Recommendation and Guideline

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No-Touch Radiofrequency Ablation for Early Hepatocellular Carcinoma: 2023 Korean Society of Image-Guided Tumor Ablation Guidelines

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Radiofrequency ablation (RFA) has been widely used to manage hepatocellular carcinomas (HCCs) equal to or smaller than 3 cm. No-touch RFA has gained attention and has recently been implemented in local ablation therapy for HCCs, despite its technical complexity, as it provides improved local tumor control compared to conventional tumor-puncturing RFA. This article presents the practice guidelines for performing no-touch RFA for HCCs, which have been endorsed by the Korean Society of Image-Guided Tumor Ablation (KSITA). The guidelines are primarily designed to assist interventional oncologists and address the limitations of conventional tumor-puncturing RFA with describing the fundamental principles, various energy delivery methods, and clinical outcomes of no-touch RFA. The clinical outcomes include technical feasibility, local tumor progression rates, survival outcomes, and potential complications.
Keywords: Hepatocellular carcinoma; No-touch radiofrequency ablation; Guideline

INTRODUCTION

Radiofrequency ablation (RFA) is widely accepted as a curative treatment option for early-stage hepatocellular carcinoma (HCC) according to guidelines proposed by major societies, including the Korean Liver Cancer Association-National Cancer Center Korea Practice Guidelines [1-4]. No-touch RFA has recently been implemented in clinical practice, with increasing evidence suggesting improved local tumor control in HCC compared with conventional tumor-puncturing RFA. No-touch RFA requires multiple electrodes; therefore, various protocols regarding tumor-to-electrode distance, interelectrode distance, and energy delivery mode should be applied according to the tumor size and geometry. Consequently, the procedure may be relatively complex compared to conventional tumor-puncturing RFA. To initiate the development of standardized protocols for no-touch RFA, this text aims to make it easier for operators to use the appropriate techniques.

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Methodology

A task force for the development of guidelines regarding no-touch RFA was organized in December 2021, including six key members of the Korean Society of Image-guided Tumor Ablation (KSITA), who are experts in liver tumor ablation. Key questions regarding the essentials of no-touch RFA were developed by task force members through discussion in both in online and face-to-face meetings.

To develop candidates for the key statements for each key question, a database search was performed by two of the task force members using the PubMed Medline database between January 2005 and November 2022 with the following keywords; “liver,” “liver tumor,” “hepatocellular carcinoma,” “radiofrequency ablation,” “microwave ablation,” and “no-touch.” The searched items, including practice guidelines, recent literature, randomized controlled trials (RCTs), and systematic reviews with meta-analysis, were reviewed. Key statements, along with their levels of evidence, were classified based on the revised Grading of Recommendations, Assessment, Development, and Evaluation (GRADE) (Table 1) [5-9]. Overall, six key questions and seven corresponding 7 key statements were developed. A modified Delphi method consisting of two rounds was used to select and modify the key statements. The preliminary statements were presented to the task force members, who were asked to vote for agreement using a 6-scale score regarding agreement as follows:1 = strongly disagree, 2 = disagree with major reservations, 3 = disagree with minor reservations, 4 = agree with major reservations, 5 = agree with minor reservations, and 6 = strongly agree. A consensus on the statements was reached when 80% of the panel agreed to the statement with a score above 5. For statements that did not reach a consensus, modifications were made according to the comments and presented for a second round of voting. The final Delphi score for agreement by the Delphi panels for each key statement is presented in Table 2.

All KSITA members reviewed the final guidelines and recommendations. Further feedback and comments were provided after the review. The current guidelines are endorsed by KSITA.

Basic Concepts

Conventional Tumor-Puncturing RFA

Traditionally, RFA is performed by placing a single radiofrequency (RF) electrode within the tumor. In monopolar RFA, the RF current flows between the exposed tip of the electrode and the grounding pads. Creating an adequate ablative margin of 0.5–1.0 cm can be challenging when using conventional tumor-puncturing RFA, particularly with a single electrode. This difficulty arises from the complexity of positioning the electrode at the center of the index tumor across all three axes. Therefore, local tumor progression (LTP) has been one of the major limitations of conventional RFA, and the 3-year LTP rate following RFA has been reported to be up to 21.4% [10]. Additionally, tract seeding through the electrode pathway is theoretically possible because of the tumor-puncturing nature of the procedure [11]. Tumor spread via draining vessels is also possible due to increased intratumoral pressure caused by vaporization of the tissue, which can result in frequent tumor recurrence [12].

