criteria. The risk of bias for the included studies were assessed according to the criteria outlined in the ROBIS and Cochrane Risk of Bias (RoB 2.0). P-values less than 5.0% were considered as statistically significant. Studies were graded according to US/ Canadian Preventive Services Task Force **(Appendix 2)**. All data were extracted and summarised in evidence tables as in **Appendix 3**.

The inclusion and exclusion criteria were:

Inclusion criteria:

Population	Patients with kidney tumour, patients with liver tumour
Interventions	Microwave ablation
Comparators	Conventional therapy, other thermal ablations
Outcomes	**Effectiveness:** Local tumour progression, overall survival, disease-free survival, progression-free survival, recurrence rate, mortality rate, distant metastasis rate **Safety:** Adverse events related to treatment or device **Organisational:** Guideline **Economic implication:** Cost-effectiveness analysis
Study design	Health Technology Assessment reports, Systematic Review and Meta-Analysis, Randomised Control Trial, Non-randomised Control Trial, cohort studies, cross-sectional studies, case studies
Type of publication	Full text articles

Exclusion criteria:

Study design	Animal studies, narrative reviews

5.0 RESULTS

5.1 Selection of the included studies

The outcomes of the study selection process are illustrated in the PRISMA flow diagram presented in **Figure 5**.[33] The initial searches generated a total of 2,267 citations from electronic databases and 217 from Google Scholar, resulting in 66 unique citations after the removal of duplicates. A screening of the titles identified 34 as potentially relevant. Subsequent examination of the abstracts led to the successful retrieval of 31 full-text articles. After evaluating these articles against the eligibility criteria, **20 were included in the study**, comprising five systematic reviews and meta-analyses, one systematic review on study guidelines, six randomised controlled trials (RCTs), seven retrospective cohort studies and one cost-effectiveness analysis. The studies were conducted mainly in United States and China, followed by United Kingdom, German, Saudi Arabia, Italy, Japan, Korea and Australia.

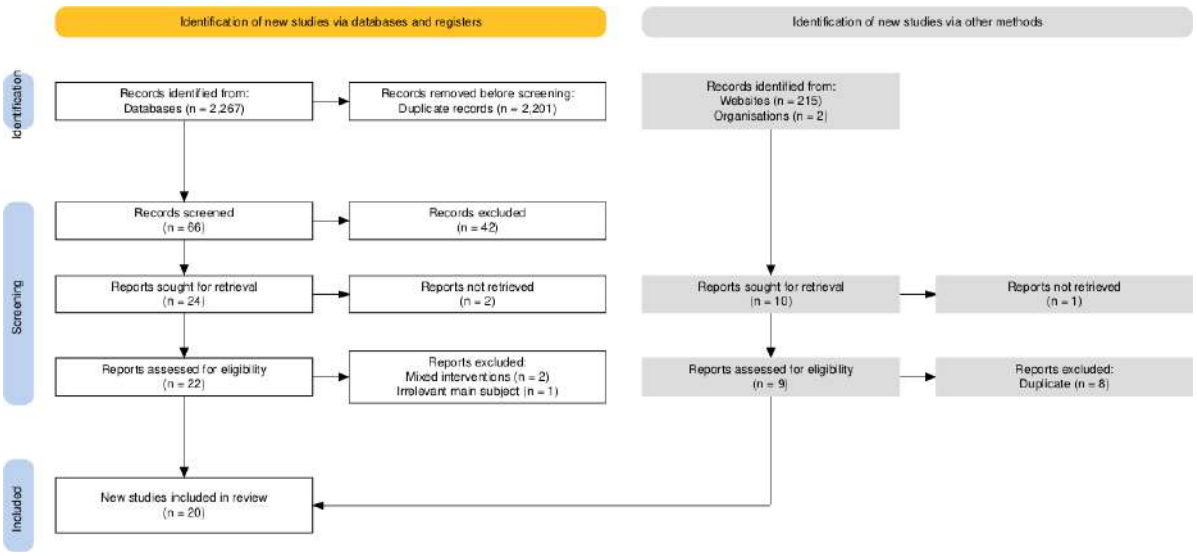


Figure 5: Flow chart of study selection for the search on microwave ablation for kidney and liver tumours (PRISMA Flow Diagram).[33]

5.2 Critical appraisal of the included studies

One reviewer conducted a risk of bias assessment in the systematic reviews using the ROBIS tool. One study listed in **Table 1** demonstrated unclear concerns related to the methods employed for identifying and selecting studies; specifically, the author did not specify any restrictions regarding publication date, format, or language, nor did they detail efforts made to minimise selection errors. Furthermore, the methods used for data collection and study appraisal were ambiguous, as the available study characteristics were insufficient for both review authors and readers to adequately interpret the results.[34, level I]

Concurrently, the Cochrane RoB 2.0 checklist was employed to evaluate the quality of RCTs **(see Figures 6 and 7)**. Two studies exhibited high-risk concerns due to potential bias in outcome measurement, as there was no information provided regarding the assessors' awareness in the trial, which could affect the outcome assessment.[35 and 36, level I]

Simultaneously, the Critical Appraisal Skills Programme (CASP) was utilised to evaluate the quality of retrospective cohort studies **(refer to Table 2)**. Two studies lacked sufficient follow-up duration for the subjects,[37,38] and four studies raised concerns regarding missing information about the authors' identification of all significant confounding factors.[37,39-41]

The CHEC-extended list was used to critically appraised the cost-effectiveness analysis study **(see Table 3)**. The study did not address clearly on the ethical and distributional issues.[53]

Table 1: Quality assessment of systematic review by using ROBIS.

	D1	D2	D3	D4	CONCLUSION
McClure T et al./ 2023	+	+	+	+	+
Choi SH et al./ 2018	+	+	+	+	+
Spiliotis AE et al./ 2021	+	+	+	+	+
Zhao J et al./ 2020	+	+	+	+	+
Wang L et al./ 2019	+	?	?	+	?

		Judgement	
D1	Concerns regarding specification of study eligibility criteria	+	Low
D2	Concerns regarding methods used to identify and/or select studies	?	Unclear
D3	Concerns regarding methods used to collect data and appraise studies	-	High
D4	Concerns regarding the synthesis and findings		
CONCLUSION	Risk of bias in the review		

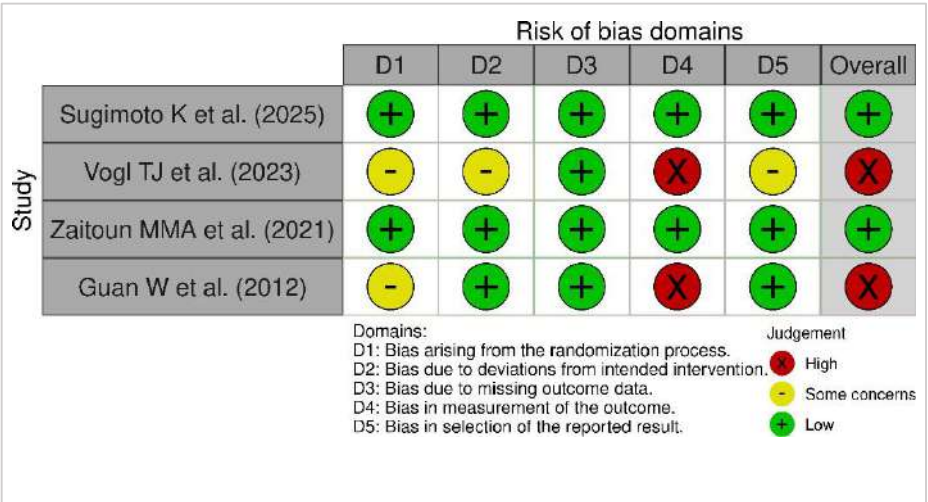


Figure 6: Risk of bias summary (Cochrane Risk of Bias 2.0) – reviewer's judgements on each domain for included studies.

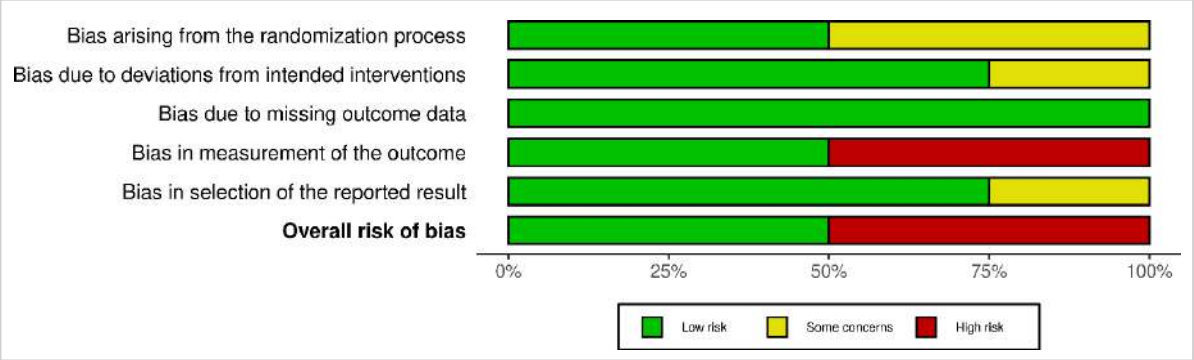


Figure 7: Risk of bias graph (Cochrane Risk of Bias 2.0) – reviewer's judgements on each domain presented as percentages across all included studies.

Table 2: Quality assessment of retrospective cohort studies by using Critical Appraisal Skills Programme.

	Sun G, 2024	Shapiro DD, 2020	de Cobelli, 2019	Hu J, 2019	Yu J, 2015	Shi J, 2014	Seki T, 1999
Q1	+	+	+	+	+	+	+
Q2	+	+	+	+	+	+	+
Q3	+	+	+	+	+	+	+
Q4	+	+	+	+	+	+	+
Q5(a)	?	?	?	+	+	+	?
Q5(b)	?	?	?	+	+	+	?
Q6(a)	+	+	+	+	+	+	+
Q6(b)	-	+	+	-	+	+	+
Q7	+	+	+	+	+	+	+
Q8	?	+	+	+	+	+	+
Q9	+	+	+	+	+	+	+
Q10	+	+	+	+	+	+	+
Q11	+	+	+	+	+	+	+
Q12	?	+	+	+	+	+	+

Q1	Did the study address a clearly focused issue?
Q2	Was the cohort recruited in an acceptable way?
Q3	Was the exposure accurately measured to minimise bias?
Q4	Was the outcome accurately measured to minimise bias?
Q5(a)	Have the authors identified all important confounding factors?
Q5(b)	Have they taken account of the confounding factors in the design and/or analysis?
Q6(a)	Was the follow up of subjects complete enough?
Q6(b)	Was the follow up of subjects long enough?
Q7	What are the results of this study?
Q8	How precise are the results?
Q9	Do you believe the results?
Q10	Can the results be applied to the local population?
Q11	Do the results of this study fit with other available evidence?
Q12	What are the implications of this study for practice?

Judgement	
+	Low
?	Cant' tell
-	No

Table 3: Quality assessment of cost-effectiveness analysis studies by using CHEC-extended.

