MR-Guided Microwave Ablation of Hepatocellular Carcinoma (HCC): Is General Anesthesia More Effective than Local Anesthesia?

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Research article

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Abstract

Background

Percutaneous MR-guided MWA procedures have traditionally been performed under local anesthesia(LA) and sedation. However, pain control is often difficult to manage, especially in some cases when the tumor is large or in a specific location, such as near the abdominal wall or close to the hepatic dome. Does different anesthesia methods could lead to different clinical outcomes? This study retrospectively compared the results of general anesthesia (GA) and local anesthesia (LA) for MR-guided microwave ablation (MWA) in patients with hepatocellular carcinoma (HCC≤5.0 cm).

Methods

The results of the analysis include procedure-related complications, imaging response, and the time consumed by the two sets of procedures. According to the type of anesthesia, the Kaplan-Meier method was used to compare the local tumor progression (LTP) of two groups who underwent MR-guided MWA.

Results

All patients achieved technical success. The mean ablation duration of each patients in the procedure of GA-group and LA-group were statistical difference(P=0.012). The both group have no difference in complications and LTP (both P[illegible]0.05). Of note, the tumor location (challenging locations) and the number of lesions (2-3 lesions) could be the main factors affecting LTP (p = 0.000, p = 0.015). Univariate Cox proportional hazard regression indicated that using different anesthesia methods (GA and LA) were not associated with longer LTP(P = 0.632 and P = 0.633, respectively) , while tumor location (challenging locations) and the number of lesions (2-3 lesions) were all related to shorter LTP(P=0.000,P=0.020,respectively). Additionally, Multivariate Cox regression further revealed that the tumor location (regular locations) and the number of lesions (single) could independently predict better LTP (both P <0.005).

Conclusions

There could be no correlation between GA and LA for LTP after MRI-guided MWA. However, tumor in challenging location and the number of lesions (2-3 lesions) seem to be the main factors affecting LTP.

Background

The treatments for early hepatocellular carcinoma (HCC) include liver transplantation, surgical resection, and local ablation. However, due to the high cost and shortage of donor's livers, many patients are not candidates for these radical treatment options[1, 2]. Therefore, most centers regard thermal ablation as the main treatment for early-stage HCC[3, 4, 5]. Recently, MR-guided thermal ablation has been used in all aspects of tumors and has shown favorable technical feasibility and treatment safety[6, 7, 8]. Most MR-guided minimally invasive treatments are performed under local anesthesia(LA). Although the treatment process under LA is more economical and speeds up the procedure and the patients' recovery, the MR-guided ablation process has a long scanning time and severe noise, which greatly affects the patient's treatment experience. Furthermore, due to the magnetic field design of closed-loop, some patients cannot guarantee the entire procedure in a small space. Therefore, general anesthesia(GA) may be a better choice for MR-guided treatment. It can improve the comfort of the patient during the procedure, and ensure the effective implementation of the entire process. Moreover, studies have shown that the choice of anesthesia may affect the clinical prognosis of patients with malignant tumors[9]. In fact, tumor recurrence involves many causes, and anesthesia methods and anesthetics have recently attracted widespread attention[10, 11].

Currently, there is no data have previously been presented that compare tumor recurrence rate of GA or LA in MR-guided MWA treatment. This study explored the relationship between anesthesia techniques (GA and LA) and local tumor progression, and tried to establish a regression model to further determine the effect of GA on tumor prognosis. The results of the study are summarized as follows.

Methods

Patients

This was a retrospective cohort study conducted in a single center approved by the institutional review board. In this retrospective study, we included 34 patients (53.4 ± 7.5 years; range 42–67 years) who received GA for MR-guided MWA, and 38 patients (52.1 ± 8.5, range 43–69 years) who received LA for MR-guided MWA(Table 1). The inclusion and exclusion criteria are listed in (Table 2).