Basic Principles of No-Touch RFA

As it is challenging to create a sufficiently large ablation zone using a single RF electrode. Various strategies, including perfusion electrodes, multiple electrodes, combined chemoembolization, and RFA, have been used to enlarge the ablation zone [13-15]. When using multiple electrodes, centripetal ablation is feasible after placing the electrodes at the peripheral portion of the tumor, in contrast to the centrifugal ablation performed by tumor-puncturing monopolar RFA. No-touch RFA is a procedure in which RFA is performed by placing multiple electrodes over the adjacent

Table 1. Modified Grading of Recommendations, Assessment, Development and Evaluation (GRADE)

	Criteria
Quality of evidence	
High (A)	Further research is unlikely to change confidence in the estimate of the clinical effect
Moderate (B)	Further research may change confidence in the estimate of the clinical effect
Low (C)	Further research is very likely to impact confidence on the estimate of clinical effect
Strength of recommendation	
Strong (1)	Factors influencing the strength of the recommendation included the quality of the evidence, presumed patient-important outcomes, and cost
Weak (2)	Variability in preferences and values, or more uncertainty. Recommendation is made with less certainty, higher cost, or resource consumption

Modified under CC BY-NC license, from a Korea practice guidelines by Korean Liver Cancer Association (KLCA) and National Cancer Center (NCC), *Korean J Radiol* 2022;23:1126-1240 [4]. For convenience, we excluded “very low quality (D)” in our guidelines which was originally included in the system.

Table 2. Consensus of the Delphi Panels for Each Key Statement

Key Questions (KQ)	Key Statements (KS)	Number of Delphi Panels in Each Agreement Level						Proportion of Agreement
		1	2	3	4	5	6	(Level 5 or 6)
KQ1. Does no-touch RFA have advantage in local tumor control over conventional tumor-puncturing RFA?	KS1. No-touch RFA provides better local tumor control than conventional tumor-puncturing RFA for HCCs ≤ 5 cm.	-	-	-	1	1	4	83.3%
KQ2. Is no-touch RFA safe to perform when compared to conventional tumor-puncturing RFA?	KS2. The complication rate following no-touch RFA is not significantly different from that following conventional RFA if the tumor is not in perivascular locations.	-	-	-	-	3	3	100%
KQ3. Does no-touch RFA benefit patient survival outcomes compared to conventional tumor-puncturing RFA?	KS3. There is a lack of evidence to conclude whether no-touch RFA results in better survival outcomes than conventional RFA.	-	-	-	1	1	4	83.3%
KQ4. In which circumstances can no-touch RFA be technically infeasible?	KS4. No-touch RFA can be challenging for tumors in perivascular or subcapsular locations due to insufficient peritumoral parenchyma	-	-	1	-	2	3	83.3%
KQ5. What is the ideal method for energy delivery during no-touch RFA?	KS5. There is a lack of evidence to conclude the ideal energy mode for no-touch RFA	-	-	-	-	3	3	100%
KQ6. How can we further improve the technical outcome of no-touch RFA in early HCCs?	KS6. Applying CT/MRI-US intermodality fusion imaging and CEUS for poorly visualized tumors can increase the technical success rate	-	-	-	-	1	5	100%
	KS7. Introduction of artificial ascites or pleural effusion can aid in ablating tumors at difficult locations	-	-	-	-	-	6	100%

Agreement levels: 1 = strongly disagree, 2 = disagree with major reservations, 3 = disagree with minor reservations, 4 = agree with major reservations, 5 = agree with minor reservations, 6 = strongly agree. RFA = radiofrequency ablation, HCC = hepatocellular carcinoma, CT = computed tomography, CEUS = contrast-enhanced ultrasound, MRI-US = magnetic resonance imaging ultrasound