Question	Checklist	Decision
		Xia Q et al./ 2025
1	Is the study population clearly described?	Y
2	Are competing alternatives clearly described?	Y
3	Is a well-defined research question posed in answerable form?	Y
4	Is the economic study design appropriate to the stated objective?	Y
5	Are the structural assumptions and the validation methods of the model properly reported?	Y
6	Is the chosen time horizon appropriate in order to include relevant costs and consequences?	Y
7	Is the actual perspective chosen appropriate?	Y
8	Are all important and relevant costs for each alternative identified?	Y
9	Are all costs measured appropriately in physical units?	Y
10	Are costs valued appropriately?	Y
11	Are all important and relevant outcomes for each alternative identified?	Y
12	Are all outcomes measured appropriately?	Y
13	Are outcomes valued appropriately?	Y
14	Is an appropriate incremental analysis of costs and outcomes of alternatives performed?	Y
15	Are all future costs and outcomes discounted appropriately?	Y
16	Are all important variables, whose values are uncertain, appropriately subjected to sensitivity analysis?	Y
17	Do the conclusions follow from the data reported?	Y
18	Does the study discuss the generalisability of the results to other settings and patient/client groups?	Y
19	Does the article/report indicate that there is no potential conflict of interest of study researcher(s) and funder(s)?	Y
20	Are ethical and distributional issues discussed appropriately?	U
	Total Yes	19
	Total No	0
	Total Unclear	1
	Total Percentage of Yes	**95%**

5.3 Effectiveness of microwave ablation

a. Kidney tumour

Seven studies enrolled patients with kidney tumour.

McClure T et al. (2023) conducted a systematic review and meta-analysis to compare **microwave ablation and cryoablation for RCC**. The initial systematic search was conducted in February 2020, followed by the most recent searches of multiple databases, including Ovid Medline and EMBASE. Study inclusion was determined based on a priori established PICOS criteria, focusing on English-language publications involving adults (≥18 years) with primary renal masses treated with microwave ablation and/or cryoablation. The review consisted of 99 studies; four comparative studies (n=460) and 95 single-arm studies (n=10,247) with median follow-up ranged from six to 95 months. The majority of studies enrolled patients **with stage T1 renal cell carcinoma** and predominantly employed the percutaneous approach for ablation. The mean tumour size, a variable known to influence ablation outcomes was comparable between the microwave ablation group (2.74 cm) and the cryoablation group (2.69 cm). The meta-analyses revealed low rates of local tumour recurrence for both microwave ablation and cryoablation, ranging from 2.0% to 5.0% at one and five years, with a 6.0% recurrence rate for cryoablation at both time points. Overall survival estimates were 98.0% at one year and 87.0% at five years for both ablations, although more microwave ablation studies reported 1-year data.[42, level I]

Additionally, disease-free survival estimates were 94.0% for microwave ablation and 89.0% for cryoablation at one year, decreasing to 78.0% and 77.0% at five years, respectively; lower

disease-free survival rates in specific studies were attributed to more severe disease states. Multivariable analyses found no significant effect of treatment type on overall survival or complications, but larger average tumour size was a significant predictor of worse 3-year overall survivor (p=0.002), while a higher proportion of male patients and increased tumour number predicted improved 5-year overall survival (p=0.01 and 0.04). Microwave ablation demonstrated significantly shorter ablation times compared to cryoablation (p<0.0001) and a lower 1-year local tumour recurrence rate (p=0.04), with time point also significantly influencing local tumour recurrence outcomes (p=0.01).[42, level I]

Another **systematic review and meta-analysis was conducted by Choi SH et al. (2018)** to determine the treatment outcomes of **percutaneous microwave ablation** in 567 patients with 616 malignant renal tumour **(ranging in diameter from 1.7 to 5.3 cm)**. After removing duplicates, 13 single-arm studies were reviewed for eligibility based on criteria including treatment with percutaneous image-guided microwave ablation, lesion follow-up and evaluation of technical and oncologic outcomes. The review covered follow-up durations of 1, 2, 3 and 5 years. The technical outcomes from the 13 individual studies, were summarised in **Figure 8**, with pooled meta-analytic values of 97.3% (95% CI, 94.3 to 99.4%, I^2=0.0%) for technical success rate and 97.6% (95% CI, 95.0 to 99.4%, I^2=48.5%) for technical efficacy rate, showing no substantial heterogeneity. Oncologic outcomes indicated a pooled local tumour recurrence rate of 2.1% (95% CI, 0.3 to 4.7%, I^2=54.1%), with six studies reporting no local recurrence. The pooled cancer-specific survival rates at 1-year was 99.1% (95% CI, 97.2 to 100.0%; I^2=0.0%). By the 5-year mark, the survival rate had decreased further, 96.9% (95% CI, 93.3−99.2%; I^2=0.0%), but it still indicated that a significant majority of patients remained alive and without cancer. Additionally, the pooled overall survival rates at the same time points showed the same pattern; 98.3% (95% CI, 96.1−99.8%; I^2=0.0%) at 1-year and 81.9% (95% CI, 75.4−87.6%; I^2=0.0%) at 5-year.[43, level I]

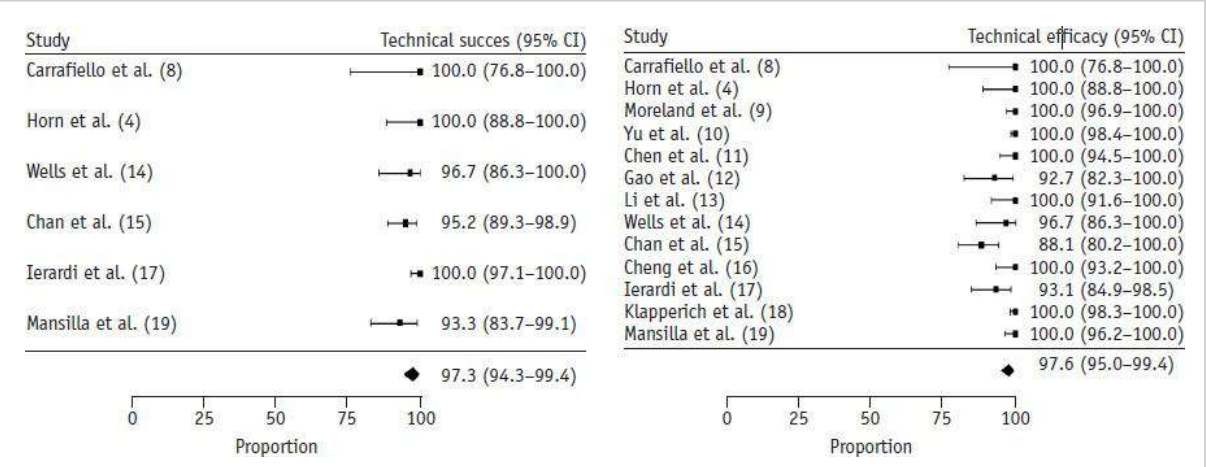


Figure 8: Meta-analytic summary of technical outcomes. Forest plots for technical success rate (left) and technical efficacy rate (right).[43, level I]
CI = confidence interval

Guan W et al. (2012) explored an RCT to study the comparison of intermediate-term outcomes of patients with small renal tumours who were treated with **partial nephrectomy or microwave ablation**. Between December 2004 and June 2008, 102 patients with a solitary, unilateral, **solid renal mass measuring ≤4 cm** were prospectively randomised to receive open/ laparoscopic partial nephrectomy (n=54; aged 46.4 ± 13.2 [21 to 79]), open/ laparoscopic microwave ablation (n=48; aged 45.5 ± 14.4 [23 to 75]). All patients were followed-up to 50 months, had no absolute contraindications to nephrectomy and did not present with bilateral tumours, metastatic disease, or hereditary renal cancer syndromes, nor had they received prior treatment. Initial microwave ablation was successful in 46 of 48 tumours (95.8%), with two incomplete ablations identified on the 1-month computed

tomography (CT) scan, leading to percutaneous re-ablation and no evidence of disease at last follow-up (41 and 50 months). During follow-up, two patients (4.2%) experienced local recurrences within the ablation margin. In the partial nephrectomy group, 52 (96.3%) achieved complete therapeutic effects, with two (3.7%) developing recurrent tumours. No patients showed evidence of metastatic disease progression.[36, level I]

Microwave ablation was compared to cryoablation in a retrospective cohort study conducted by Sun G et al. (2024). The study aimed to evaluate whether microwave ablation yields outcomes comparable to cryoablation regarding technical success, adverse events, local tumour recurrence and survival in adult patients with solid enhancing **renal masses measuring ≤4 cm**. A comparative analysis was conducted on 279 consecutive percutaneous ablative treatments performed on 257 patients (median age 71 years [range, 40 to 92 years; interquartile range, IQR 11 years]) with contrast-enhancing solid renal masses measuring between February 2008 and December 2020 at a single centre. Prior to referral to interventional radiology, all patients were assessed by a urologist. Poor surgical candidates, defined as those at high risk for anaesthesia, with significant comorbidities, advanced chronic kidney disease, a solitary kidney, or a personal or family history of RCC were referred to interventional radiology for potential thermal ablation. Procedure planning was informed by cross-sectional CT or magnetic resonance imaging (MRI) of the abdomen. There were 88 patients (66 males, 22 females) in microwave group and 191 patients (123 males, 68 females) in cryoablation group included in the cohort.[37]

Among patients with biopsy-proven RCC, recurrence rates were not significant between both groups (p=0.77). Disease-free survival rates were not significant (p=0.32), with cancer-specific survival at 100.0% for microwave ablation and 98.2% for cryoablation (p=0.31). Two patients developed metastatic disease, both associated with index lesions treated by cryoablation. Overall survival was 70.8% for cryoablation and 91.2% for microwave ablation (p=0.001). Secondary analyses showed no significant differences in local recurrence rates, adverse event rates, cancer-free survival or overall survival between matched cohorts of both groups.[37]

Shapiro DD et al. (2020) in another retrospective cohort study compared perioperative and oncologic outcomes for patients with clinical **T1b RCC (diameters of 4 to 7 cm)** following treatment with **microwave ablation, partial nephrectomy or radical nephrectomy**, at the University of Wisconsin from January 2000 to June 2018. Nonsurgical patients with clinical T1b RCC who declined active surveillance or exhibited tumour growth >5 mm/year were offered microwave ablation. Procedures were performed under general anaesthesia, followed by immediate post-ablation CT to confirm tumour destruction. The study encompassed 325 patients (215 males, 110 females), stratified into three treatment groups: microwave ablation (n=40, median age 69 years [range 65 to 77]), partial nephrectomy (n=74, median age 58 years [range 51 to 66]), and radical nephrectomy (n=211, median age 59 years [range 51 to 71]). Patients were monitored for follow-up periods extending up to 36 months. The study revealed that:[39]

- The median hospitalisation was shorter for the microwave group (1 day, IQR 1-1) compared to the partial nephrectomy and radical nephrectomy groups (4 days, IQR 3-6; 4 days, IQR 3-4; p<0.0001).
- No statistically significant differences were observed in blood transfusion rates among the groups (p=0.38).
- The median percent change in estimated glomerular filtration rate at three months post-operatively were microwave: -4.5% (IQR -19.6% to 7.6%), partial nephrectomy: -3.2% (IQR -20% to 10%), radical nephrectomy: -29% (IQR -39% to -19%). There was no statistically significant difference in the change in estimated glomerular filtration rate between the microwave ablation and partial nephrectomy groups (p=0.65); however, the reduction in estimated glomerular filtration rate was significantly greater in the radical

nephrectomy group compared to both the microwave ablation group (p<0.001) and the partial nephrectomy group (p<0.001).

- The overall local recurrence rate was 1.2% (4/325), with higher rates in microwave (5.0%) compared to partial nephrectomy (1.4%) and radical nephrectomy (0.5%). Estimated 5-year local recurrence-free survival was the highest in radical nephrectomy (99.2%), followed by partial nephrectomy (97.9%) and microwave (94.5%).
- Metastatic progression occurred in 7.1% (23/325) of patients, with none in the microwave group, while 5.4% of partial nephrectomy and 9.0% of radical nephrectomy patients developed metastasis. Tumour grade 3 to 4 (hazard ratio [HR] 7.49, p<0.001) and sarcomatoid features (HR 12.36, p=0.15) were associated with metastatic progression.
- No deaths from cancer-specific causes were reported in the microwave group. High tumour grade was the only factor associated with cancer-specific mortality (HR 11.5, p<0.001).

