



MASSACHUSETTS

Blue Cross Blue Shield of Massachusetts is an independent
Licensee of the Blue Cross and Blue Shield Association

Medical Policy

Microwave Tumor Ablation

Table of Contents

- [Policy: Commercial](#)
- [Policy: Medicare](#)
- [Authorization Information](#)
- [Coding Information](#)
- [Description](#)
- [Policy History](#)
- [Information Pertaining to All Policies](#)
- [References](#)

Policy Number: 912

BCBSA Reference Number: 7.01.133 (For Plan internal use only)

NCD/LCD: NA

Related Policies

- Cryosurgical Ablation of Miscellaneous Solid Tumors Other Than Liver, Prostate, or Dermatologic Tumors, #[260](#)
- Cryosurgical Ablation of Primary or Metastatic Liver Tumors, #[633](#)
- Intraoperative Radiation Therapy, #[278](#)
- Radiofrequency Ablation of Miscellaneous Solid Tumors Excluding Liver Tumors, #[259](#)
- Radiofrequency Ablation of Primary or Metastatic Liver Tumors, #[286](#)
- Radioembolization for Primary and Metastatic Tumors of the Liver, #[292](#)

Policy

Commercial Members: Managed Care (HMO and POS), PPO, and Indemnity Medicare HMO BlueSM and Medicare PPO BlueSM Members

Microwave ablation of primary or metastatic hepatic tumors may be considered **MEDICALLY NECESSARY** under the following conditions:

- The tumor is unresectable due to location of lesion[s] and/or comorbid conditions
- A single tumor of ≤ 5 cm or up to 3 nodules ≤ 3 cm each.

Microwave ablation of primary or metastatic lung tumors may be considered **MEDICALLY NECESSARY** under the following conditions:

- The tumor is unresectable due to location of lesion and/or comorbid conditions
- A single tumor of ≤ 3 cm.

Microwave ablation of more than a single primary or metastatic tumor in the lung is considered **INVESTIGATIONAL**.

Microwave ablation of primary or metastatic tumors other than liver or lung is considered **INVESTIGATIONAL**.

Prior Authorization Information

Inpatient

- For services described in this policy, precertification/preauthorization **IS REQUIRED** for all products if the procedure is performed **inpatient**.

Outpatient

- For services described in this policy, see below for products where prior authorization **might be required** if the procedure is performed **outpatient**.

	Outpatient
Commercial Managed Care (HMO and POS)	Prior authorization is not required .
Commercial PPO and Indemnity	Prior authorization is not required .
Medicare HMO Blue SM	Prior authorization is not required .
Medicare PPO Blue SM	Prior authorization is not required .

CPT Codes / HCPCS Codes / ICD Codes

Inclusion or exclusion of a code does not constitute or imply member coverage or provider reimbursement. Please refer to the member's contract benefits in effect at the time of service to determine coverage or non-coverage as it applies to an individual member.

Providers should report all services using the most up-to-date industry-standard procedure, revenue, and diagnosis codes, including modifiers where applicable.

CPT Codes

There is no specific CPT code for microwave ablation.

DESCRIPTION

Microwave Ablation

Microwave ablation (MWA) uses microwave energy to induce an ultra-high-speed, 915 MHz or 2 450 MHz (2.45 GHz), alternating electric field, which causes water molecule rotation and creates heat. This results in thermal coagulation and localized tissue necrosis. In MWA, a single microwave antenna or multiple antennas connected to a generator are inserted directly into the tumor or tissue to be ablated; energy from the antennas generates friction and heat. The local heat coagulates the tissue adjacent to the probe, resulting in a small, 2 cm to 3 cm elliptical area (5-3 cm) of tissue ablation. In tumors greater than 2 cm in diameter, 2 to 3 antennas may be used simultaneously to increase the targeted area of MWA and shorten the operative time. Multiple antennas may also be used simultaneously to ablate multiple tumors. Tissue ablation occurs quickly, within 1 minute after a pulse of energy, and multiple pulses may be delivered within a treatment session, depending on tumor size. The cells killed by MWA are typically not removed but are gradually replaced by fibrosis and scar tissue. If there is a local recurrence, it occurs at the margins. Treatment may be repeated as needed. Microwave ablation may be used for the following purposes: (1) to control local tumor growth and prevent recurrence; (2) to palliate symptoms; and (3) to prolong survival.

Microwave ablation is similar to radiofrequency (RFA) and cryosurgical ablation. However, MWA has potential advantages over RFA and cryosurgical ablation. In MWA, the heating process is active, which produces higher temperatures than the passive heating of RFA and should allow for more complete thermal ablation in less time. The higher temperatures reached with MWA (>100°C) can overcome the "heat sink" effect in which tissue cooling occurs from nearby blood flow in large vessels, potentially resulting in incomplete tumor ablation. Microwave ablation does not rely on the conduction of electricity for heating and, therefore, does not flow electrical current through patients and does not require grounding pads, because there is no risk of skin burns. Additionally, MWA does not produce electric noise, which allows ultrasound guidance during the procedure without interference, unlike RFA. Finally, MWA can take 20% to 30% less time than RFA, because multiple antennas can be used simultaneously

for multiple ablations. There is no comparable RFA system with the capacity to drive multiple electrically dependent electrodes.