Table 1
Patient characteristics

Characteristics	GA group (*n* = 34)	LA group (*n* = 38)	*P* value
Age	53.4 ± 7.5	52.1 ± 8.5	0.254‡
Sex			0.149*
Male	24	20	
Female	10	18	
ECOG performance status			1.000*
0	27	30	
1	7	8	
Etiology			0.487§
Hepatitis B	5	3	
Hepatitis C	19	25	
Alcohol	8	6	
Unknown	2	4	
Child–Pugh class			1.000*
A	20	23	
B	14	15	
Location of tumour			1.000*
Challenging locations	17	18	
Other parts	17	20	
AFP level(ng)			0.808*
<200	21	25	
>200	13	13	
Tumour diameter			1.000*

Note.—Unless indicated, data are numbers of patients, and numbers in parentheses are percentages. ECOG = Eastern Cooperative Oncology Group. Note—general anesthesia (GA) and local anesthesia (LA) ; Challenging locations(Hepatic dome, Close to the heart/diaphragm/hepatic hilum)

*Pearson χ2 test was used. §Fisher exact test was used.

Characteristics	GA group (*n* = 34)	LA group (*n* = 38)	*P* value
< 3cm	18	20	
3⩾cm,<5cm	16	18	
Tumour number			0.633*
Single(1)	22	25	
2	7	10	
> 3	5	3	
Duration of procedure (min)	128.7 ± 40.3	90.8 ± 33.3	0.003‡
Generator power (wt)	55.5 ± 5.6	50.7 ± 6.1	0.012‡
Note.—Unless indicated, data are numbers of patients, and numbers in parentheses are percentages. ECOG = Eastern Cooperative Oncology Group. Note—general anesthesia (GA) and local anesthesia (LA) ; Challenging locations(Hepatic dome, Close to the heart/diaphragm/hepatic hilum)			
*Pearson χ2 test was used. §Fisher exact test was used.			

Table 2
Inclusion and exclusion criteria

Inclusion criteria	Exclusion criteria
1 Age range: 18–75 years	Age < 18 or > 75 years
2 HCC diagnosed according to EASL standards	No pathology or image evidence
3 Child–Pugh grade A or B	Child–Pugh grade C
3 BCLC grades are A and B	BCLC grades are C
4 ECOG score ≦ 2	ECOG score>2
4 Liver lesions ≤ 3	The liver lesions number>3
5 Single tumour diameter < 5 cm	Single tumour diameter ≧ 5
6 The expected survival time >3 months	The expected survival time ≤ 3 months
7 No portal vein thrombus	Portal vein thrombus
8 No extrahepatic metastases	Extrahepatic metastases
9 PLT >40 × 109/L or PT ≤ 25 s	PLT ≤ 40 × 109/L or PT >25 s

European Association for the Study of the Liver, EASL; Eastern Cooperative Oncology Group, ECOG; platelet, PLT; prothrombin time: PT; HCC, small hepatocellular carcinoma

Anesthesia Mode

Patients need sedation, laryngeal mask insertion and hemodynamic monitoring during general anesthesia. The GA group was given propofol, midazolam, fentanyl/sufentanil to complete anesthesia induction and received laryngeal mask placement and mechanical ventilation. All patients lost consciousness during the procedure. Use sevoflurane and/or propofol to maintain GA management. The patient recovered in the Post-Anaesthesia Care Unit (PACU) and was treated with sufentanil or non-steroidal antiinflammatory drugs (NSAIDs) for post-operative pain. In the LA group, less than 10 mL of 2% lidocaine was injected subcutaneously at the puncture point. When the patient experienced unbearable pain again during the treatment process, NSAIDs could be used to complete intraoperative pain management. The patient was awake and breathed spontaneously during the operation. The placement of MR and anesthesia equipment during treatment was shown in **(Fig. 1)**