The subsequent **retrospective cohort study conducted by de Cobelli F et al. (2019)** aimed to assess the efficacy and safety of **microwave ablation in comparison to cryoablation** for the treatment of small renal tumours within a homogeneous patient population. The comparative analysis was conducted on 83 renal nodules in 72 consecutive patients treated with image-guided percutaneous ablation, utilising either cryoablation (n=44, median age 69.9 [range 34 to 89]) or microwave ablation (n=28, median age 66.2 [range 44 to 85]). Patients presented between January 2014 and March 2018 with **T1a renal cancer** and had either contraindications for surgery or declined surgical intervention. Patients were monitored for a duration of up to 24 months following the procedure. The findings showed that, the technical success rates, follow-up difference and disease recurrence demonstrated no significant difference between both groups. Conversely, the median procedure time was significantly shorter for microwave ablation (40 minutes, IQR 34) compared to cryoablation (110 minutes, IQR 17.5) (p=0.003).[40]

Yu J et al. (2015) also conducted retrospective cohort study to evaluate midterm results of **microwave ablation versus laparoscopic radical nephrectomy** in patients with small RCC. The medical records of patients who underwent renal microwave ablation or laparoscopic radical nephrectomy between April 2006 and October 2012 were reviewed. The study included patients with **RCC measuring ≤4 cm**. A total of 98 patients (23.0%, 98/426; mean age 65.7 ± 13.8 [range 27 to 87] years) with 105 lesions received microwave ablation, while 328 patients (77.0%, 328/426; mean age 51.4 ± 12.3 [range 22 to 86] years) with 331 lesions underwent laparoscopic radical nephrectomy. Microwave ablation procedures were performed by three interventional radiologists under moderate sedation. Follow-up protocols included contrast-enhanced imaging at 1-, 3- and 6-month, with recurrence assessments conducted up to 32-month post-procedure. The results revealed that:[46]

- The operative time and post-operative hospitalisation for the laparoscopic radical nephrectomy group were significantly longer than for the microwave ablation group (p<0.0001), resulting in higher hospitalisation costs for the laparoscopic radical nephrectomy group (p<0.0001). Estimated blood loss was also greater in the laparoscopic radical nephrectomy group, with 12 patients requiring blood transfusions (400 to 1,800 mL), while no transfusions were needed in the microwave ablation group.
- Median follow-up periods were shorter in microwave ablation group (25.8 months, IQR 3.7 to 75.2) as compared to laparoscopic radical nephrectomy group (26.1 months, IQR 3.0 to 73.6). In the microwave ablation group, five patients (5.1%) died from various causes, whereas three patients (0.9%) in the laparoscopic radical nephrectomy group died, attributed to sudden cardiac death and RCC progression.
- Follow-up imaging demonstrated 100.0% technique effectiveness for both groups. One local tumour progression lesion was identified at 32-month post-ablation, with no local tumour progression lesions reported after laparoscopic radical nephrectomy.

- Extrarenal metastasis occurred in three cases for both microwave ablation and laparoscopic radical nephrectomy (p=0.27). The 1-, 3-, and 5-year overall survival rates were 98.3%, 93.3%, and 82.6% for microwave ablation, and 99.7%, 98.6%, and 98.6% for laparoscopic radical nephrectomy, indicating a significant difference (p=0.0004). Nonetheless, the RCC-related survival rates showed no significant difference between groups (p=0.38).
- Significant differences (p<0.0001) in survival rates were associated with sex, tumour type, treatment modality, presence of laparoscopic radical nephrectomy and extrarenal metastasis.

Overall findings:
The systematic review and meta-analysis by McClure et al. (2023) compared microwave ablation and cryoablation for RCC, finding low rates of local tumour recurrence (2.0% to 5.0%) and high overall survival rates (98.0% at one year) for both techniques. Microwave ablation showed a statistically significant advantage in shorter ablation times and lower local recurrence rates compared to cryoablation.[42, level I] Additional studies, including those by Choi et al. (2018) and Sun et al. (2024), confirmed similar technical success and oncologic outcomes for both modalities, with microwave ablation demonstrating slightly better overall survival.[37, 43 level I]

Further comparisons, such as those by Shapiro et al. (2020) and de Cobelli et al. (2019), indicated that microwave ablation had shorter hospital stays and comparable safety profiles to surgical options like partial nephrectomy.[39,40] Overall, while both microwave and cryoablation are effective for treating small renal tumours, microwave ablation offers benefits in terms of procedural efficiency and lower recurrence rates, positioning it as a viable option for patients, particularly those unfit for surgery.

b. Liver tumour

Ten studies enrolled patients with liver tumour.

Spiliotis AE et al. (2021) conducted a systematic review and meta-analysis to compare **microwave with radiofrequency ablation** in the treatment of liver cancer. A systematic search was performed in MEDLINE (PubMed and Ovid) and the Cochrane Central Register of Controlled Trials for relevant studies. The search, conducted in July 2020, included studies that met the following criteria: (i) adult population with primary liver cancer or hepatic metastases; (ii) interventions involving radiofrequency ablation and microwave ablation as monotherapy or in combination with surgical resection; (iii) microwave and radiofrequency ablation performed percutaneously, laparoscopically or via laparotomy; and (iv) comparators focusing on the effectiveness and safety of microwave versus radiofrequency ablation. The review encompassed 15 studies involving a total of 2,169 patients, comprising four RCTs, 10 retrospective cohort studies and one prospective cohort study, with participant ages ranging from 52 to 68 years. The average or median tumour **diameter varied between 1.7 cm and 3.75 cm**. The meta-analysis indicated no significant difference in complete ablation rates, intrahepatic distal recurrence and local tumour progression between both groups. On the other hand, subgroup analysis of two randomised controlled trials revealed significantly lower local tumour progression rates in the microwave group compared to radiofrequency group (odds ratio [OR], 0.40; 95% CI, 0.18 to 0.92; p=0.03, I^2=0.0%).[45, level I]

Another **systematic review and meta-analysis was conducted by Zhao J et al. (2020)** to compare the efficiency and safety of **TACE combined with radiofrequency (TACE + RFA; n=238) or microwave (TACE + MW; n=295)** ablation. Related articles published before August 2019 were searched in PubMed, Scopus, Web of Science, Ovid Medline, Embase, ScienceDirect, Google Scholar and the Cochrane Library. The inclusion criteria were as

follows: patients with unresectable HCC were identified as patients who had a late tumour stage, an unsuitable tumour location, extensive disease, limited liver functional reserve and high operative risk. The review included nine studies comprising 533 patients with the mean **tumour dimension ranged from 2.4 cm to 5.55 cm**. In a comparative analysis involving 316 patients across five studies, the TACE + MW group demonstrated significantly longer overall survival than the TACE + RFA group (HR 1.55; 95% CI, 1.09 to 2.21, p=0.01) **(see Figure 9)**, with superior 2-year (relative risk [RR] 0.68; 95% CI, 0.53 to 0.88, p=0.003) and 3-year (RR 0.46; 95% CI, 0.32 to 0.66, p<0.0001) overall survival rates. While no significant difference was observed in progression-free survival (p=0.13), the TACE + MW group had a higher 24-month progression-free survival rate (RR 0.67; 95% CI, 0.46 to 0.96, p=0.03).[46, level I]

The objective response rate and disease control rate were comparable between groups (p=0.46), but the TACE + MW group exhibited a higher complete response rate (RR 0.87; 95% CI, 0.79 to 0.96, p=0.003) and a lower partial response rate (RR 2.16; 95% CI, 1.30 to 3.57, p=0.003). Subgroup analyses revealed the TACE + MW group's advantages were most pronounced in younger patients (ages 50 to 60; HR 1.58; 95% CI, 1.03 to 2.24, p=0.04) and those with larger tumours (≥3 cm; HR 1.62; 95% CI, 1.04 to 2.53, p=0.03). Notably, patients undergoing TACE in the microwave group had extended overall survival (HR 1.58; 95% CI, 1.03 to 2.24, p=0.04).[46, level I]

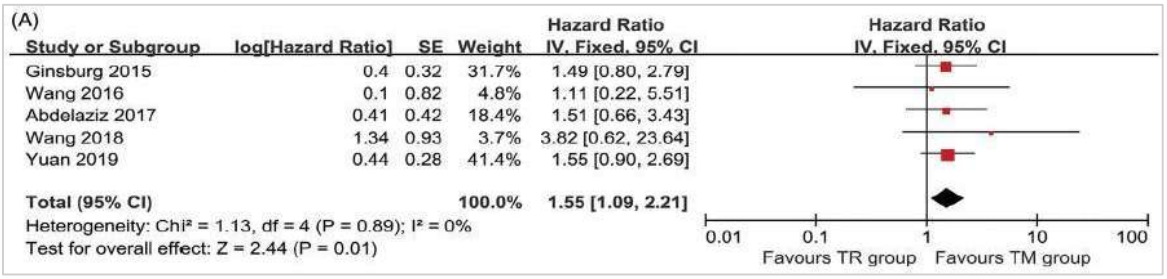


Figure 9: Forest plot of the hazard ratio or relative risk of overall survival associated with the TACE + MW group versus the TACE + MW group.[46, level I]

The subsequent **systematic review and meta-analysis was performed by Wang L et al. (2019)** to evaluate the clinical value of TACE + MW ablation for unresectable HCC. This meta-analysis was conducted following PRISMA guidelines, utilising databases such as PubMed, MedLine, Embase, the Cochrane Library and Web of Science. The literature search commenced in January 2018, concluding in August 2019. Inclusion criteria comprised: i) patients diagnosed with HCC; ii) patients with unresectable tumours or unwilling to undergo resection; iii) an experimental group receiving **TACE + MW ablation versus a control group receiving TACE alone**; and iv) outcomes reporting on short-term or long-term effects and adverse events. The review encompassed nine studies involving a total of 964 patients, comprising one RCT and eight retrospective studies, with 295 patients receiving TACE + MW and 613 patients receiving TACE alone. The average or median **tumour diameter varied between 2.7 ± 1.1 cm and 12.9 ± 2.5 cm**. Using a fixed-effect model, the pooled OR for 1-, 2-, and 3-year survival rates favored the TACE + MWA group (OR 3.29; 95% CI, 2.26 to 4.79; OR 2.82, 95% CI, 2.01 to 3.95; OR 4.50, 95% CI, 2.96 to 6.86, respectively). The overall response rate comparison between the TACE + MWA and TACE alone groups indicated a significant advantage for TACE + MWA (OR 4.64; 95% CI, 3.11 to 6.91) across six studies without significant heterogeneity (I^2=0.0%). Local recurrence rates also favored TACE + MWA (OR 3.93; 95% CI, 2.64 to 5.87) with minor heterogeneity (I^2=18.0%).[51, level I]

In subgroup analyses, patients with tumours <5 cm showed no significant differences in 1- and 2-year survival rates between the groups. Conversely, for tumours >5 cm, the TACE + MWA group demonstrated significantly better survival rates at 1-, 2- and 3-year (OR 3.82; 95% CI, 2.38 to 6.13; OR 3.83; 95% CI, 2.37 to 6.19; OR 4.12; 95% CI, 2.51 to 6.77, respectively).[51, level

Sugimoto K et al. (2025) executed an RCT to evaluate and compare the therapeutic efficacy of **microwave ablation (n=119, mean age 74.0 ± 9.9) versus radiofrequency ablation (n=117, mean age 74.1 ± 9.0)** in patients with HCC. The study was conducted across five tertiary centres in Japan with inclusion criteria encompassing: (i) adults aged ≥20 years; (ii) diagnosis of HCC via contrast-enhanced CT or gadoxetic acid-enhanced MRI within four weeks prior to enrolment, adhering to Japan Society of Hepatology guidelines; (iii) **HCC lesions <4 cm** in size, with up to four nodules; (iv) absence of extrahepatic manifestations or vascular invasion; (v) Child-Pugh score <9; (vi) lesions amenable to both microwave and radiofrequency ablation; (vii) Eastern Cooperative Oncology Group performance status of 0 to 2; (viii) specific hematological and biochemical parameters; and (viiii) patients ineligible for or unwilling to undergo surgery. Patients were monitored for a duration of up to 42 months in the microwave ablation group and 44 months in the radiofrequency ablation group.[47, level I]