Adverse Events

Complications from MWA may include pain and fever. Other complications associated with MWA include those caused by heat damage to normal tissue adjacent to the tumor (eg, intestinal damage during MWA of the kidney or liver), structural damage along the probe track (eg, pneumothorax as a consequence of procedures on the lung), liver enzyme elevation, liver abscess, ascites, pleural effusion, diaphragm injury, or secondary tumors if cells seed during probe removal. Microwave ablation should be avoided in pregnant women because potential risks to the patient and/or fetus have not been established, and in patients with implanted electronic devices (eg, implantable pacemakers) that may be adversely affected by microwave power output.

Applications

Microwave ablation was first used percutaneously in 1986 as an adjunct to liver biopsy. Since then, MWA has been used to ablate tumors and tissue to treat many conditions including hepatocellular carcinoma, breast cancer, colorectal cancer metastatic to the liver, renal cell carcinoma, renal hamartoma, adrenal malignant carcinoma, non-small-cell lung cancer, intrahepatic primary cholangiocarcinoma, secondary splenomegaly and hypersplenism, abdominal tumors, and other tumors not amenable to resection. Well-established local or systemic treatment alternatives are available for each of these malignancies. The potential advantages of MWA for these cancers include improved local control and other advantages common to any minimally invasive procedure (eg, preserving normal organ tissue, decreasing morbidity, shortening length of hospitalization). Microwave ablation also has been investigated as a treatment for unresectable hepatic tumors, as both primary and palliative treatment, and as a bridge to a liver transplant. In the latter setting, MWA is being assessed to determine whether it can reduce the incidence of tumor progression while awaiting transplantation and thus maintain a patient's candidacy while awaiting a liver transplant.

Summary

Microwave ablation (MWA) is a technique to destroy tumors and soft tissue using microwave energy to create thermal coagulation and localized tissue necrosis. Microwave ablation is used to treat tumors not amenable to resection and to treat patient's ineligible for surgery due to age, comorbidities, or poor general health. Microwave ablation may be performed as an open procedure, laparoscopically, percutaneously, or thoracoscopically under image guidance (eg, ultrasound, computed tomography, magnetic resonance imaging) with sedation, or local or general anesthesia. This technique is also referred to as microwave coagulation therapy.

For individuals who have an unresectable primary or metastatic hepatic tumor who receive microwave ablation (MWA), the evidence includes randomized controlled trials (RCTs), comparative observational studies, and systematic reviews comparing MWA to radiofrequency ablation (RFA) and to surgical resection. Relevant outcomes are overall survival (OS), disease-specific survival, symptoms, quality of life (QOL), and treatment-related mortality and morbidity. The body of evidence indicates that MWA is an effective option in patients for whom resection is not an option. Although studies had methodological limitations, results consistently showed that MWA and RFA had similar survival outcomes with up to 5 years of follow-up in patients with a single tumor <5 cm or up to 3 nodules <3 cm each. In a meta-analysis of observational studies, patients receiving MWA had higher local recurrence rates and lower survival than those who received resection, but the patient populations were not limited to those who had unresectable tumors. Microwave ablation was associated with lower complications, intraoperative blood loss, and hospital length of stay. The evidence is sufficient to determine that the technology results in an improvement in the net health outcome.

For individuals who have an unresectable primary or metastatic lung tumor who receive MWA, the evidence includes a single RCT, retrospective observational studies, and systematic reviews of these studies. Relevant outcomes are OS, disease-specific survival, symptoms, QOL, and treatment-related mortality and morbidity. The body of evidence indicates that MWA is an effective option in patients for whom resection is not an option. In the RCT, direct comparison of MWA and RFA in patients with primary

or metastatic lung cancer (mean tumor size, 1.90 cm [\pm 0.89] at baseline) found similar mortality rates up to 12 months of follow-up. In the first of 3 systematic reviews that included 12 retrospective observational studies, local recurrence rates were similar for MWA and RFA at a range of 9 to 47 months of follow-up. In the second systematic review with a meta-analysis, there was lower OS with MWA compared to RFA but studies were not directly comparable due to clinical and methodological heterogeneity. However, the authors concluded that percutaneous RFA and MWA were both effective with a high safety profile. In the third systematic review using a network meta-analysis, the weighted average OS rates for MWA were 82.5%, 54.6%, 35.7%, 29.6%, and 16.6% at 1, 2, 3, 4, and 5 years, respectively. Limitations of the body of evidence included a lack of controlled studies and heterogeneity across studies. The RCT did not report results by tumor size or the number of metastases. The observational studies included in the systematic reviews did not report sufficient information to assess the effectiveness or safety of MWA in subgroups based on the presence of multiple tumors or total tumor burden. Therefore, conclusions about the evidence sufficiency can only be made about patients with single tumors. For this population, the evidence is sufficient to determine that the technology results in an improvement in the net health outcome.

For individuals who have an unresectable primary or metastatic renal tumor who receive MWA, the evidence includes a single RCT that compared MWA to partial nephrectomy, retrospective reviews, systematic reviews, and meta-analyses of the retrospective reviews (with or without the single RCT) and case series. Relevant outcomes are OS, disease-specific survival, symptoms, QOL, and treatment-related mortality and morbidity. In the RCT, overall local recurrence-free survival at 3 years was 91.3% for MWA and 96.0% for partial nephrectomy ($p=.54$). This positive outcome should be replicated in additional RCTs. There are also no controlled studies comparing MWA to other ablation techniques in patients with renal tumors. The evidence is insufficient to determine that the technology results in an improvement in the net health outcome.