liver parenchyma externally to the tumor [16-18]. No-touch RFA has several advantages over conventional tumor-puncturing RFA [19-21]. First, the sequential or paired activation of multiple electrodes provides a sufficient ablative margin, which results in improved local tumor control. In a retrospective study on HCC ≤ 5 cm [17], tumor size larger than 3 cm was not a predictive factor for LTP following no-touch RFA. This result was attributed to the lower LTP rate following no-touch RFA than that following conventional RFA for HCCs measuring 3–5 cm [20]. Second, centripetal tumor ablation using the no-touch technique can obliterate the peritumoral feeding and draining vessels early in the ablation process. Therefore, theoretically, it may improve the thermal efficiency of RF energy by reducing the heat sink effect. Thus it may reduce the possibility of tumor spread via the peritumoral vessel owing to the destruction of the peritumoral vessels. Third, as the electrodes do not penetrate the tumor, they cannot spread tumor tissue through the electrode pathway and prevents any tumor cells being drawn through the pathway as it is retracted.

Key Question 1) Does no-touch RFA present an advantage in local tumor control over conventional tumor-puncturing RFA?

Key Statement 1) No-touch RFA provides better local tumor control than conventional tumor-puncturing RFA for HCCs ≤ 5 cm (A1).

The theoretical advantages of no-touch RFA over conventional tumor-puncturing RFA have been confirmed in multiple retrospective studies [17,20,22-26], prospective studies [16,27,28], RCTs [29,30], systematic reviews, and meta-analyses [19]. Either the multiple switching monopolar mode [16,23,29] or the multi-bipolar mode [17,20,22,24-28,30] was used in these studies.

According to a systematic review and meta-analysis [19], the pooled 1-, 2-, and 3-year cumulative LTP rates following no-touch RFA for HCCs ≤ 5 cm were 3% [95% confidence interval (CI), 2%–5%], 5% (95% CI,

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3%–9%), and 8% (95% CI, 6%–11%), respectively. No-touch RFA demonstrated significantly lower LTP rates than conventional tumor-puncturing RFA (hazard ratio, 0.28; 95% CI, 0.11–0.70; relative risk, 0.26; 95% CI, 0.16–0.41; $P < 0.01$, respectively). Subgroup analysis of only RCTs also demonstrated a lower LTP rate with no-touch RFA (hazard ratio, 0.13; 95% CI, 0.04–0.42) [29,30]. The study reported that prospective studies [16,27,28] showed significantly lower rates of LTP (2.4%; 95% CI, 1.1%–5.1%) than retrospective ones (6.9%; 95% CI, 5.1%–9.5%; P = 0.01). Interestingly, a mean/median HCC size cutoff of 2 cm, number of HCCs, inclusion of recurrent HCC, study population (Asian vs. Western), and energy delivery mode (multi-bipolar vs. multiple monopolar modes) were not significantly associated with LTP [19].

In a retrospective multicenter study (n = 362) [20], conventional RFA, HCC > 3 cm, and perivascular HCCs were independent factors associated with global RFA failure (primary RFA failure or LTP). Notably, local tumor control was better with no-touch RFA than with conventional RFA for perivascular HCCs (P = 0.021). In contrast, there was no significant difference between the two treatments for subcapsular HCCs (P = 0.207). In the intra-group multivariate analysis based on the RFA technique, perivascular HCCs and HCCs > 3 cm were associated with global RFA failure only in the conventional RFA group (P = 0.046 and P = 0.001, respectively). No such associations were observed in the no-touch RFA group.

No-touch RFA also demonstrated lower rates of intra-segmental recurrence than conventional RFA (2.9%–5.5% vs. 13.2%–19.2%, respectively) [17,25,31]. This result is not surprising because there is no direct tumor penetration in no-touch RFA and the peritumoral vessels are destroyed with a sufficient ablative margin.

Key Question 2) Is no-touch RFA safe to perform when compared to conventional tumor-puncturing RFA?

Key Statement 2) The complication rate after no-touch RFA was not significantly different from that after conventional RFA if the tumor was not in a perivascular location (B1).

Considering the technical complexity, the manipulation of multiple electrodes and the increased ablation zone, no-touch RFA is generally assumed to be more prone to complications than conventional RFA. Therefore, in daily practice, tumors in high-risk locations or in patients with borderline liver function are usually treated with less aggressive ablation and the number of electrodes is limited. However, it is challenging to directly compare the complication rates between no-touch RFA and conventional RFA, particularly in retrospective studies. To date, few studies have evaluated the complication rates of no-touch and conventional RFA with a higher level of evidence.