At the 2-year follow-up, the incidence of local tumour progression was significantly lower in the microwave group (16.4%, 20 lesions) compared to the radiofrequency group (30.4%, 38 lesions), with a RR of 0.54 (95% CI, 0.33 to 0.87; p=0.007) and an absolute risk difference of 0.14 (95% CI, 0.04 to 0.24; p=0.007). Kaplan-Meier analysis indicated no significant differences in overall survival between groups (p=0.350) or in intrahepatic recurrence-free survival (p=0.099). Extrahepatic recurrence-free survival also showed no significant differences (p=0.307). Post-hoc analysis identified maximum tumour diameter (HR 1.51; 95% CI, 1.06 to 2.17), type of ablation device (microwave ablation: HR 0.53; 95% CI, 0.31 to 0.91), and ablation margin (<3 mm: HR 2.14; 95% CI, 1.22 to 3.77) as independent predictors of local tumour progression. Additional factors associated with intrahepatic recurrence included aetiology (non-viral: HR 1.39; 95% CI, 1.13 to 1.71), non-naive nodules (HR 1.86; 95% CI, 1.24 to 2.77), number of nodules (HR 2.00; 95% CI, 1.34 to 2.97) and des- γ-carboxy prothrombin levels (HR 1.001, 95% CI, 1.000 to 1.002), while des- γ-carboxy prothrombin also emerged as a predictor of extrahepatic recurrence (HR 1.003; 95% CI, 1.000 to 1.04).[47, level I]

Vogl TJ et al. (2023) in another RCT compared the therapeutic response and clinical outcome of CT-guided percutaneous **microwave and radiofrequency ablation** for the treatment of small- and medium-sized HCC in 50 patients (38 males, 12 females; mean age 62.9 ± 10.5 years). The inclusion criteria were established as follows: (i) histologically and/or radiologically confirmed diagnosis of HCC; (ii) planned single thermal ablation treatment using microwave or radiofrequency ablation; (iii) age ≥ 18 years; (v) sufficient general health to undergo MRI; (vi) MRI conducted with either a 1.5 tesla or 3.0 tesla scanner; (vii) presence of a solitary lesion measuring <5 cm; (viii) a **maximum of three lesions, each measuring <3 cm**; and (viiii) absence of extrahepatic manifestations or vascular invasion. The two groups comprised of 25 patients in microwave ablation (mean age 63.2 ± 10.3 years) and other 25 in radiofrequency ablation (mean age 62.7 ± 10.8 years). The distribution of **tumour grades (G1, G2, G3) was similar between microwave and radiofrequency groups, with respective counts of 4/19/2 and 3/20/2**, and no statistically significant difference observed (p>0.05). The study demonstrated significantly larger ablation volumes for microwave group at 66.5 ± 35.8 cm^3 compared to radiofrequency group at 29.2 ± 22.2 cm^3 (p<0.01).[35, level I]

Intrahepatic distant recurrence occurred more frequent in radiofrequency group (56.0%) as compared to microwave group (32.0%). Moreover, disease-free survival as shown in **Figure 10** significantly favored microwave group (p=0.01). For patients classified as Barcelona Clinic Liver Cancer Stage A, microwave ablation significantly improved both overall survival (p=0.037) and disease-free survival (p<0.01) compared to radiofrequency ablation, with relative HR of 0.302 and 0.232, respectively.[35, level I]

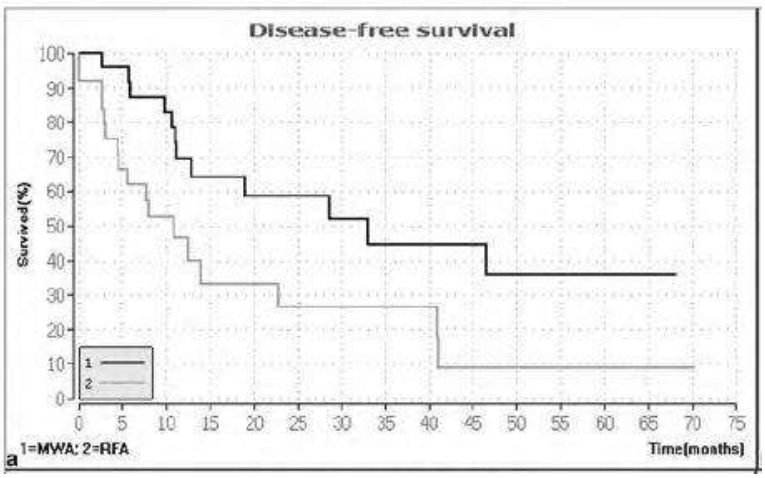
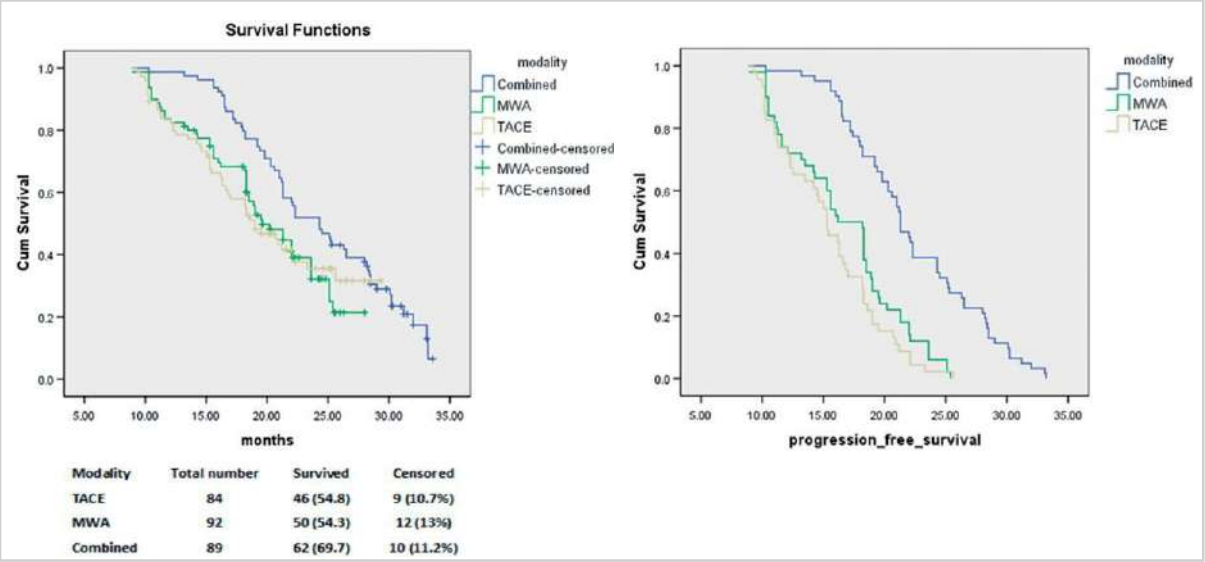


Figure 10: Kaplan-Meier curves show the disease-free survival data (microwave ablation = black; radiofrequency ablation = grey); the overall survival in months with numbers at risk shown below.[35, level I]

Zaitoun MMA et al. (2021) examined the safety and efficacy of combined therapy of **TACE + MW ablation** (n=89; 52 males, 37 females; mean age 52.1 ± 9.5 [range 48 to 76 years]) versus **only TACE** (n=84; 52 males, 32 females; mean age 51.3 ± 9.2 [range 41 to 75]) **or microwave ablation** (n=92; 50 males, 42 females; mean age 53.8 ± 10.3 [38 to 72]) for treatment of HCC. **An RCT** was conducted from January 2017 to May 2020, screening 265 (154 males and 111 females; mean age 54.5 ± 11.8 years [range 38 to 76 years]) patients for enrolment. Inclusion criteria encompassed solitary **HCC lesions measuring >3 to <5 cm**, no extra-hepatic metastases, no history of encephalopathy or refractory ascites and Child-Pugh class A or B cirrhosis. Patients were monitored for a duration of up to 36 months.[48, level I]

After one month, combined therapy resulted in tumour response rates of 86.5% complete response, 3.3% partial response, 5.6% stable disease, and 4.5% progressive disease, significantly outperforming TACE (54.8% complete response) and microwave ablation alone (56.5% complete response) groups (p=0.0002). Recurrence rates at 12 months were significantly lower in the combined group (22.47%) compared to TACE (60.7%) and microwave ablation alone (51.1%) (p=0.0001). Overall mortality was also lower in the combined group (19.1%) versus TACE (34.5%) and microwave ablation (32%) (p=0.02), with improved overall survival **(see Figure 11a)** (69.6% versus 54.8% for TACE and 54.3% for microwave ablation) and median survival times (24 months versus 19 for TACE and 21 for microwave ablation) (p=0.02). Additionally, mean progression-free survival was higher in the combined group (22.3 months) than in TACE (15.4 months) and microwave ablation (16.7 months) (p<0.001) **(see Figure 11b)**.[48, level I]



Modality	Total number	Survived	Censored
TACE	84	46 (54.8)	9 (10.7%)
MWA	92	50 (54.3)	12 (13%)
Combined	89	62 (69.7)	10 (11.2%)

(a) (b)

Figure 11: a) Comparison of the survival function among the three groups, b) progression-free survival analysis.[48, level I]

TACE, transarterial chemoembolisation; MWA, microwave ablation; TACE + MWA, combined therapies

The next **RCT was conducted by Fang L et al. (2019)** to study the clinical effect of **ultrasound-guided microwave ablation** (n=47; 26 males, 21 females; mean age 56.5 ± 1.4 years [range 41 to 75 years]) on primary HCC. Ninety-four patients (154 males, 111 females; mean age 54.5 ± 11.8 years [range 38 to 76 years]) with primary hepatic carcinoma, admitted between August 2014 and November 2016, were selected based on criteria including adherence to diagnostic standards set by the Chinese Medical Association, first-time treatment without significant comorbidities, Child-Pugh grades A or B, complete clinical data and ethical approval with informed consent. The control group received **conventional surgical excision** (n=47; 27 males, 20 females; mean age 58.2 ± 1.5 years [range 40 to 76 years]) via laparotomy under general anaesthesia. Both groups were followed-up to three months. The microwave group demonstrated significantly shorter operation duration and length of stay, along with lower intraoperative bleeding and blood transfusion volumes compared to the control group ($p<0.05$). However, the total effective treatment rate in the study group was significantly lower ($p<0.05$). Biochemical analysis revealed that alanine aminotransferase and aspartate transaminase levels were significantly higher in the control group ($p<0.05$), while albumin and total bilirubin levels were significantly lower in the study group ($p<0.05$).[49, level I]

Hu J et al. (2019) carried out a retrospective cohort study to assess the clinical outcomes of **image-guided percutaneous microwave ablation** (n=64; mean age 54.9 ± 11.3 [range 28 to 75]) **versus cryoablation** (n=56; mean age 54.9 ± 11.3 [28-75]) in patients with HCC located in high-risk areas, as well as to identify prognostic factors linked to both treatment approaches. In this single-centre study, medical records of HCC 120 patients (88 males, 32 females; with 134 HCC lesions) admitted from April 2014 to March 2017 were retrospectively reviewed, including only those diagnosed via preoperative core biopsy, classified as Child-Pugh grades A or B, with tumours in high-risk locations (within 1 cm of abdominal wall and adjacent organs), untreated prior, with **fewer than three tumours each <5 cm**, and without vascular invasion or metastasis. Additionally, patients who declined liver transplantation and opted for microwave ablation or cryoablation due to concerns about liver resection, general anaesthesia or complications were included. Patients in both groups were monitored for 19.9 months.[38]