For individuals who have unresectable primary or metastatic solid tumors other than hepatic, lung, or renal who receive MWA, the evidence includes systematic reviews and case series. No RCTs on the use of MWA for other tumors or conditions were identified. Relevant outcomes are OS, disease-specific survival, symptoms, QOL, and treatment-related mortality and morbidity. The evidence is insufficient to determine that the technology results in an improvement in the net health outcome.

Policy History

Date	Action
12/2024	Annual policy review. Description, summary, and references updated. Policy statements unchanged.
12/2023	Annual policy review. Description, summary, and references updated. Policy statements unchanged.
12/2022	Annual policy review. Description, summary, and references updated. Policy statements unchanged.
12/2021	Annual policy review. Description, summary, and references updated. Policy statements unchanged.
12/2020	Annual policy review. Description, summary, and references updated. Policy statements unchanged.
2/2020	Policy statements changed to medically necessary for lung and liver tumors; statements for other tumor types unchanged. Effective 2/1/2020
10/2018	Annual policy review. Description, summary, and references updated. Policy statements unchanged.
1/2018	Clarified coding information.
10/2017	Annual policy review. New references added.
4/2016	Annual policy review. New references added.
12/2014	Annual policy review. New references added.
1/2014	Annual policy review. New references added.
4/2013	Annual policy review. New references added.

2/2013	New policy describing non-coverage.
--------	-------------------------------------

Information Pertaining to All Blue Cross Blue Shield Medical Policies

Click on any of the following terms to access the relevant information:

[Medical Policy Terms of Use](#)

[Managed Care Guidelines](#)

[Indemnity/PPO Guidelines](#)

[Clinical Exception Process](#)

[Medical Technology Assessment Guidelines](#)

References

1. Chinnaratha MA, Chuang MY, Fraser RJ, et al. Percutaneous thermal ablation for primary hepatocellular carcinoma: A systematic review and meta-analysis. *J Gastroenterol Hepatol*. Feb 2016; 31(2): 294-301. PMID 26114968
2. Bertot LC, Sato M, Tateishi R, et al. Mortality and complication rates of percutaneous ablative techniques for the treatment of liver tumors: a systematic review. *Eur Radiol*. Dec 2011; 21(12): 2584-96. PMID 21858539
3. Ong SL, Gravante G, Metcalfe MS, et al. Efficacy and safety of microwave ablation for primary and secondary liver malignancies: a systematic review. *Eur J Gastroenterol Hepatol*. Jun 2009; 21(6): 599-605. PMID 19282763
4. Glassberg MB, Ghosh S, Clymer JW, et al. Microwave ablation compared with hepatic resection for the treatment of hepatocellular carcinoma and liver metastases: a systematic review and meta-analysis. *World J Surg Oncol*. Jun 10 2019; 17(1): 98. PMID 31182102
5. Cui R, Yu J, Kuang M, et al. Microwave ablation versus other interventions for hepatocellular carcinoma: A systematic review and meta-analysis. *J Cancer Res Ther*. 2020; 16(2): 379-386. PMID 32474527
6. Dou Z, Lu F, Ren L, et al. Efficacy and safety of microwave ablation and radiofrequency ablation in the treatment of hepatocellular carcinoma: A systematic review and meta-analysis. *Medicine (Baltimore)*. Jul 29 2022; 101(30): e29321. PMID 35905207
7. 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*. Apr 15 1999; 85(8): 1694-702. PMID 10223562
8. Shibata T, Iimuro Y, Yamamoto Y, et al. Small hepatocellular carcinoma: comparison of radiofrequency ablation and percutaneous microwave coagulation therapy. *Radiology*. May 2002; 223(2): 331-7. PMID 11997534
9. Xu HX, Xie XY, Lu MD, et al. Ultrasound-guided percutaneous thermal ablation of hepatocellular carcinoma using microwave and radiofrequency ablation. *Clin Radiol*. Jan 2004; 59(1): 53-61. PMID 14697375
10. Lu MD, Xu HX, Xie XY, et al. Percutaneous microwave and radiofrequency ablation for hepatocellular carcinoma: a retrospective comparative study. *J Gastroenterol*. Nov 2005; 40(11): 1054-60. PMID 16322950
11. Tanaka K, Shimada H, Nagano Y, et al. Outcome after hepatic resection versus combined resection and microwave ablation for multiple bilobar colorectal metastases to the liver. *Surgery*. Feb 2006; 139(2): 263-73. PMID 16455336
12. Wang ZL, Liang P, Dong BW, et al. Prognostic factors and recurrence of small hepatocellular carcinoma after hepatic resection or microwave ablation: a retrospective study. *J Gastrointest Surg*. Feb 2008; 12(2): 327-37. PMID 17943391
13. Ohmoto K, Yoshioka N, Tomiyama Y, et al. Comparison of therapeutic effects between radiofrequency ablation and percutaneous microwave coagulation therapy for small hepatocellular carcinomas. *J Gastroenterol Hepatol*. Feb 2009; 24(2): 223-7. PMID 18823439
14. Yin XY, Xie XY, Lu MD, et al. Percutaneous thermal ablation of medium and large hepatocellular carcinoma: long-term outcome and prognostic factors. *Cancer*. May 01 2009; 115(9): 1914-23. PMID 19241423
15. Kuang M, Xie XY, Huang C, et al. Long-term outcome of percutaneous ablation in very early-stage hepatocellular carcinoma. *J Gastrointest Surg*. Dec 2011; 15(12): 2165-71. PMID 21972056