In a single-center retrospective study [24], the complication rate was not significantly different between the two treatments (P = 0.269). However, the severity of complications was not stratified, and the authors excluded patients with HCCs in high-risk locations, including the subcapsular, subphrenic, or pericholecystic sites. Therefore, it is difficult to draw reliable conclusions.

In a multicenter retrospective study [20], the rate of major complications according to the Society of Interventional Radiology classification, did not differ between the two treatment groups (P > 0.999). Notably, the rate of complications worse than Clavien-Dindo grade 3a (requiring surgery, intensive care unit admission, or death) tended to be higher with no-touch RFA than with tumor-puncturing RFA (4.4 % [8/181] vs. 1.1 % [2/181], respectively; P = 0.054).

Two RCTs (bipolar no-touch RFA vs. conventional RFA using twin internally cooled wet electrodes for HCCs ≤ 2.5 cm [30]; monopolar no-touch RFA vs. conventional RFA using internally cooled electrodes for HCCs ≤ 2.5 cm [29]) reported that there was no significant difference in major complications between the two groups. However, these studies had a selection bias, as perivascular HCCs (adjacent to the portal or hepatic veins with < 5 mm proximity) were not included. In a multicenter prospective study of 140 participants [16], the major complication rate of no-touch RFA was 2.1%, similar to that of conventional RFA. However, this study was limited by the absence of a control tumor-puncturing RFA group.

In summary, although there are a limited number of well-designed studies, the complication rates do not appear to be significantly different between no-touch RFA and conventional RFA if the tumor is not in a high-risk location. Further, well-designed prospective studies with larger study populations are warranted to draw definite conclusions.

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Key Question 3) Does no-touch RFA benefit patient survival outcomes compared to conventional tumor-puncturing RFA?

Key Statement 3) There is not sufficient evidence to conclude that no-touch RFA results in better survival outcomes than conventional RFA (C2).

No-touch RFA has been recently developed, and the primary endpoint in most studies has been local tumor control. Only a few studies have focused on long-term survival outcomes. A prospective study (n = 140) reported that the overall survival (OS) rates in the no-touch RFA group were 100% and 98.3% at 1 and 2 years, respectively [16]. However, in a multicenter retrospective study of HCCs using the Milan criteria (n = 362), the five-year OS rate was not significantly different between the conventional and no-touch RFA groups (37.2% vs. 46.4%; $P = 0.378$) [20]. In a multicenter prospective study (n = 231) [28], the 3-year OS rate tended to be higher in the no-touch RFA group than in the conventional RFA group; however, the difference was not statistically significant (93.3% vs. 86.8%, respectively; $P = 0.110$). However, this study has some limitations, including selection bias due to non-random allocation.

In summary, with a limited number of well-designed studies, it is challenging to conclude whether no-touch RFA results in better survival outcomes than conventional RFA. Therefore, further investigation is warranted to evaluate the advantages of no-touch RFA in terms of survival outcomes in patients with small HCCs.

Key Question 4) In which circumstances is no-touch RFA technically infeasible?

Key Statement 4) No-touch RFA can be challenging for tumors in perivascular or subcapsular locations owing to insufficient peritumoral parenchyma (B1).

However, there are other conditions no-touch RFA is not always feasible. In a multicenter prospective study with HCCs of 1.0–2.5 cm in size, conversion to conventional tumor-puncturing RFA using the monopolar mode was unavoidable in 8.6% (12/140) of patients because of the lack of a safe insertion route for multiple electrodes [16]. Therefore, the technical success rate of the planned no-touch RFA was 91.4% (128/140). Insufficient peritumoral liver parenchyma, defined as a peritumoral parenchyma < 5 mm wide in more than half of the tumors, was the only significant predictor of technical failure in no-touch RFA. Similar results were noted in an RCT that compared no-touch RFA and conventional RFA using the bipolar mode [30]. In this study, conversion to conventional RFA was needed in 10.8% (4/37) of the patients in the no-touch RFA group. The primary factors for conversion was the absence of a secure access pathway and the subcapsular location of the tumor, which had an inadequate peritumoral parenchyma (less than 5 mm). Although previous studies have reported that bipolar no-touch RFA is well-suited for subcapsular tumors with little adjacent liver parenchyma [20,22], these studies may have limitations, including selection bias, due to their retrospective study design. In another RCT that compared no-touch RFA and conventional RFA for HCCs ≤ 2.5 cm in size, no-touch RFA using the monopolar mode was feasible in all patients in the no-touch RFA group (n = 58) [29]. However, this study should be interpreted with caution because tumors abutting the main hepatic vessels (≥ 5 mm in diameter) were excluded. In summary, although debatable, no-touch RFA may be challenging for tumors in perivascular or subcapsular locations owing to insufficient peritumoral parenchyma.