In the study, 64 patients with 70 tumours underwent 76 treatments in the microwave ablation group, successfully treating 64 tumours in one session and six tumours in two sessions. In contrast, 56 patients with 64 tumours received 68 sessions in the cryoablation group, with 60 tumours effectively treated in one session and four in two sessions. Surgical time, blood loss, cost and hospitalisation were comparable between groups. The mortality rate was 18.8% in the microwave group, primarily due to tumour progression, while the cyroablation group had a 14.3% mortality rate, mainly from local/ systemic HCC. Both groups achieved a 100.0% method success rate, with 75.0% of microwave ablation and 25.0% of cryoablation patients developing local tumour progression lesions. In addition, distant metastasis occurred in 19.6% of microwave ablation and 17.8% of cryoablation patients. Survival rates showed no significant differences between groups, while local tumour progression rates differed significantly (p=0.039). Univariate and multivariate analyses identified age (≥65 years), **tumour size (3 to 5 cm)**, and Child-Pugh grade B as independent predictors of poor overall survival, and tumour size (≥3 cm), multiple tumours and treatment sessions as independent factors affecting recurrence-free survival.[38]

Shi J et al. (2014) compared the efficacy of **microwave ablation** (n=117; 143 nodules; mean age 56.6 ± 9.2) and **surgical resection** (n=107; mean age 54.5 ± 9.9) in the treatment of HCC conforming to Milan criteria. The **retrospective cohort study** enrolled 224 patients (180 males, 44 females), meeting the inclusion criteria of Milan criteria for HCC **(single tumour ≤5 cm or up to three tumours <3 cm)**, absence of extrahepatic metastasis or vascular invasion, Child-Pugh Class A or B liver function and no prior malignancies or treatments for HCC. The study revealed that:[50]

- During follow-up, 43 patients in the microwave and 40 in the control group died, primarily from cancer recurrence.
- The 1-, 3- and 5-year overall survival rates were comparable between the groups.
- The disease-free survival rates were significantly higher in the control group (p=0.005).
- For solitary HCC ≤3 cm, overall survival and disease-free survival rates showed no significant differences between the groups, while for HCC between 3 and 5 cm, although overall survival rates were similar, disease-free survival favored the control group (p=0.014).
- Univariate analysis identified age, hepatitis B and hepatitis C infections as significant factors for overall survival, with age being the sole significant factor in multivariate analysis (HR 2.017; p=0.006).
- The overall recurrence rates were higher in the microwave group (p=0.048), with significantly more early-stage recurrences and local recurrences compared to the control group. Treatment strategies for recurrences showed no significant differences in curative treatment rates overall, but microwave ablation patients with solitary HCC between 3 and 5 cm had more recurrences receiving curative treatment (p=0.041).

Seki T et al. (1999) compared the efficacy of **percutaneous microwave coagulation therapy (PMCT)** (n=48) and **percutaneous ethanol injection therapy (PEIT)** (n=42) in the treatment of patients with cirrhosis and a solitary nodular **HCC ≤2 cm** in greatest dimension. In the **retrospective cohort study**, of the 43 patients with well-differentiated HCC, 23 (mean age 60.9 ± 7.9) received PMCT, while 20 (mean age 61.5 ± 8.6) were treated with PEIT. Meanwhile, among the 47 patients with moderately or poorly differentiated HCC, 25 (24 moderately and 1 poorly differentiated; mean age 65.2 ± 8.0) underwent PMCT, and 22 (21 moderately and 1 poorly differentiated; mean age 61.0 ± 8.4) received PEIT.[39]

For PMCT, 93.8% (45/48) patients exhibited complete necrosis of tumours ≤1.5 cm after three to four microwave irradiations and tumours >1.5 cm after four to six irradiations, achieving a treated margin ≥5 mm on dynamic CT. However, in three patients, despite complete necrosis, surrounding parenchyma remained viable due to anatomical constraints. For PEIT, 61.9%

(26/42) patients achieved complete necrosis with a treated margin ≥5 mm, while 16 showed complete necrosis but insufficient margins due to ethanol leakage. For moderately or poorly differentiated HCC, overall survival rates were higher in PMCT (78.0%) as compared to PEIT (35.0%) (p=0.03; **see Figure 12**). Cancer-free survival rates at four years were similar between treatment modalities for well-differentiated HCC but favored PMCT for moderately or poorly differentiated HCC, though not significantly.[41]

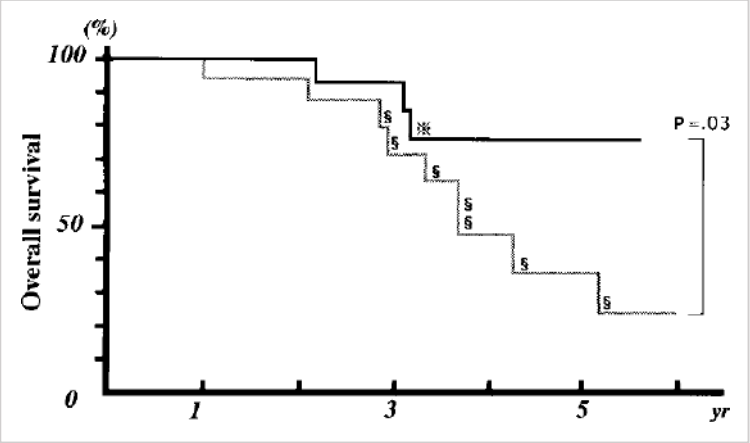


Figure 12: Overall survival of patients with moderately or poorly differentiated HCC treated with PMCT or PEIT.[41]
Heavy line, PMCT; light line, PEIT

Overall findings:
Systematic reviews and meta-analyses by Spiliotis et al. (2021) and Zhao et al. (2020) revealed key findings on the effectiveness of microwave versus radiofrequency ablation for liver cancer.[45 and 46, level I] Spiliotis et al. (2021) found no significant differences in overall outcomes between the two methods, but microwave ablation had lower local tumour progression.[45, level I] Zhao et al. (2020) demonstrated that combining TACE with microwave ablation (TACE + MW) significantly improved overall and progression-free survival compared to TACE with radiofrequency ablation (TACE + RFA), especially in younger patients and those with larger tumours.[46, level I]

Supporting studies by Wang et al. (2019) and Sugimoto et al. (2025) confirmed better survival rates and lower recurrence for TACE + MW.[47 and 51, level I] Vogl et al. (2023) highlighted the larger ablation volumes achieved with microwave ablation, contributing to improved disease-free survival.[35, level I] Overall, TACE + MW showed superior efficacy compared to single modalities in enhancing treatment response and survival outcomes.

The findings presented above are summarised in **Table 4**, which outlines the effectiveness data for microwave ablation in the treatment of kidney and liver tumours.

Table 4: The effectiveness of microwave ablation in treating kidney and liver tumours.

Study	Patient characteristic	Follow up duration	Intervention		Findings
			Treatment	Control	
Kidney tumour					
McClure T et al. 2023 SR & MA[42]	N=10,707 Mostly on T1 RCC	6 to 95 months	MWA	CRA	• LTP ranged from 2.0% to 5.0% at 1- and 5-year in both groups. • OS was 98.0% and 87.0% at 1- and 5-year in both groups. • DFS were higher in microwave group at 1-year (94.0% vs. 89.0%) and 5-year (78.0% vs. 77.0%). • Ablation time was significantly shorter in MWA (p<0.0001) and lower 1-year local tumour recurrence rate (p=0.04) as compared to CRA.
Choi SH et al. 2018 SR & MA[43]	N=567 Malignant renal tumours (diameter from 1.7 to 5.3 cm)	1, 2, 3 and 5 years	Percutaneous MWA	Not available	• Technical success rate was 97.3% (95% CI, 94.3 to 99.4%, I^2=0.0%). • The cancer-specific survival rates at 1-year was 99.1% (95% CI, 97.2 to 100.0%; I^2=0.0%). • The survival rate had decreased at 5-year, 96.9% (95% CI, 93.3−99.2%; I^2=0.0%). • Pooled OS rates was 98.3% (95% CI, 96.1−99.8%; I^2=0.0%) at 1-year and 81.9% (95% CI, 75.4−87.6%; I^2=0.0%) at 5-year.
Guan W et al. 2021 RCT[36]	N=102 Small renal tumours ≤4 cm	36 months	MWA	PN	• Initial microwave ablation was successful in 46 of 48 tumours (95.8%). • During follow-up, two patients (4.2%) experienced local recurrences within the ablation margin.
Sun G et al. 2024 RC[37]	N=257 Small renal masses ≤4 cm	CT and MRI: 4, 8, 12, 18 and 24 months Continue imaging annually for up to 10 years	MWA	CRA	• OS was higher in MWA as compared to CRA (p=0.001).
Shapiro DD et al. 2020 RC[39]	N=325 T1b RCC (4 to 7 cm)	Up to 49.5 months	MWA	PN, RN	• Median hospitalisation was the shortest for MWA (p<0.0001). • Local recurrence rate was the highest in MWA (5.0%) versus PN (1.4%) and RN (0.5%). • High tumour grade was the only factor associated with cancer-specific mortality (HR 11.5, p<0.001).
de Cobelli F et al. 2019 RC[40]	N=72 T1a renal cancer	24 months	MWA	CRA	• Median procedure time was significantly shorter for MWA (40 vs. 110 minutes; p=0.003) as compared to CRA.
Yu J et al. 2015 RC[44]	N=98 RCC ≤4 cm	1, 3 and 6 months	MWA	Laparoscopic RN	• Shorter operative time and post-operative hospitalisation, and lower hospitalisation cost in MWA (p<0.0001). • No transfusions were needed in MWA. • Shorter median follow-up in MWA (25.8 vs. 26.1 months). • Lower OS rates in MWA for 1-, 3- and 5-year as compared to control (p=0.0004).
Liver tumour					
Spiliotis AE et al. 2021 SR & MA[45]	N=2,169 Liver cancer (diameter from 1.7 to 3.75 cm)	Not available	MWA	RFA	• Significant lower LTP rates in the MWA compared to RFA (p=0.03).
Zhao J et al. 2020 SR & MA[46]	N=533 Unresectable HCC (diameter from 2.4 cm to 5.55 cm)	1 to 82 months	TACE+MWA	TACE+RFA	• Longer OS in TACE+MWA (p=0.01). • Higher response rate in TACE+MWA (p=0.003). • Higher advantage was pronounced in younger patients of TACE+MWA (ages 50 to 60; p=0.04) and those with larger tumours (≥3 cm; p=0.03).
Wang L et al. 2019 SR & MA[51]	N=964 Unresectable HCC (diameter from 2.7 ± 1.1 to 12.9 ± 2.5 cm)	8 to 41 months	TACE+MWA	TACE	• Significant advantage for TACE+MWA in OS rate as compared to control (OR 4.64; 95% CI, 3.11 to 6.91). • Local recurrence rates favoured TACE+MWA (OR 3.93; 95% CI, 2.64 to 5.87). • Significant survival rates in TACE+MWA for tumours >5 cm at 1-, 2- and 3-year.