16. Imura S, Shimada M, Utsunomiya T, et al. Ultrasound-guided microwave coagulation assists anatomical hepatic resection. *Surg Today*. Jan 2012; 42(1): 35-40. PMID 22075665
17. Qian GJ, Wang N, Shen Q, et al. Efficacy of microwave versus radiofrequency ablation for treatment of small hepatocellular carcinoma: experimental and clinical studies. *Eur Radiol*. Sep 2012; 22(9): 1983-90. PMID 22544225
18. Chinnaratha MA, Sathananthan D, Pateria P, Tse E, MacQuillan G, Wigg AJ. Predictors of hepatocellular carcinoma recurrence post thermal ablation. *J Gastroenterol Hepatol*. 2013;28(Suppl. 2):66-67.
19. Ding J, Jing X, Liu J, et al. Comparison of two different thermal techniques for the treatment of hepatocellular carcinoma. *Eur J Radiol*. Sep 2013; 82(9): 1379-84. PMID 23726122
20. Stättner S, Jones RP, Yip VS, et al. Microwave ablation with or without resection for colorectal liver metastases. *Eur J Surg Oncol*. Aug 2013; 39(8): 844-9. PMID 23769976
21. Takami Y, Ryu T, Wada Y, et al. Evaluation of intraoperative microwave coagulo-necrotic therapy (MCN) for hepatocellular carcinoma: a single center experience of 719 consecutive cases. *J Hepatobiliary Pancreat Sci*. Mar 2013; 20(3): 332-41. PMID 22710886
22. Zhang L, Wang N, Shen Q, et al. Therapeutic efficacy of percutaneous radiofrequency ablation versus microwave ablation for hepatocellular carcinoma. *PLoS One*. 2013; 8(10): e76119. PMID 24146824
23. Abdelaziz A, Elbaz T, Shousha HI, et al. Efficacy and survival analysis of percutaneous radiofrequency versus microwave ablation for hepatocellular carcinoma: an Egyptian multidisciplinary clinic experience. *Surg Endosc*. Dec 2014; 28(12): 3429-34. PMID 24935203
24. Shi J, Sun Q, Wang Y, et al. Comparison of microwave ablation and surgical resection for treatment of hepatocellular carcinomas conforming to Milan criteria. *J Gastroenterol Hepatol*. 2014; 29(7): 1500-7. PMID 24628534
25. Tan K, DU X, Yin J, et al. Microwave tissue coagulation technique in anatomical liver resection. *Biomed Rep*. Mar 2014; 2(2): 177-182. PMID 24649092
26. Zhang NN, Cheng XJ, Liu JY. Comparison of high-powered MWA and RFA in treating larger hepatocellular carcinoma. *J Pract Oncol*. 2014;29:349-356.
27. Abdelaziz AO, Nabeel MM, Elbaz TM, et al. Microwave ablation versus transarterial chemoembolization in large hepatocellular carcinoma: prospective analysis. *Scand J Gastroenterol*. Apr 2015; 50(4): 479-84. PMID 25592058
28. Vogl TJ, Farshid P, Naguib NN, et al. Ablation therapy of hepatocellular carcinoma: a comparative study between radiofrequency and microwave ablation. *Abdom Imaging*. Aug 2015; 40(6): 1829-37. PMID 25601438
29. Xu J, Zhao Y. Comparison of percutaneous microwave ablation and laparoscopic resection in the prognosis of liver cancer. *Int J Clin Exp Pathol*. 2015; 8(9): 11665-9. PMID 26617907
30. Potretzke TA, Ziemlewicz TJ, Hinshaw JL, et al. Microwave versus Radiofrequency Ablation Treatment for Hepatocellular Carcinoma: A Comparison of Efficacy at a Single Center. *J Vasc Interv Radiol*. May 2016; 27(5): 631-8. PMID 27017124
31. Zhang EL, Yang F, Wu ZB, et al. Therapeutic efficacy of percutaneous microwave coagulation versus liver resection for single hepatocellular carcinoma ≤ 3 cm with Child-Pugh A cirrhosis. *Eur J Surg Oncol*. May 2016; 42(5): 690-7. PMID 26995115
32. Li W, Zhou X, Huang Z, et al. Short-term and long-term outcomes of laparoscopic hepatectomy, microwave ablation, and open hepatectomy for small hepatocellular carcinoma: a 5-year experience in a single center. *Hepatol Res*. Jun 2017; 47(7): 650-657. PMID 27487979
33. Philips P, Scoggins CR, Rostas JK, et al. Safety and advantages of combined resection and microwave ablation in patients with bilobar hepatic malignancies. *Int J Hyperthermia*. Feb 2017; 33(1): 43-50. PMID 27405728
34. Ryu T, Takami Y, Wada Y, et al. Oncological outcomes after hepatic resection and/or surgical microwave ablation for liver metastasis from gastric cancer. *Asian J Surg*. Jan 2019; 42(1): 100-105. PMID 29254868
35. Song P, Sheng L, Sun Y, et al. The clinical utility and outcomes of microwave ablation for colorectal cancer liver metastases. *Oncotarget*. Aug 01 2017; 8(31): 51792-51799. PMID 28881688
36. Xu Y, Shen Q, Wang N, et al. Microwave ablation is as effective as radiofrequency ablation for very-early-stage hepatocellular carcinoma. *Chin J Cancer*. Jan 19 2017; 36(1): 14. PMID 28103953