Procedure

The patient’s position was determined according to the preoperative puncture plan on CT/MR. Routine electrocardiogram and oxygen saturation monitoring (Invivo, Orlando, USA) and an ECO-100E MR-compatible MWA system were placed at a distance of 3 meters next to the MR-compatible operating table. All procedures were performed by an alternating team of two trained interventional radiologists with 6–10 years of experience in ablation procedures. After marking with the cod liver oil capsule matrix on the body surface, a standard MR protocol was carried out to locate intrahepatic lesions. Under the guidance of MR, a microwave probe (ECO-100AI13, 1.8 mm, 15 cm, Co., Ltd. Nanjing, China) was inserted into the tumor center, and multiple scans were carried out to confirm that the applicator tip was beyond the distal tumor 0.5–1 cm. Additionally, the tumor at each site was ablated with 45–65 wt for 4–9 mins **(Fig. 2)**. During ablation, a series of monitoring T2 Haste and T1 Vibe sequences were performed continuously to monitor the ablated scope every 16 s. If MR showed that the ablation area did not cover 110% of the lesion, the probe was requisitioned, and multiple overlapping ablations were needed. The MR scanning sequences and parameters used in our study are listed in (Table 3**).**

Table 3
MR scanning sequences and parameters

Section	Sequence	TE (ms)	TR (ms)	Slice thicknes (mm)	Matrix	Flip angle	Band Width (Hz/pixel)
Transverse section	T1 Vive	1.93	4.56	3.3	216×288	9.0	400
Transverse section	T2 Haste	106	1000	4.5	137×256	180	781
Transverse section	Diffusion	83	7100	5.0	192×144	90	1670
Coronal section	T1 vibe	2.46	6.11	3.0	179×256	9.0	410
Sagittal	T2 Haste	106	1000	4.0	137×256	180	781

Definitions

Local tumour progression is defined as the appearance of tumour foci at the edge of the ablation zone after at least one contrast-enhanced follow-up study has documented adequate ablation and an absence of viable tissue in the target tumour and surrounding ablation margin by using imaging criteria. The ablation evaluation standards were based on the modified response evaluation criteria in solid tumours RECIST guidelines (version 1.1). Intervention-related complications were jointly evaluated according to the National Cancer Institute Common Terminology Criteria for Adverse Events (CTCAE Version 4.03) and Society of Interventional Radiology (SIR) classification system.

Follow Up

Electronic medical records were reviewed to collect pre- and posttreatment laboratory results and information on treatment-related complications. Imaging follow-up was performed with contrast-enhanced MR or CT at intervals of 1, 3, and 6 months with a 6-month interval for follow-up thereafter. All post-procedure and follow-up images were reviewed for consensus between a senior radiology resident and a board-certified interventional radiology faculty member with 5 years of experience in oncologic imaging and interventions. If tumor recurrence was found during the period, a second TACE-MWA or MWA procedure was performed separately depending on the patient's condition. The patients were followed up to April 2020 or until death.

Results

Patient Characteristics

A total of 72 patients with HCC ≤ 5.0 cm were included in the present study (GA-group, n = 34; LA-group, n = 38). There were no significant differences in age, gender, ECOG score, etiology, Child–Pugh classification, tumor location, and tumor diameter between the two types of anesthesia. Patients in the GA-group and in the LA-group, the mean energy of each tumor was 55.5 ± 5.6 wt and 50.7 ± 6.1 wt, respectively. The mean ablation duration of each patients in the procedure of GA-group and LA-group were 128.7 ± 40.3 and 90.8 ± 33.3, respectively, and the difference between the two groups was statistically significant ($P = 0.012$).

Safety and Complication

Postoperative pain, fever (with/without treatment) were the most common adverse events after treatment (Table 4). With four exceptions, all adverse events and complications were CTCAE grade 1 or 2 (mild symptoms, no or local/noninvasive intervention indicated), or interventional radiology society Grade A or B (no or nominal treatment, no consequences). Of the exceptions, The incidence of liver abscess, asymptomatic perihepatic fluid, pleural effusion and subcapsular hepatic hemorrhage under GA group were 1(3%), 1(3%), 2(6%) and 1(3%), respectively. Corresponding to the LA group complication rate were 2(5%), 1(3%), 1(3%) and 1(3%), respectively. Of note, there are no statistical differences between the two anesthesia methods. Secondly, patients with sub-hepatic hemorrhage need to undergo interventional embolization; patients with pleural effusion need to be treated with auxiliary thoracic drainage, and these complications will undoubtedly prolong the patient's hospital stay. None of the patients had life-threatening complications during or after treatment.