Sugimoto K et al. 2025 RCT[47]	N=236 HCC ≤4 cm	MWA: 44 months RFA: 42 months	MWA	RFA	• Significant lower of LTP in MWA at 2-year (p=0.007). • Independent predictors of LTP were maximum tumour diameter, type of ablation device and ablation margin.
Vogl TJ et al. 2023 RCT[35]	N=50 Small and medium-sized HCC (max. 3 lesions, <3 cm)	Not available	MWA	RFA	• Lower intrahepatic distant recurrence in MWA as compared to RFA (32.0 vs. 56.0%). • MWA significantly improved OS (p=0.037) and DFS (p<0.01) as compared to RFA.
Zaitoun MMA et al. 2021 RCT[48]	N=265 HCC >3 to <5 cm	1, 6, 12, 24 and 36 months	TACE+MWA	TACE alone, MWA alone	• TACE+MWA outperformed the control groups in complete response (p=0.0002). • Lowest recurrence rates (p=0.0001) and OS (p=0.02) in TACE+MWA. • Highest PFS in TACE+MWA (p<0.001).
Fang L et al. 2019 RCT[49]	N=94 Primary HCC	3 months	US-MWA	Surgical resection	• Significant shorter operation duration and length of stay in MWA, along with lower intraoperative bleeding and blood transfusion volumes compared to the control group (p<0.05). • Albumin and total bilirubin levels were significantly lower in the MWA (p<0.05).
Hu J et al. 2019 RC[38]	N=120 High-risk location HCC <5 cm	19.9 months	US-MWA	CRA	• The mortality rate was 18.8% in the US-MWA (primarily due to tumour progression), while the CRA had a 14.3% mortality rate (mainly from local/ systemic HCC). • MWA developed higher LTP than CRA (75.0 vs. 25.0%). • Distant metastasis occurred higher in MWA as compared to CRA (19.6 vs. 17.8%). • Age (≥65 years), tumour size (3 to 5 cm), and Child-Pugh grade B were identified as independent predictors of poor OS. • Tumour size (≥3 cm), multiple tumours and treatment sessions were estimated as independent factors affecting recurrence-free survival.
Shi J et al. 2014 RC[50]	N=24 HCC <3 cm to ≤5 cm	Serum AF and US: every 3 months Contrast-enhance CT: every 6 months CXR: every 3 months	MWA	Surgical resection	• Higher patients in MWA died as compared to control (43 vs. 40), primarily from cancer recurrence. • DFS rates were significantly higher in control (p=0.005). • Age being the sole significant factor for OS rates (p=0.006). • Overall recurrence rates were higher in MWA (p=0.048) with significantly more early-stage recurrences and local recurrences compared to the control group. • MWA patients with solitary HCC between 3 and 5 cm had more recurrences receiving curative treatment (p=0.041).
Seki T et al. 1999 RC[41]	N=90 HCC ≤2 cm	Survival: 5 years Cancer free survival rate: 4 years US: every 2 months CT and MRI: every 3 to 5 months Serum AF: monthly Clinical observatio n: ranged from 12 to 72 month	PMCT	PEIT	• OS rates were higher in PMCT as compared to PEIT in moderately/ poorly differentiated HCC (p=0.03). Clinical observatio n: ranged from 12 to 72 month

SR & MA, systematic review & meta-analysis; RCC, renal cell carcinoma; MWA, microwave ablation; CRA, cryoablation; LTP, local tumour progression; OS, overall survival; DFS, disease-free survival; CI, confidence interval; RCT, randomised controlled trial; PN, partial nephrectomy; RC, retrospective cohort; CT, computed tomography; MRI, magnetic resonance imaging; RN, radical nephrectomy; HR, hazard ratio; RFA, radiofrequency ablation; HCC, hepatocellular carcinoma; TACE, transcatheter arterial chemoembolisation; PFS, progression-free survival; US, ultrasound; AF, alpha fetoprotein; CXR, chest x-ray; PMCT, percutaneous microwave coagulation therapy; PEIT, percutaneous ethanol injection therapy

5.4 Safety

a. Kidney tumour

Six studies reported on the safety of microwave ablation in kidney tumour.

McClure T et al. (2023) reported overall complication rates (i.e., ≥ grade 2), for microwave ablation and cryoablation were 6.0% (95% CI, 6% to 8%) and 8.0% (95% CI, 6% to 11%), respectively, with major complications (i.e., ≥ grade 3) occurring in 3.0% (95% CI, 3% to 4%) of microwave cases and 4.0% (95% CI, 3% to 5%) of cryoablation cases. Most complications were periprocedural, with microwave ablation complications included bleeding, pain at the ablation site and haematuria.[42, level I]

The meta-analytic in Choi SH et al. (2018) pooled rates of major and minor complications were 1.8% (95% CI, 0.6 to 3.3%; I^2=0.0%) and 17.5% (95% CI, 5.8 to 33.4%; I^2=90.1%), respectively. The incidence of major complications exhibited minimal heterogeneity, while minor complications demonstrated significant heterogeneity.[43, level I]

Guan W et al. (2012) reported 26 complications at post-operatively in 24 patients (23.5%), with six (12.5%) in the microwave ablation group and 18 (33.3%) in the partial nephrectomy group (p=0.0187). Microwave ablation complications included one urine leak leading to nephrectomy and temporary haematuria in another patient. Serum creatinine remained stable after microwave ablation but increased significantly after partial nephrectomy (p=0.0004).[36, level I]

Within 90 days post-operatively in Shapiro DD et al. (2020), complications were reported in seven (17.5%) patients from the microwave ablation group, 18 (24.3%) from the partial nephrectomy group and 28 (13.3%) from the radical nephrectomy group (p=0.006).[39]

de Cobelli F et al. (2019) demonstrated no mortalities or intra-procedural complications. Following cryoablation, five complications (9.8%) were reported and two complications (6.2%) followed microwave ablation, all classified as Cardiovascular and Interventional Radiological Society of Europe (CIRSE) grade I. Overall, no significant difference in complications was found between treatments (p=0.57), but a significant reduction in the likelihood of severe complications (grades II to IV) was observed with microwave ablation compared to cryoablation (p=0.03).[40]

Yu J et al. (2015) showed no grade V complications (deaths) directly linked to treatments. In the microwave ablation group, two grade II complications occurred (1.7%) after 119 sessions, including hepatic encephalopathy and a urinary fistula. Overall complication rates were similar between the two groups (p=0.75).[44]

b. Liver tumour

Nine studies reported on the safety of microwave ablation in liver tumour.

The most frequently reported major complications in Spiliotis AE et al. (2021) in both radiofrequency ablation and microwave ablation included subcapsular and perihepatic haematomas, arterial bleeding requiring intervention, hepatic abscess, biliary fistula, bowel

perforation, abdominal wall burns and pleural effusion with no significant difference (p=0.4129).[45, level I]

Four studies assessed liver function post-treatment in Zhao J et al. (2020), revealing no significant differences in aspartate transaminase (p=0.31) or alanine transaminase (p=0.26) levels. There were also no significant differences in total complications between the TACE + MWA and TACE + RFA groups (p=0.95), with common complications including recurrence, ascites, pain, and bleeding, indicating similar safety profiles for both groups.[46, level I]

The comparison of severe adverse events in Wang L et al. (2019) showed there was no significant difference in the incidence between the two groups (OR 0.67, 95% CI, 0.27 to 1.66).[51, level I]

Sugimoto K et al. (2025) revealed there were no significant differences in grade I complications between the microwave group (44.5%) and the radiofrequency group (44.4%), or in grade II complications (both groups at 1.7%). Additionally, no treatment-related deaths were reported.[47, level I]

No moderate or severe adverse events were reported in Vogl TJ et al. (2023). Mild adverse events occurred in six cases (five minimal pleural effusions and one minimal pneumothorax), with no significant difference between the two groups (p>0.05).[35, level I]

In Zaitoun MMA et al. (2021), post-procedural minor adverse events, including nausea, vomiting, abdominal pain and low-grade fever, were reported in 24.7% of the combined group, 47.6% of the TACE group and 38.0% of the microwave group. The combined therapy was generally well-tolerated, with only one case of severe hepatic dysfunction. In the TACE group, three patients experienced severe hepatic dysfunction, while two patients in the microwave group had tumour seeding.[48, level I]

Fang L et al. (2019) reported the complication rate in the control group was significantly higher than in the study group (p<0.05).[49, level I]

No treatment-related fatalities occurred in Hu J et al. (2019). In the microwave ablation group, there were four major complications; one liver abscess, one instance of tumour seeding and two cases of pleural effusion requiring drainage. In contrast, the cryoablation group reported no major complications. Consequently, the major complication rate was significantly higher in the microwave ablation group (6.3%) compared to the cryoablation group (0.0%) (p=0.039). Additionally, minor complications, such as post-operative pain and fever, were more frequent in the microwave ablation group (p=0.001).[38]

In Seki T et al. (1999), no clinically serious side effects or complications were reported with either PMCT or PEIT. Most patients undergoing PMCT experienced a heat sensation in the upper abdomen, with half reporting mild pain that did not lead to treatment cessation. For PEIT, nearly all patients experienced transient pain during ethanol injection.[41]

5.5 Economic Implication

A study was identified that evaluated the cost-effectiveness of microwave ablation for kidney tumours, however, no studies were found addressing its cost-effectiveness for liver tumours.

A Markov state-transition model was developed by Xia Q et al. (2025), to simulate the progression of Australian patients with unilateral early stage **RCCs (tumour size ≤4 cm)** undergoing **microwave ablation or robotic-assisted partial nephrectomy (RA-PN)** over a 10-year period. Transition probabilities and utility values were derived from extensive literature reviews, while cost estimates were based on the Australian healthcare system perspective.

Life-years, quality-adjusted life-years (QALYs) and lifetime costs were calculated, with a willingness-to-pay (WTP) threshold of $50,000 per QALY. All costs were reported in 2022 Australian dollars and discounted at an annual rate of 3.0%. To enhance the generalisability of the findings, a validated cost-adaptation method was used to extend the analysis to eight other high-income countries (France, Germany, Italy, Netherlands, Slovenia, Spain, United Kingdom and United States).[52]

The base-case cost-effectiveness analysis over a 10-year horizon in Australia indicated that microwave ablation was dominant compared to RA-PN. Specifically, the microwave group had lower rates of local recurrence (0.03 versus 0.06) and distant metastasis (0.05 versus 0.08) than the RA-PN group. In a cohort of 1,000 patients, this resulted in 30 fewer cases of distant metastases, leading to a reduced rate of RCC-related deaths and an overall increase in total life-years compared to RA-PN. Additionally, **Figure 13** presents the results of the one-way sensitivity analyses, evaluating the incremental net monetary benefit (NBM) of microwave ablation versus RA-PN.[52]