37. Yu J, Yu XL, Han ZY, et al. Percutaneous cooled-probe microwave versus radiofrequency ablation in early-stage hepatocellular carcinoma: a phase III randomised controlled trial. *Gut*. Jun 2017; 66(6): 1172-1173. PMID 27884919
38. Zhang QB, Zhang XG, Jiang RD, et al. Microwave ablation versus hepatic resection for the treatment of hepatocellular carcinoma and oesophageal variceal bleeding in cirrhotic patients. *Int J Hyperthermia*. May 2017; 33(3): 255-262. PMID 27817240
39. Chen ZB, Qin F, Ye Z, et al. Microwave-assisted liver resection vs. clamp crushing liver resection in cirrhosis patients with hepatocellular carcinoma. *Int J Hyperthermia*. Dec 2018; 34(8): 1359-1366. PMID 29353503
40. Chong CCN, Lee KF, Chu CM, et al. Microwave ablation provides better survival than liver resection for hepatocellular carcinoma in patients with borderline liver function: application of ALBI score to patient selection. *HPB (Oxford)*. Jun 2018; 20(6): 546-554. PMID 29352659
41. Chinnaratha MA, Sathananthan D, Pateria P, et al. High local recurrence of early-stage hepatocellular carcinoma after percutaneous thermal ablation in routine clinical practice. *Eur J Gastroenterol Hepatol*. Mar 2015; 27(3): 349-54. PMID 25563141
42. Cillo U, Noaro G, Vitale A, et al. Laparoscopic microwave ablation in patients with hepatocellular carcinoma: a prospective cohort study. *HPB (Oxford)*. Nov 2014; 16(11): 979-86. PMID 24750429
43. Correa-Gallego C, Fong Y, Gonen M, et al. A retrospective comparison of microwave ablation vs. radiofrequency ablation for colorectal cancer hepatic metastases. *Ann Surg Oncol*. Dec 2014; 21(13): 4278-83. PMID 24889486
44. Di Vece F, Tombesi P, Ermili F, et al. Coagulation areas produced by cool-tip radiofrequency ablation and microwave ablation using a device to decrease back-heating effects: a prospective pilot study. *Cardiovasc Intervent Radiol*. Jun 2014; 37(3): 723-9. PMID 24196263
45. Hompes R, Fieuws S, Aerts R, et al. Results of single-probe microwave ablation of metastatic liver cancer. *Eur J Surg Oncol*. Aug 2010; 36(8): 725-30. PMID 20605397
46. Kamal A, Elmoety AAA, Rostom YAM, et al. Percutaneous radiofrequency versus microwave ablation for management of hepatocellular carcinoma: a randomized controlled trial. *J Gastrointest Oncol*. Jun 2019; 10(3): 562-571. PMID 31183208
47. Lee KF, Wong J, Hui JW, et al. Long-term outcomes of microwave versus radiofrequency ablation for hepatocellular carcinoma by surgical approach: A retrospective comparative study. *Asian J Surg*. Jul 2017; 40(4): 301-308. PMID 26922631
48. Liu Y, Li S, Wan X, et al. Efficacy and safety of thermal ablation in patients with liver metastases. *Eur J Gastroenterol Hepatol*. Apr 2013; 25(4): 442-6. PMID 23470267
49. Liu W, Zheng Y, He W, et al. Microwave vs radiofrequency ablation for hepatocellular carcinoma within the Milan criteria: a propensity score analysis. *Aliment Pharmacol Ther*. Sep 2018; 48(6): 671-681. PMID 30063081
50. Sakaguchi H, Seki S, Tsuji K, et al. Endoscopic thermal ablation therapies for hepatocellular carcinoma: a multi-center study. *Hepatol Res*. Jan 2009; 39(1): 47-52. PMID 18761680
51. Santambrogio R, Chiang J, Barabino M, et al. Comparison of Laparoscopic Microwave to Radiofrequency Ablation of Small Hepatocellular Carcinoma (≤ 3 cm). *Ann Surg Oncol*. Jan 2017; 24(1): 257-263. PMID 27581608
52. Sever I H, Sucu M, Biyikli E. Radiofrequency and Microwave Ablation in the Treatment of Hepatocellular Carcinoma. *Iran J Radiol*. 2018;15(3):e62396. doi: 10.5812/iranradiol.62396.
53. Shady W, Petre EN, Do KG, et al. Percutaneous Microwave versus Radiofrequency Ablation of Colorectal Liver Metastases: Ablation with Clear Margins (A0) Provides the Best Local Tumor Control. *J Vasc Interv Radiol*. Feb 2018; 29(2): 268-275.e1. PMID 29203394
54. Simo KA, Sereika SE, Newton KN, et al. Laparoscopic-assisted microwave ablation for hepatocellular carcinoma: safety and efficacy in comparison with radiofrequency ablation. *J Surg Oncol*. Dec 2011; 104(7): 822-9. PMID 21520094
55. Sparchez Z, Mocan T, Hajjar NA, et al. Percutaneous ultrasound guided radiofrequency and microwave ablation in the treatment of hepatic metastases. A monocentric initial experience. *Med Ultrason*. Aug 31 2019; 21(3): 217-224. PMID 31476199
56. Tian W, Kuang M, Lv M, et al. A randomised comparative trial on liver tumors treated with ultrasound-guided percutaneous radiofrequency versus microwave ablation. *Chin J Hepatobiliary Surg* 2014;20:11922.