Table 4
Adverse events and complications

Categories	GA group (n = 34)		LA group (n = 38)		*P*
	Grades				
Adverse events	**CTCAE**		**CTCAE**		
Fever, maximum 38°C, no treatment		4(12)		6(16)	0.740*
Fever, > 38°C,treatment		22(65)		25(66)	1.000*
Nausea or vomiting		5(15)		3(8)	0.463§
Mild pain, requiring nonopioid oral analgesic treatment		17(50)		13(34)	0.233*
Moderate pain, requiring opioid oral analgesic treatment		10(29)		9(24)	0.604*
Mild liver dysfunction, requiring conservative treatment		12(35)		9(24)	0.310*
complications					
Liver abscess		1(3)		2(5)	1.000§
Asymptomatic perihepatic fluid		1(3)		1(3)	1.000§
pleural effusion		2(6)		1(3)	0.599§
Subcapsular liver hemorrhage		1(3)		1(3)	1.000§
National Cancer Institute Common Terminology Criteria for Adverse Event (CTCAE version 4.03)					
Society of Interventional Radiology (SIR) classification system for Complications. Data are numbers of events. Data in parentheses are percentages.					
Note—general anesthesia (GA) and local anesthesia (LA) .Data are numbers of events. Data in parentheses are percentages. *Pearson χ2 test was used. §Fisher exact test was used.					

Local Tumor Progression

Comparison of local tumor progression (LTP) after MWA under local anesthesia(LA) and general anesthesia(GA). The mean LTP was 33.434 months (95% CI: 31.133, 35.734) in GA versus 31.132 months (95% CI: 28.535, 33.730) in LA ($p = 0.230$, log-rank test). The 12-, 24-, and 36-month LTP rates in GA were 94.1%, 87.9% and 74.4%, respectively, and the 12-, 24-, and 36-month LTP rates in LA were 94.7%,84.2% and 62.1%, respectively **(Fig. 3A)**. Comparison of different anesthesia methods on LTP of tumor in challenging locations. The mean LTP was 32.055 months (95% CI: 28.973, 35.138) in GA versus 26.551

months (95% CI: 22.049, 31.053) in LA (*p* = 0.180, log-rank test). The 12-, 24-, and 36-month LTP rates in GA were 100.0%, 76.0% and 48.4%, respectively, and the 12-, 24-, and 36-month LTP rates in LA were 88.9%,66.7% and 35.4%, respectively **(Fig. 3B)**.

Factors Affecting Ltp

Univariate Cox proportional hazard regression indicated that using different anesthesia methods (GA and LA) were not associated with longer LTP(P = 0.237), while tumor location (challenging locations) and the number of lesions (2–3 lesions) were all related to shorter LTP (*P* = 0.000 and *P* = 0.020, respectively). Additionally, Multivariate Cox regression further revealed that the tumor location (regular locations) and the number of lesions (single) can independently predict better LTP (both *P* < 0.005)**(**Table 5**)**. More specifically, The mean LTP was 35.533 months (95% CI:34.903, 36.162) in regular locations versus 28.607 months (95% CI: 25.423, 31.792) in challenging locations (*p* = 0.000, log-rank test). The 12-, 24-, and 36-month LTP rates in tumor with regular locations were 100.0%, 100.0% and 91.6%, respectively, and the12-, 24-, and 36-month LTP rates in tumor with challenging locations were 88.6%,71.2% and 40.2%, respectively **(Fig. 4A)**; The mean LTP was 33.111 months (95% CI: 31.147, 35.075) for procedures with a single lesion versus 30.424 months (95% CI: 26.992, 33.855) for procedures with 2–3 lesions (*p* = 0.015, log-rank test). The 12-, 24-, and 36-month LTP-free survival rates in patients with a single lesion were 97.9%, 87.0% and 77.8%, respectively, and the 12-, 24-, and 36-month LTP-free survival rates in patients with 2–3 lesions were 88.0%,84.0% and 47.6%, respectively**(Fig. 4B)**.