Key Question 5) What is the ideal method of energy delivery during no-touch RFA?

Key Statement 5) There is insufficient evidence to determine the ideal energy mode for no-touch RFA (C2).

There is still an ongoing debate regarding the ideal RF energy delivery mode for no-touch RFA. Thus far, a standardized energy delivery method has not been established for no-touch RFA. Many factors, including the energy delivery mode, tumor size and location, interelectrode distance, and distance between the electrodes and tumor margin, should be considered for tailored RFA in each case. In an ex vivo simulation study using triple electrodes [32], the size of the ablation zone was determined in the following order: dual-switching monopolar mode > combined dual-switching monopolar and switching bipolar modes > switching bipolar mode. However, in determining the sphericity of the ablation zone, this order is reversed.

As energy is radiated centrifugally from each RF electrode in switching monopolar mode, the ablation zones around each electrode grow and gradually merge to form the

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final ablation zone [32]. In contrast, in switching bipolar mode, current flows between the electrodes and the energy concentrated between the electrodes creates an ablation zone mainly between the electrodes in a centripetal manner [33]. Therefore, the bipolar mode generally produces a smaller ablation zone than the switching monopolar mode [32]. Switching bipolar mode offers a faster, more circular, and predictable ablation zone than switching monopolar mode [32-34]. Furthermore, the switching bipolar mode is better than the switching monopolar mode in terms of complications because it avoids unnecessary overextension of the ablation zone [35,36]. Repositioning the electrodes is usually necessary to ablate tumors as large as 3–4 cm in diameter in the switching bipolar mode, even with the use of triple electrodes [17].

One of the concerns of switching bipolar mode is the rapid increase in temperature in the tissue circumscribed by the electrodes [34]. If the electrode is unintentionally positioned very close to the tumor surface, a rapid increase in temperature can occur. This could result in an inadequate ablative margin, potentially compromising the effective destruction of the peritumoral tissue. Although there is no concrete evidence to support this assumption, utilizing the switching monopolar mode before employing the switching bipolar mode might prove beneficial for effectively destroying peritumoral vessels owing to its comparatively larger ablation zone. Moreover, the complementary nature of the switching monopolar and bipolar modes allows a combination of the two to enhance local tumor control. This was achieved by addressing the potential blind spots in the ablation zone of each mode while capitalizing on the advantages of botha more expansive ablation zone with the switching monopolar mode and a more uniform, spherical ablation zone with the switching bipolar mode (Fig. 1) [32].

A few early studies reported promising results with the bipolar switching mode using multiple electrodes [20,33]. Studies have also reported excellent local tumor control using no-touch RFA using only switching monopolar mode [16,29]. However, the shape of the ablation zone produced by the switching monopolar mode becomes less spherical as the inter-electrode distance increases, particularly when ablating large tumors, owing to the centrifugal ablation nature of each electrode [32,33]. In such cases, the switching bipolar mode can be added to improve the circularity of the ablation zone (Fig. 1) [32].

In summary, because each energy mode has different physical properties, the operator should comprehensively understand the characteristics of each energy delivery mode and use the appropriate energy mode or combine the monopolar and bipolar modes accordingly for the size, shape, and location of the tumor. Indeed, repositioning the electrodes is necessary to achieve an adequate ablative margin around the tumor after careful monitoring of the ablation zone during RFA [16]. Further studies are warranted to evaluate the ideal energy delivery mode for no-touch RFA.

Key Question 6) How can we further improve the technical outcome of no-touch RFA in early stage HCCs?

Key Statement 6) Applying Computed Tomography/Magnetic Resonance Imaging Ultrasound (CT/MRI-US) intramodality fusion imaging and contrast-enhanced ultrasound (CEUS) to poorly visualized tumors can increase the technical success rate (A1).