57. van Tilborg AA, Scheffer HJ, de Jong MC, et al. MWA Versus RFA for Perivascular and Peribiliary CRLM: A Retrospective Patient- and Lesion-Based Analysis of Two Historical Cohorts. *Cardiovasc Intervent Radiol*. Oct 2016; 39(10): 1438-46. PMID 27387188
58. Vietti Violi N, Duran R, Guiu B, et al. Efficacy of microwave ablation versus radiofrequency ablation for the treatment of hepatocellular carcinoma in patients with chronic liver disease: a randomised controlled phase 2 trial. *Lancet Gastroenterol Hepatol*. May 2018; 3(5): 317-325. PMID 29503247
59. Yang B, Li Y. A comparative study of laparoscopic microwave ablation with laparoscopic radiofrequency ablation for colorectal liver metastasis. *J BUON*. 2017; 22(3): 667-672. PMID 28730772
60. Chong CCN, Lee KF, Cheung SYS, et al. Prospective double-blinded randomized controlled trial of Microwave versus RadioFrequency Ablation for hepatocellular carcinoma (McRFA trial). *HPB (Oxford)*. Aug 2020; 22(8): 1121-1127. PMID 32044268
61. 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. *Rofo*. May 2024; 196(5): 482-490. PMID 38065541
62. 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. PMID 33615957
63. Loveman E, Jones J, Clegg AJ, et al. The clinical effectiveness and cost-effectiveness of ablative therapies in the management of liver metastases: systematic review and economic evaluation. *Health Technol Assess*. Jan 2014; 18(7): vii-viii, 1-283. PMID 24484609
64. Bala MM, Riemsma RP, Wolff R, et al. Microwave coagulation for liver metastases. *Cochrane Database Syst Rev*. Oct 13 2013; (10): CD010163. PMID 24122576
65. Pathak S, Jones R, Tang JM, et al. Ablative therapies for colorectal liver metastases: a systematic review. *Colorectal Dis*. Sep 2011; 13(9): e252-65. PMID 21689362
66. Mimmo A, Pegoraro F, Rhaïem R, et al. Microwave Ablation for Colorectal Liver Metastases: A Systematic Review and Pooled Oncological Analyses. *Cancers (Basel)*. Mar 03 2022; 14(5). PMID 35267612
67. Yuan Z, Wang Y, Zhang J, et al. A Meta-Analysis of Clinical Outcomes After Radiofrequency Ablation and Microwave Ablation for Lung Cancer and Pulmonary Metastases. *J Am Coll Radiol*. Mar 2019; 16(3): 302-314. PMID 30642784
68. Jiang B, McClure MA, Chen T, et al. Efficacy and safety of thermal ablation of lung malignancies: A Network meta-analysis. *Ann Thorac Med*. 2018; 13(4): 243-250. PMID 30416597
69. Nelson DB, Tam AL, Mitchell KG, et al. Local Recurrence After Microwave Ablation of Lung Malignancies: A Systematic Review. *Ann Thorac Surg*. Jun 2019; 107(6): 1876-1883. PMID 30508527
70. He W, Hu XD, Wu DF, et al. Ultrasonography-guided percutaneous microwave ablation of peripheral lung cancer. *Clin Imaging*. 2006; 30(4): 234-41. PMID 16814137
71. Wolf FJ, Grand DJ, Machan JT, et al. Microwave ablation of lung malignancies: effectiveness, CT findings, and safety in 50 patients. *Radiology*. Jun 2008; 247(3): 871-9. PMID 18372457
72. Vogl TJ, Naguib NN, Gruber-Rouh T, et al. Microwave ablation therapy: clinical utility in treatment of pulmonary metastases. *Radiology*. Nov 2011; 261(2): 643-51. PMID 22012906
73. Lu Q, Cao W, Huang L, et al. CT-guided percutaneous microwave ablation of pulmonary malignancies: Results in 69 cases. *World J Surg Oncol*. May 07 2012; 10: 80. PMID 22564777
74. Carrafiello G, Mangini M, Fontana F, et al. Microwave ablation of lung tumours: single-centre preliminary experience. *Radiol Med*. Jan 2014; 119(1): 75-82. PMID 24234180
75. Liu H, Steinke K. High-powered percutaneous microwave ablation of stage I medically inoperable non-small cell lung cancer: a preliminary study. *J Med Imaging Radiat Oncol*. Aug 2013; 57(4): 466-74. PMID 23870347
76. Vogl TJ, Worst TS, Naguib NN, et al. Factors influencing local tumor control in patients with neoplastic pulmonary nodules treated with microwave ablation: a risk-factor analysis. *AJR Am J Roentgenol*. Mar 2013; 200(3): 665-72. PMID 23436860
77. Wei Z, Ye X, Yang X, et al. Microwave ablation in combination with chemotherapy for the treatment of advanced non-small cell lung cancer. *Cardiovasc Intervent Radiol*. Feb 2015; 38(1): 135-42. PMID 24809754