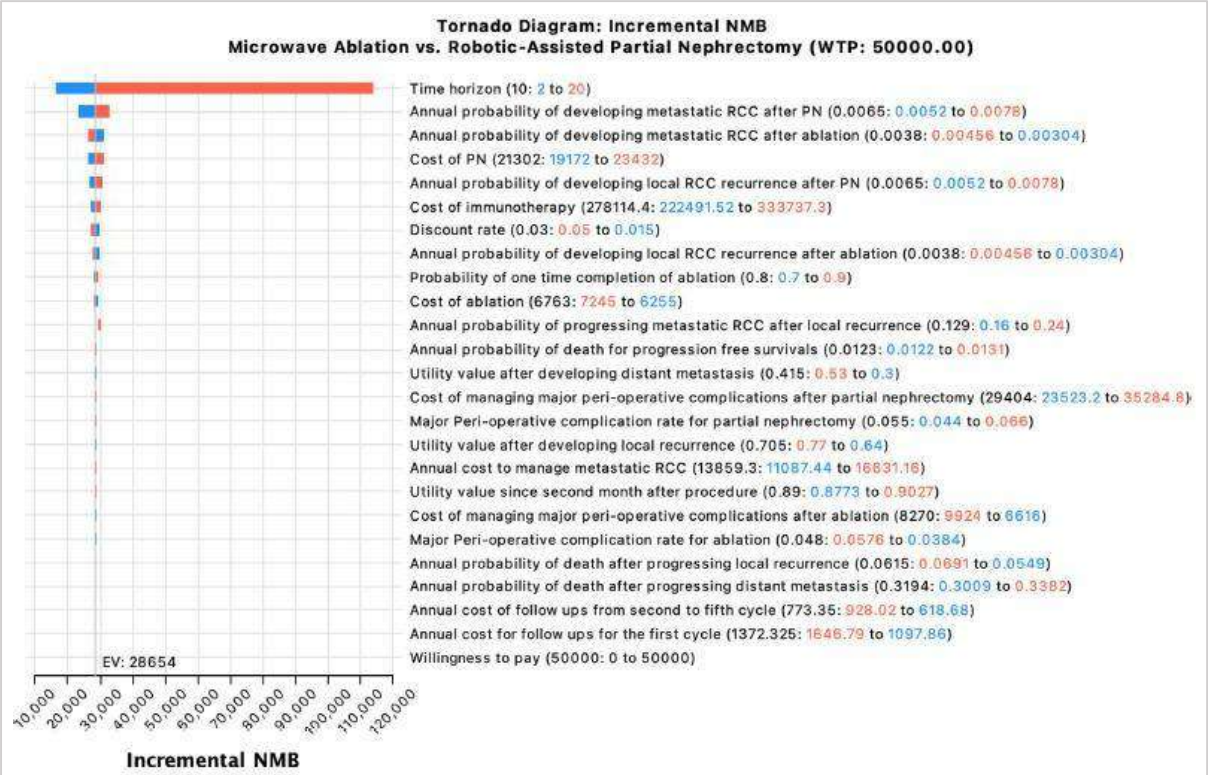


Figure 13: Tornado diagram showing the results of the one-way sensitivity analysis over 10-year horizon. Blue bars (left) represent the lower bound values within the range applied in sensitivity analyses, while orange bars (right) reflect the upper bound.[52]

The results of the probabilistic sensitivity analyses further reinforced the robustness of the model. In 98.3% of simulations, microwave ablation was the dominant strategy, demonstrating its preference across a broad range of assumptions at a WTP threshold of $50,000 per QALY. **Table 4** presents the results of the cost-adaptation analysis across the eight high-income countries. For each country, the table shows the cost of microwave ablation and RA-PN, the cost difference (microwave ablation minus RA-PN), the ICER and the incremental NBM. The cost difference figures showed that microwave ablation consistently less costly than RA-PN in all adapted countries, with savings ranging from EUR 5,888 in Slovenia to US$ 32,142 in the USA. The ICER column in **Table 4** showed large negative values for all eight countries. These negative ICER values, combined with the negative cost differences shown in the same table, reflect the finding that microwave ablation was less costly and also offered improved effectiveness (as established in the Australian base case results, showing more total life years

and QALYs for microwave ablation). Therefore, similar to the Australian base case which resulted in a "dominant" ICER, the results adapted to other high-income countries in **Table 4** also indicated that microwave ablation was the dominant strategy. This means microwave ablation was both less expensive and more effective than RA-PN in these comparable healthcare settings.[52]

Table 4: Cost adaptation of the healthcare perspective results to eight different high-income countries.[52]

Location	Cost		Cost difference	ICER	Incremental NMB
	MWA	RA-PN			
Germany (EUR)	15,134.41	30,070.64	−14,936	−217,882	29,467
France (EUR)	11,849.52	23,543.88	−11,694	−135,784	20,436
UK (EUR)	9,706.42	19,285.74	−9,579	−106,312	17,194
Italy (EUR)	6,960.84	13,830.53	−6,870	−87,085	15,079
The Netherlands (EUR)	14,583.45	28,975.94	−14,392	−62,452	12,370
Slovenia (EUR)	5,966.38	11,854.64	−5,888	−130,841	19,892
Spain (EUR)	7,038.90	13,985.63	−6,947	−53,530	11,388
USA (US$)	32,567.97	64,709.48	−32,142	−63,152	12,447

ICER, incremental cost effectiveness ratio; MWA, microwave ablation; NMB, net monetary benefit; RA-PN, robotic-assisted partial nephrectomy

5.6 Organisational Issue

There were three studies examined the organisational aspects of implementing microwave ablation for kidney and liver tumours.

The Society of American Gastrointestinal and Endoscopic Surgeons (SAGES) and the Americas Hepato-Pancreato-Biliary Association (AHPBA) had published guidelines on the use of microwave and radiofrequency ablation for the surgical management of HCC and colorectal liver metastases measuring **less than 5 cm**. **A systematic review** evaluated six key questions on microwave and radiofrequency ablation for solitary liver tumours in patients unsuitable for first-line therapy. The review concluded that both ablations could be safe and feasible in appropriately selected patients, but caution was needed when considering tumours with differing biologies. Limited data suggested that laparoscopic microwave ablation might have higher morbidity for anatomically complex tumours but provides similar 1-year survival to percutaneous microwave ablation. The choice between approaches should be guided by patient-specific factors, though the evidence remains of very low certainty.[53]

Nonetheless, these recommendations should be interpreted with great caution, as they were based on limited and very low-quality evidence. Furthermore, the necessity of combining two distinct tumour types due to data limitations further restricted the applicability and reliability of these recommendations.[53]

Another guideline from the CIRSE (2020) reviewed literature and provided best practices for image-guided thermal ablation (including microwave ablation) of liver tumours. In terms of the evaluation of bleeding risk, the international normalised ratio < 1.5 to 1.8 (or < 2.5 in chronic liver disease) and platelet count > 50,000/IL (or > 30,000/IL in chronic liver disease) are required. Antiplatelet/ anticoagulation medications should ideally be discontinued. The applicator track can be coagulated during thermal ablation. For peri-procedural manoeuvres or medications, patients should be fasting for four to six hours. Routine prophylactic antibiotics (e.g., cefazolin) are recommended, especially for high-risk patients.[54]

The CIRSE (2017) produced another guideline on percutaneous ablation of small RCC, focuses on the use of percutaneous ablation (including microwave ablation) for treating RCC, specifically cT1a lesions. For T1a tumours, the guideline discusses surgical approach, active

surveillance and ablation therapy; the microwave ablation was reported to have a potentially higher risk of pelvicalyceal injury. Additionally, essential for planning access, probe placement, risk of injury and need for ancillary procedures, the contrast-enhanced CT or MRI is necessary to define the relationship with adjacent organs and needle pathway. Computed tomography is usually the modality of choice for probe guidance. Ideally, treatment is performed under general anaesthesia for pain control and a controlled environment. Conscious sedation with Bispectral Index monitoring may be used if general anaesthesia is not possible. The clotting function (international normalised ratio < 1.5, platelet count > 50,000), full blood count and biochemistry tests are required pre-procedure. Antiplatelet/ anticoagulation treatment should be stopped five-days prior. In terms of managing patient's safety, adjunctive techniques are used to protect adjacent organs from thermal injury. These techniques include:[55]

- Fluid and carbon dioxide (CO_2) dissection: Injecting fluid (e.g., cold 5.0% dextrose for thermal ablation) or CO_2 into the perirenal space to separate organs like the bowel. CO_2 is quickly reabsorbed.

- Ureteric stent with perfusion: Inserting a retrograde stent for perfusion with cold dextrose to protect the pelvicalyceal system.

- Transarterial embolisation: May be performed before thermal ablation to reduce the heat sink effect and bleeding risk and enhance ablation.

5.7 Limitation

Conducting this systematic review came with several limitations that could impact the reliability and applicability of its findings. One major challenge was the quality and potential bias of included studies. Most of the included studies had small sample sizes. Additionally, publication bias could distort findings, as studies with significant or positive results were more likely to be published than those with negative or inconclusive outcomes. Methodological challenges also arise, including selection bias when defining inclusion and exclusion criteria, subjectivity in study appraisal and difficulties in conducting meta-analyses due to variations in study design, populations or outcome measures. Lastly, generalisability remained a concern, as findings might not be applicable across different populations, healthcare settings or regions. The rapidly evolving nature of evidence also means that new studies might emerge after the review was published, potentially altering its conclusions. Despite these limitations, this review remains a valuable tool for synthesising evidence when conducted rigorously.

6.0 CONCLUSION

There was high certainty evidence supporting the use of microwave ablation, either as a standalone treatment or in combination with existing therapies, for managing kidney and liver tumours. In kidney tumours, microwave ablation is associated with low local recurrence rates, high overall survival, shorter ablation times and reduced 1-year recurrence rates. For liver tumours, evidence indicates that microwave ablation results in lower local tumour progression, larger ablation volumes and improved disease-free survival, particularly among patients with larger tumours or those in earlier cancer stages. When combined with transcatheter arterial chemoembolization (TACE), microwave ablation significantly improves both overall and progression-free survival, with notable benefits in tumour response and recurrence reduction. In terms of safety, microwave ablation is associated with fewer complications compared to surgical interventions. Additionally, one study on kidney tumours found microwave ablation to be a cost-effective option, with lower costs than robot-assisted partial nephrectomy (RA-PN).