Key Statement 7) The introduction of artificial ascites or pleural effusion can aid in ablating tumors in difficult locations (A1).

Some tumors can be difficult to visualize under US guidance if they are small, isoechoic, or located in blinded areas, such as the liver dome or the far lateral tip of the left lobe. Cirrhotic or fatty changes in the background liver can also hinder adequate visualization of HCCs under US guidance. Poor tumor visualization can lead to the mistargeting of the index tumor and decrease the technical success rate [37,38]. Furthermore, it can increase the risk of complications due to unexpected vascular or biliary injuries.

Since its development, several studies have reported the benefits of intermodality fusion imaging in ablating poorly visualized HCCs [39-42]. CT/MRI–US fusion imaging based on electromagnetic tracking is the most commonly used method for ablative procedures [43]. By matching real-time US images with previously acquired CT/MRI images, the operator can accurately locate the tumor. Previous studies have reported that the fusion technique also improves the visualization of the tumor and the operator's confidence, thereby improving the operator's success [43-46]. Moreover, fusion imaging can aid precise monitoring of the ablation zone during the generation of echo clouds, which hinder the sonic window of adjacent structures [43]. In a prospective study, the technical effectiveness of fusion imaging for invisible tumors was similar to that for visible tumors (96.1% vs. 97.6%) [46]. Based on the aforementioned studies, we

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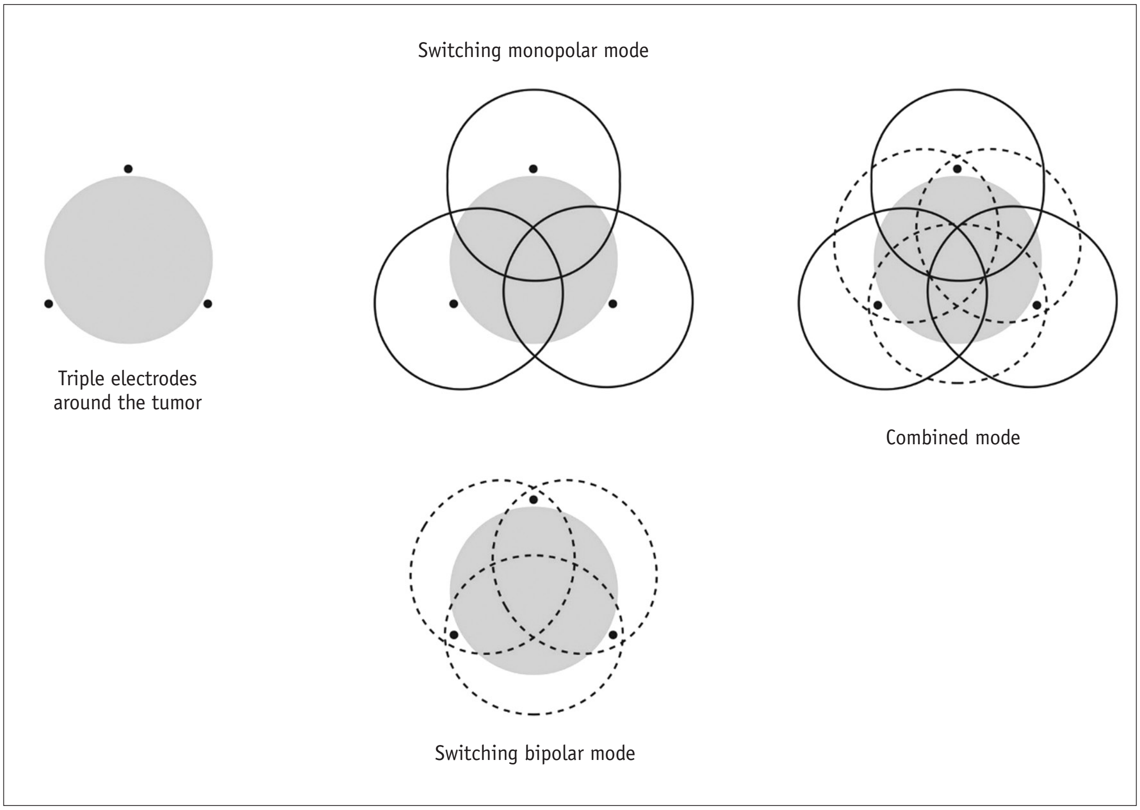