78. Yang X, Ye X, Zheng A, et al. Percutaneous microwave ablation of stage I medically inoperable non-small cell lung cancer: clinical evaluation of 47 cases. *J Surg Oncol*. Nov 2014; 110(6): 758-63. PMID 24965604
79. Zheng A, Wang X, Yang X, et al. Major complications after lung microwave ablation: a single-center experience on 204 sessions. *Ann Thorac Surg*. Jul 2014; 98(1): 243-8. PMID 24793688
80. Acksteiner C, Steinke K. Percutaneous microwave ablation for early-stage non-small cell lung cancer (NSCLC) in the elderly: a promising outlook. *J Med Imaging Radiat Oncol*. Feb 2015; 59(1): 82-90. PMID 25335916
81. Wei Z, Ye X, Yang X, et al. Microwave ablation plus chemotherapy improved progression-free survival of advanced non-small cell lung cancer compared to chemotherapy alone. *Med Oncol*. Feb 2015; 32(2): 464. PMID 25572816
82. Egashira Y, Singh S, Bandula S, et al. Percutaneous High-Energy Microwave Ablation for the Treatment of Pulmonary Tumors: A Retrospective Single-Center Experience. *J Vasc Interv Radiol*. Apr 2016; 27(4): 474-9. PMID 26944360
83. Ko WC, Lee YF, Chen YC, et al. CT-guided percutaneous microwave ablation of pulmonary malignant tumors. *J Thorac Dis*. Oct 2016; 8(Suppl 9): S659-S665. PMID 28066666
84. Li B, Wang Z, Zhou K, et al. Safety and feasibility within 24 h of discharge in patents with inoperable malignant lung nodules after percutaneous microwave ablation. *J Cancer Res Ther*. Dec 2016; 12(Supplement): C171-C175. PMID 28230012
85. Macchi M, Belfiore MP, Floridi C, et al. Radiofrequency versus microwave ablation for treatment of the lung tumours: LUMIRA (lung microwave radiofrequency) randomized trial. *Med Oncol*. May 2017; 34(5): 96. PMID 28417355
86. Maxwell AW, Healey TT, Dupuy DE. Percutaneous Thermal Ablation for Small-Cell Lung Cancer: Initial Experience with Ten Tumors in Nine Patients. *J Vasc Interv Radiol*. Dec 2016; 27(12): 1815-1821. PMID 27776982
87. Vogl TJ, Eckert R, Naguib NN, et al. Thermal Ablation of Colorectal Lung Metastases: Retrospective Comparison Among Laser-Induced Thermotherapy, Radiofrequency Ablation, and Microwave Ablation. *AJR Am J Roentgenol*. Dec 2016; 207(6): 1340-1349. PMID 27680945
88. Zheng A, Ye X, Yang X, et al. Local Efficacy and Survival after Microwave Ablation of Lung Tumors: A Retrospective Study in 183 Patients. *J Vasc Interv Radiol*. Dec 2016; 27(12): 1806-1814. PMID 27789077
89. Healey TT, March BT, Baird G, et al. Microwave Ablation for Lung Neoplasms: A Retrospective Analysis of Long-Term Results. *J Vasc Interv Radiol*. Feb 2017; 28(2): 206-211. PMID 27993505
90. Nour-Eldin NA, Exner S, Al-Subhi M, et al. Ablation therapy of non-colorectal cancer lung metastases: retrospective analysis of tumour response post-laser-induced interstitial thermotherapy (LITT), radiofrequency ablation (RFA) and microwave ablation (MWA). *Int J Hyperthermia*. Nov 2017; 33(7): 820-829. PMID 28540791
91. Wei Z, Ye X, Yang X, et al. Advanced non small cell lung cancer: response to microwave ablation and EGFR Status. *Eur Radiol*. Apr 2017; 27(4): 1685-1694. PMID 27436020
92. Yang X, Ye X, Huang G, et al. Repeated percutaneous microwave ablation for local recurrence of inoperable Stage I nonsmall cell lung cancer. *J Cancer Res Ther*. 2017; 13(4): 683-688. PMID 28901314
93. Zhong L, Sun S, Shi J, et al. Clinical analysis on 113 patients with lung cancer treated by percutaneous CT-guided microwave ablation. *J Thorac Dis*. Mar 2017; 9(3): 590-597. PMID 28449467
94. Uhlig J, Strauss A, R cker G, et al. Partial nephrectomy versus ablative techniques for small renal masses: a systematic review and network meta-analysis. *Eur Radiol*. Mar 2019; 29(3): 1293-1307. PMID 30255245
95. Guan W, Bai J, Liu J, et al. Microwave ablation versus partial nephrectomy for small renal tumors: intermediate-term results. *J Surg Oncol*. Sep 01 2012; 106(3): 316-21. PMID 22488716
96. Katsanos K, Mailli L, Krokidis M, et al. Systematic review and meta-analysis of thermal ablation versus surgical nephrectomy for small renal tumours. *Cardiovasc Intervent Radiol*. Apr 2014; 37(2): 427-37. PMID 24482030
97. Martin J, Athreya S. Meta-analysis of cryoablation versus microwave ablation for small renal masses: is there a difference in outcome?. *Diagn Interv Radiol*. 2013; 19(6): 501-7. PMID 24084196