7.0 REFERENCES

1. Padala SA, Barsouk A, Thandra KC et al. Epidemiology of Renal Cell Carcinoma. World J Oncol. 2020; 11(3): 79-87. doi: 10.14740/wjon1279.
2. Cirillo L, Innocenti S and Becherucci F. Global Epidemiology of Kidney Cancer. Nephrology Dialysis Transplantation. 2024; 39(6): 920-928. doi:10.1093/ndt/gfae036.
3. Bajorin DF. Tumors of the Kidney, Bladder, Ureters and Renal Pelvis. In Goldman-Cecil Medicine. 1362.
4. Renal Cell Carcinoma. Elsevier ClinicalKey. Clinical Overview.
5. Wilms Tumor. Elsevier ClinicalKey. Clinical Overview.
6. Kelley RK and Venook AP. Liver and Biliary Tract Tumors. In Goldman-Cecil Medicine. 1357.
7. McKinley SK, Chawla A and Ferrone CR. Inoperable Biliary Tract and Primary Liver Tumors. Surg Oncol Clin N Am. 2019; 28(4): 745-762. doi:10.1016/j.soc.2019.06.009.
8. Cho S. Pediatric Liver Tumors. Surg Pathol Clin. 2020; 13(4):601-623. doi:10.1016/j.path.2020.09.002.
9. Tsai S and Gamblin TC. Molecular Characteristics of Biliary Tract and Primary Liver Tumors. Surg Oncol Clin N Am. 2019; 28(4) :685-693. doi:10.1016/j.soc.2019.06.004.
10. Meyers R, Hiyama E, Czauderna P et al. Liver Tumors in Pediatric Patients. Surg Oncol Clin N Am. 2021; 30(2): 253-274. doi:10.1016/j.soc.2020.11.006.
11. Li Q, Cao M and Lei L. Burden of Liver Cancer: From Epidemiology to Prevention. Chin J Cancer Res. 2022; 34(6): 554-566. doi: 10.21147/j.issn.1000-9604.2022.06.02.
12. Rumgay H, Arnold M, Ferlay J et al. Global Burden of Primary Liver Cancer in 2020 and Predictions to 2040. Research Article. 2022; 77(6). 1598-1606.
13. Singam P, Ho C, Hong GE et al. Clinical Characteristics of Renal Cancer in Malaysia : A Ten Year Review. Asian Pacific J Cancer Prev. 2010; 11: 503-506.
14. Summary of the Malaysia National Cancer Registry Report 2017-2021. Ministry of Health Malaysia.
15. Global Cancer Observatory. International Agency for Research on Cancer. World Health Organization. Globocan 2022.
16. Roskoski R. Combination Immune Checkpoint and Targeted Protein Kinase Inhibitors for the Treatment of Renal Cell Carcinomas. Pharmacological Research. 2024; 203: 107181. doi:10.1016/j.phrs. 2024.107181.
17. Lopyan NM and Ehrlich PF. Surgical Management of Wilms Tumor (Nephroblastoma) and Renal Cell Carcinoma in Children and Young Adults. Surg Oncol Clin N Am. 2021; 30(2): 305-323. doi:10.1016/j.soc.2020.11.002.
18. Liver Cancer Guidance. National Institute for Health and Care Excellence. Available from https://www.nice.org.uk/guidance/conditions-and-diseases/cancer/liver-cancers/products?ProductType=Guidance&Status=Published. Accessed on 22.4.2025.
19. Cancer Facts and Statistics. American Cancer Institute. Available from https://www.cancer.org/research/cancer-facts-statistics.html. Accessed on 5.2.2025.
20. Renal Cell Cancer Treatment (PDQ®)-Patient Version. National Cancer Institute. Available from https://www.cancer.gov/types/kidney/patient/kidney-treatment-pdq?utm_source=chatgpt.com. Accessed on 5.2.2025.
21. Mahmoud AM, Nabavizadeh R, Rodrigues PR et al Antibody-based Therapeutics for the Treatment of Renal Cell Carcinoma: Challenges and Opportunities. The Oncologist. 2023; 28(4): 297-308. doi:10.1093/oncolo/oyac263.
22. Anwanwan D, Singh SK, Singh S et al. Challenges in Liver Cancer and Possible Treatment Approaches. Biochimica Et Biophysica Acta. Reviews on Cancer. 2020; 1873(1): 188314. doi:10.1016/j.bbcan.2019.188314.
23. Tomasian A and Jennings JW. Hot and Cold Spine Tumor Ablations. Neuroimaging Clin N Am. 2019; 29(4): 529-538. doi:10.1016/j.nic.2019.07.001.
24. Quirk MT, Lee S, Murali N et al. Alternatives to Surgery for Early-stage Non-small Cell Lung Cancer. Clin Chest Med. 2020; 41(2): 197-210. doi:10.1016/j.ccm.2020.02.002.
25. Stanborough RO, Long JR and Garner HW. Bone and Soft Tissue Tumors. Radiol Clin North Am. 2022; 60(2): 311-326. doi:10.1016/j.rcl.2021.11.009.
26. Tomasian A, Khan MA and Jennings JW. Percutaneous Treatment of Spinal Metastases. Neuroimaging Clin N Am. 2023; 33(3): 499-506. doi:10.1016/j.nic.2023.03.005.
27. Narayan N and Gulati R. Microwave Ablation - Uses, Advantages, and Disadvantages. Available from https://www.icliniq.com/articles/cancer/microwave-ablation. Accessed on 5.2.2025.
28. Brace CL. Microwave Ablation Technology: What Every User Should Know. Curr Probl Diagn Radiol. 2009; 38: 61-67.
29. Duck F. Physical Properties of Tissue: A Comprehensive Reference Book. London: Academic Press, 1990; 176-204.
30. Wright AS, Lee FT Jr and Mahvi DM. Hepatic Microwave Ablation with Multiple Antennae Results in Synergistically Larger Zones of Coagulation Necrosis. Ann Surg Oncol. 2003; 10: 275- 823.
31. Lubner MG, Brace CL, Hinshaw JL et al. Microwave Tumor Ablation: Mechanism of Action, Clinical Results, and Devices. J Vasc Interv Radiol. 2010; 21: 192-203.

32. Zhou Y, Yang Y, Zhou B et al. Challenges Facing Percutaneous Ablation in the Treatment of Hepatocellular Carcinoma: Extension of Ablation Criteria. J Hepatocell Carcinoma. 2021; 8: 625-644. doi:10.2147/JHC.S298709.
33. Haddaway NR, Page MJ, Pritchard CC et al. PRISMA2020: An R Package and Shiny App for Producing PRISMA 2020-compliant Flow Diagrams, with Interactivity for Optimised Digital Transparency and Open Synthesis Campbell Systematic Reviews. 2022; 18. e1230. doi:10.1002/cl2.1230.
34. Sugi L, Ke Q, Lin N et al. The Efficacy of Transarterial Chemoembolization Combined with Microwave Ablation for Unresectable Hepatocellular Carcinoma: A Systematic Review and Meta-analysis. Int J Hyperthermia. 2019; 36(1): 1287-1295.
35. Vogl TJ, Martin SS, Gruber-Rouh T et al. Comparison of Microwave and Radiofrequency Ablation for the Treatment of Small- and Medium-sized Hepatocellular Carcinomas in a Prospective Randomized Trial. Interv Radiol. 2023; 196: 482-490.
36. Guan W, Bai J, Liu J et al. Microwave Ablation Versus Partial Nephrectomy for Small Renal Tumors: Intermediate-term Results. J Surg Oncol. 2012.
37. Sun G, Eisenbrey JR, Smolock AR et al. Percutaneous Microwave Ablation versus Cryoablation for Small Renal Masses (≤4 cm): 12-year Experience at a Single Center. J Vasc Interv Radiol. 2024; 35 (6): 865-873.
38. Hu J, Chen S, Wang X et al. Image-guided Percutaneous Microwave Ablation Versus Cryoablation for Hepatocellular Carcinoma in High-risk Locations: Intermediate-term Results. Cancer Manag Res. 2019; 11: 9801-9811.
39. Shapiro DD, Wells SA, Best SL. Comparing Outcomes for Patients with Clinical T1b Renal Cell Carcinoma Treated with Either Percutaneous Microwave Ablation or Surgery. Urology. 2020; 135: 88-94.
40. de Cobelli F, Papa M, Panzeri M et al. Percutaneous Microwave Ablation Versus Cryoablation in the Treatment of T1 Renal Tumors. Cardiovasc Intervent Radiol. 2019.
41. Seki T, Wakabayashi M, Nakagawa T et al. Percutaneous Microwave Coagulation Therapy for Patients with Small Hepatocellular Carcinoma: Comparison with Percutaneous Ethanol Injection Therapy. Cancer: 1999; 85(8): 1694-1702.
42. McClure T, Lansing A, Ferko N et al. A Comparison of Microwave Ablation and Cryoablation for the Treatment of Renal Cell Carcinoma: A Systematic Literature Review and Meta-analysis. Urology. 2023; 180. DOI 10.1016/j.urology. 2023.06.001
43. Choi SH, Kim JW, Kim Jh et al. Efficacy and Safety of Microwave Ablation for Malignant Renal Tumors: An Updated Systematic Review and Meta-analysis of the Literature Since 2012. Korean J Radiol. 2018; 19(5): 938-949. DOI https://doi.org/10.3348/kjr.2018.19.5.938
44. Yu J, Zhang G, Liang P et al. Midterm Results of Percutaneous Microwave Ablation Under Ultrasound Guidance Versus Retroperitoneal Laparoscopic Radial Nephrectomy for Small Renal Cell Carcinoma. Abdom Imaging. 2015; DOI 0.1007/s00261-015-0500-2.
45. Spiliotis AE, Gabelein G, Hollander S et al. Microwave Ablation Compared with Radiofrequency for the Treatment of Liver Cancer: A Systematic Review and Meta-analysis. Radiol Oncol. 2021; 55(3): 247-258.
46. Zhao J, Wu J, He M et al. Comparison of Transcatheter Arterial Chemoembolization Combined with Radiofrequency Ablation or Microwave Ablation for the Treatment of Unresectable Hepatocellular Carcinoma: A Systematic Review and Meta-analysis. Int J Hyperthermia. 2020; 37 (1): 624-633.
47. Sugimoto K, Imajo K, Kuroda H et al. Microwave Ablation vs. Single-needle Radiofrequency Ablation for the Treatment of HCC up to 4 cm: A Randomized-controlled Trial. JHEP Reports. 2025; 7: 101269.
48. Zaitoun MMA, Elsayed SB, Zaitoun NA et al. Combined Therapy with Conventional Trans-arterial Chemoembolization (cTACE) and Microwave Ablation (MWA) for Hepatocellular Carcinoma >3-<5 cm. Int J Hyperthermia. 2021; 38(1): 248-256.
49. Fang L, Meng X, Luo W et al. Treatment of Primary Hepatic Carcinoma Through Ultrasound-guided Microwave Ablation. Niger J Clin Pract. 2019; 22(10): 1408-1411.
50. Shi J, Sun Q, Jing X et al. Comparison of Microwave Ablation and Surgical Resection for Treatment of Hepatocellular Carcinomas Conforming to Milan Criteria. Journal of Gastroenterology and Hepatology. 2014; 29: 1500-1507.
51. Wang L, Ke Q, Lin N et al. The Efficacy of Transarterial Chemoembolization Combined with Microwave Ablation for Unresectable Hepatocellular Carcinoma: A Systematic Review and Meta-analysis. Int J Hyperthermia. 2019; 36(1): 1287-1295.
52. Xia Q, Senanayake SJ, Kularatna S et al. Cost-effectiveness Analysis of Microwave Ablation versus Robot-assisted Partial Nephrectomy for Patients with Small Renal Masses in Australia. Urol Oncol. 2025; 43(62): 15-26.
53. Ceppa EP, Collings AT, Abdalla M et al. SAGES/AHPBA Guidelines for the Use of Microwaveand Radiofrequency Liver Ablation for the SurgicalTreatment of Hepatocellular Carcinoma or ColorectalLiver Metastases less than 5 cm. Surg Endosc. 2022.
54. Crocetti L, de Bae´re T, Pereira PL et al. CIRSE Standards of Practice on Thermal Ablation of Liver Tumours. Cardiovasc Intervent Radiol. 2020; 43: 951-962.
55. Krokidis ME, Orsi F, Katsanos K et al. CIRSE Guidelines on Percutaneous Ablation of Small Renal Cell Carcinoma. Cardiovasc Intervent Radiol. 2017; 40: 177-191.

8.0 APPENDICES

8.1 Appendix 1: Literature search strategy

Ovid MEDLINE(R) <1946 to January 3rd, 2025>

1	KIDNEY NEOPLASMS/	83270
2	(kidney adj cancer*).tw.	7022
3	(kidney adj neoplasm*).tw.	315
4	(renal adj cancer*).tw.	7998
5	(renal adj neoplasm*).tw.	1638
6	LIVER NEOPLASMS/	187133
7	(liver adj2 cancer*).tw.	38839
8	(hepatic adj cancer*).tw.	1707
9	(hepatic adj neoplasm*).tw.	760
10	(hepatocellular adj cancer*).tw.	2457
11	(liver adj neoplasm*).tw.	844
12	1 or 2 or 3 or 4 or 5 or 6 or 7 or 8 or 9 or 10 or 11	293029
13	MICROWAVES/	20735
14	(micro adj wave*).tw.	134
15	(microwave adj radiation*).tw.	1939
16	13 or 14 or 15	21600
17	12 and 16	1390
18	limit 17 to humans	1307

OTHER DATABASES	
EMBASE Cochrane Library INAHTA US FDA	Sama MeSH and keywords as per MEDLINE search

8.2 Appendix 2: Hierarchy of evidence for effectiveness/ diagnostic

I	Evidence obtained from at least one properly designed randomised controlled trial.
II-I	Evidence obtained from well-designed controlled trials without randomization.
II-2	Evidence obtained from well-designed cohort or case-control analytic studies, preferably from more than one centre or research group.
II-3	Evidence obtained from multiple time series with or without the intervention. Dramatic results in uncontrolled experiments (such as the results of the introduction of penicillin treatment in the 1940s) could also be regarded as this type of evidence.
III	Opinions or respected authorities, based on clinical experience; descriptive studies and case reports; or reports of expert committees.

SOURCE: US/CANADIAN PREVENTIVE SERVICES TASK FORCE (Harris 2001)

TECHNOLOGY REVIEW (MINI-HTA) MICROWARE ABLATION FOR KIDNEY AND LIVER TUMOURS

e ISBN 978-967-2887-98-0

MAHTAS
(online)