Fig. 1. Diagram depicting the energy delivery modes. For no-touch radiofrequency ablation, triple electrodes (black dots) are symmetrically positioned in the liver parenchyma outside the tumor (gray zone) and close to the tumor margin (upper left figure). The switching monopolar mode (upper middle figure) creates ablation zones (black circles) around each electrode, and if the interelectrode distance is not far, the ablation zones will gradually merge to make a final confluent ablation zone. If the electrodes are positioned farther than 5 mm outside the margin of the tumor, an unnecessarily overextended ablation zone is created, which results in a high rate of complications subsequently. Furthermore, the final ablation zone is less spherical. Therefore, the electrode should be positioned as close to the tumor margin as possible in the switching monopolar mode, and this can also provide a more spherical ablation zone by decreasing the interelectrode distance. In the switching bipolar mode (lower middle figure), centripetal ablation zones (dotted circles) between each pair of two electrodes are created. A faster but smaller ablation zone is created when compared with the switching monopolar mode as the applied radiofrequency energy is concentrated between the electrodes. Therefore, the ablative margin in the area around each electrode may not be large enough to ablate the potential microscopic satellite nodules. The switching monopolar mode and the switching bipolar mode can be combined to take advantage of each energy delivery mode (upper right figure). Although no consensus has yet been achieved regarding the sequence of applying the modes, initial application of the monopolar mode for a few minutes can create a sufficient ablative margin and destroy the peritumoral feeding and draining vessels before direct ablation of the tumor. Subsequently, the switching bipolar mode can be used to destroy the tumor.

conclude that intermodality fusion imaging can improve the outcomes of ablation procedures for poorly visualized tumors. Nevertheless, the current fusion technology cannot compensate for minor registration errors induced by a mismatch in the patient's respiratory status between the current procedure time and the time when the reference CT/MRI image was acquired [43]. Operators should be aware of these limitations, especially when ablating peripheral lesions, which are most prone to mistargeting.

Several studies have reported the use of CEUS for local ablation. CEUS has proved beneficial in localizing invisible lesions and monitoring the ablation zone, thereby increasing the efficacy and local tumor control of the ablation procedure [47-52]. CEUS can also directly detect vascular complications including active bleeding by visualizing the extravasation of the contrast agents [47,52]. However, the injection of contrast agents can reduce the visualization of the electrode because of the decreased contrast between the electrode and the enhanced liver parenchyma [52]. In this situation, the combination of CEUS and the aforementioned intermodality fusion technique can effectively and safely treat lesions with poor visibility [43,48-50,52].

Artificial ascites and pleural effusion can be introduced for lesions in areas of poor sonic window due to lung or bowel shadows or in areas in which ablation is dangerous due to other adjacent abdominal organs [53,54]. This can improve the sonic window and separate other organs from the ablation site, thereby enhancing the technical feasibility and reducing major complications [55,56]. It can also reduce pain caused by thermal injury to the abdominal wall after ablation of subcapsular tumors [57]. However, in patients with previous surgery or trauma, the introduction of artificial ascites or pleural effusion may be difficult because of severe adhesions.

In summary, the intermodality fusion technique, CEUS, artificial ascites, and pleural effusion can increase the overall technical feasibility of the ablation procedure, thereby enhancing the technical outcomes. Nevertheless, these techniques have limitations in challenging cases and further attempts should be made to overcome these limitations.

Conflicts of Interest

Jeong Min Lee, Min Woo Lee, and Young Joon Lee, contributing editors of the *Korean Journal of Radiology*, were not involved in the editorial evaluation or decision to publish this article. Jeong Min Lee reports grants from Philips Healthcare, grants from GE Healthcare, grants from CMS, grants from Guerbet, grants from Samsung Medison, grants from Bracco, personal fees from Bayer Healthcare, personal fees from Siemens Healthineer, personal fees from Samsung Medison, personal fees from Guerbet, outside the submitted work. Min Woo Lee reports personal fees from STARmed outside the submitted work. All remaining authors have declared no conflicts of interest.

Author Contributions

Conceptualization: Min Woo Lee, Jeong Min Lee. Funding acquisition: Jeong Min Lee. Writing—original draft: Seungchul Han, Min Woo Lee. Writing—review & editing: all authors.

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