98. 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*. Oct 2023; 180: 1-8. PMID 37331485
99. Guo J, Arellano RS. Percutaneous Microwave Ablation of Category T1a Renal Cell Carcinoma: Intermediate Results on Safety, Technical Feasibility, and Clinical Outcomes of 119 Tumors. *AJR Am J Roentgenol*. Jan 2021; 216(1): 117-124. PMID 32603227
100. Aarts BM, Prevoo W, Meier MAJ, et al. Percutaneous Microwave Ablation of Histologically Proven T1 Renal Cell Carcinoma. *Cardiovasc Intervent Radiol*. Jul 2020; 43(7): 1025-1033. PMID 32052093
101. Zhao Z, Wu F. Minimally-invasive thermal ablation of early-stage breast cancer: a systemic review. *Eur J Surg Oncol*. Dec 2010; 36(12): 1149-55. PMID 20889281
102. Zhou W, Zha X, Liu X, et al. US-guided percutaneous microwave coagulation of small breast cancers: a clinical study. *Radiology*. May 2012; 263(2): 364-73. PMID 22438362
103. Keane MG, Bramis K, Pereira SP, et al. Systematic review of novel ablative methods in locally advanced pancreatic cancer. *World J Gastroenterol*. Mar 07 2014; 20(9): 2267-78. PMID 24605026
104. Cui T, Jin C, Jiao D, et al. Safety and efficacy of microwave ablation for benign thyroid nodules and papillary thyroid microcarcinomas: A systematic review and meta-analysis. *Eur J Radiol*. Sep 2019; 118: 58-64. PMID 31439259
105. Wu X, Jiang Z, Liu J, et al. The efficacy and safety of microwave ablation versus conventional open surgery for the treatment of papillary thyroid microcarcinoma: a systematic review and meta-analysis. *Gland Surg*. Jun 2022; 11(6): 1003-1014. PMID 35800741
106. Li X, Fan W, Zhang L, et al. CT-guided percutaneous microwave ablation of adrenal malignant carcinoma: preliminary results. *Cancer*. Nov 15 2011; 117(22): 5182-8. PMID 21523760
107. Pusceddu C, Sotgia B, Fele RM, et al. Treatment of bone metastases with microwave thermal ablation. *J Vasc Interv Radiol*. Feb 2013; 24(2): 229-33. PMID 23200605
108. Yu MA, Liang P, Yu XL, et al. Sonography-guided percutaneous microwave ablation of intrahepatic primary cholangiocarcinoma. *Eur J Radiol*. Nov 2011; 80(2): 548-52. PMID 21300500
109. Egorov AV, Vasilyev IA, Musayev GH, et al. The role of microwave ablation in management of functioning pancreatic neuroendocrine tumors. *Gland Surg*. Dec 2019; 8(6): 766-772. PMID 32042685
110. Howington JA, Blum MG, Chang AC, et al. Treatment of stage I and II non-small cell lung cancer: Diagnosis and management of lung cancer, 3rd ed: American College of Chest Physicians evidence-based clinical practice guidelines. *Chest*. May 2013; 143(5 Suppl): e278S-e313S. PMID 23649443
111. Campbell SC, Clark PE, Chang SS, et al. Renal Mass and Localized Renal Cancer: Evaluation, Management, and Follow-Up: AUA Guideline: Part I. *J Urol*. Aug 2021; 206(2): 199-208. PMID 34115547
112. National Comprehensive Cancer Network (NCCN). NCCN Clinical Practice Guidelines in Oncology: Hepatocellular Carcinoma. Version 2.2024. <https://www.nccn.org/guidelines/guidelines-detail?category=1&id=1514>. Accessed August 2, 2024.
113. National Comprehensive Cancer Network (NCCN). NCCN Clinical Practice Guidelines in Oncology: Non-Small Cell Lung Cancer. Version 7.2024. https://www.nccn.org/professionals/physician_gls/pdf/nscl.pdf. Accessed August 6, 2024.
114. National Comprehensive Cancer Network (NCCN). NCCN Clinical Practice Guidelines in Oncology: Small Cell Lung Cancer. Version 3.2024. https://www.nccn.org/professionals/physician_gls/pdf/sclc.pdf. Accessed August 7, 2024.
115. National Comprehensive Cancer Network (NCCN). NCCN Clinical Practice Guidelines in Oncology: Neuroendocrine and Adrenal Tumors. Version 2.2024. https://www.nccn.org/professionals/physician_gls/pdf/neuroendocrine.pdf. Accessed August 5, 2024.
116. National Comprehensive Cancer Network (NCCN). NCCN Clinical Practice Guidelines in Oncology: Kidney Cancer. Version 1.2025. https://www.nccn.org/professionals/physician_gls/pdf/kidney.pdf. Accessed August 3, 2024.
117. National Comprehensive Cancer Network (NCCN). NCCN Clinical Practice Guidelines in Oncology: Breast Cancer. Version 4.2024. https://www.nccn.org/professionals/physician_gls/pdf/breast.pdf. Accessed August 1, 2024.

118. National Comprehensive Cancer Network (NCCN). NCCN Clinical Practice Guidelines in Oncology: Thyroid Cancer. Version 3.2024. https://www.nccn.org/professionals/physician_gls/pdf/thyroid.pdf. Accessed August 8, 2024.
119. National Institute for Health and Care Excellence (NICE). Microwave ablation for treating liver metastases [IPG553]. 2016; <https://www.nice.org.uk/guidance/ipg553>. Accessed August 9, 2024.
120. National Institute for Health and Care Excellence (NICE). Microwave Ablation of Hepatocellular Carcinoma [IPG214]. 2007; <https://www.nice.org.uk/guidance/ipg214>. Accessed August 10, 2024.
121. National Institute for Health and Care Excellence (NICE). Microwave ablation for treating primary lung cancer and metastases in the lung [IPG469]. 2022; <https://www.nice.org.uk/guidance/ipg716>. Accessed August 11, 2024.
122. Ceppa EP, Collings AT, Abdalla M, et al. SAGES/AHPBA guidelines for the use of microwave and radiofrequency liver ablation for the surgical treatment of hepatocellular carcinoma or colorectal liver metastases less than 5 cm. *Surg Endosc.* Dec 2023; 37(12): 8991-9000. PMID 37957297