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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

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.

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.

Results and conclusion:

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.