Table 5
Factors affecting LTP

Parameters	**LTP**			***P***	**LTP**			***P***
	HR	***95%*CI**			**HR**	***95%*CI**		
		Univariate Cox's regression				Multivariate Cox's regression		
		Lower	Higher			Lower	Higher	
Age (> 60 vs ≤ 60)	0.811	0.330	1.989	0.647	.862	0.336	2.209	0.757
AFP (> 200 vs ≤ 200ng/mL)	1.422	0.614	3.295	0.411	2.230	0.912	5.450	0.079
Tumour diameter (3⩾,<5 vs < 3cm)	0.783	0.334	1.832	0.572	2.766	0.787	9.722	0.113
Tumour location (challenging locations vs regular locations)	35.832	10.530	3.095	**0.000**	27.843	5.718	135.571	**0.000**
Number of lesion (single VS 2–3 lesions)	2.712	1.169	6.294	**0.020**	4.615	1.571	13.556	**0.005**
Child–Pugh stage (A vs B)	1.456	0.629	3.373	0.380	1.668	0.539	5.156	0.375
Anesthesia(GA VS LA)	1.690	0.709	4.032	0.237	2.465	1.003	6.061	0.049

Note—general anesthesia (GA) and local anesthesia (LA) ; Challenging locations(Hepatic dome, Close to the heart/diaphragm/hepatic hilum)

Discussion

Radiofrequency ablation (RFA) and microwave ablation (MWA) are the most commonly used thermal ablation methods for hepatic malignancies. In comparison with RFA, MWA can bring the target lesion to a higher temperature in a shorter period, which allows for the production of a larger ablation zone, thereby reducing the procedure duration. Percutaneous MR-guided MWA procedures have traditionally been performed under local anesthesia(LA) and sedation. However, pain control is often difficult to manage, especially in some cases when the tumor is large or in a specific location, such as near the abdominal wall or close to the hepatic dome. If intraoperative pain is not well controlled, interventional procedure will inevitably be affected. Additionally, LA may affect respiratory activity and cause complications related to anesthesia, such as respiratory depression or respiratory arrest. Furthermore, due to the claustrophobic environment and intense noise in the MRI room, some patients have to experienced severe anxiety and insecurity, preventing the completion of the procedure, which also leads to an insufficient tumor ablation area. In fact, there may be significant differences in the rate of local recurrence between patients who have reached a sufficient ablation area and those who have not. Therefore, it is essential to ensure adequate tumor ablation during MRI-guided MWA to optimize the treatment effect. As a preferred alternative to LA, general anesthesia (GA) can cause deeper sedation and better analgesia in patients undergoing MWA procedure in the MRI room. In the course of this study, it was found that intravenous GA could ensure more stable hemodynamics, but there was no statistical difference in postoperative complications between the two anesthesia.

Some studies have shown that different anesthesia may affect the long-term results of cancer treatment[12, 13]. The retrospective analysis of Lai et al[14]. believed that treatment of small HCC with RFA under GA is associated with reducing the risk of cancer recurrence. Moreover, the study by Wang et al further revealed that the use of GA in the management of thermal ablation, anesthesia could significantly improve the survival time of patients[15]. In these studies, GA may have had a small and temporary effect on suppression of NK cell cytotoxicity (NKCC)[16]. MWA under LA are often painful because of referred pain which may force the physician to decrease the current intensity, shorten the coagulation duration, or to limit the number of overlapping coagulations[17]. Additionally, another advantage of GA is that systolic blood pressure can be reduced, with the goal of decreasing hepatic blood flow and increasing coagulation diameter[18]. And all of the above may account for this results. However, in this research that the difference of anesthesia did not seem to have an impact on the local tumor progression(LTP) rate of patients ($P = 0.230$). Moreover, the research conducted a stratified study on the LTP of HCC in challenging sites, and got a similar conclusion ($P = 0.180$). In fact, multivariate Cox regression revealed that the tumor location (regular locations) and the number of lesions (single) could independently predict better LTP ($P < 0.005$). Therefore, during the limited follow-up period, MR-guided MWA under different anesthesia methods did not seem to have significant effect on LTP.

There are several limitations of our research. First, the real-time MR thermometry technique was not used in this study due to software limitations. Second, the cost of MRI-guided ablation treatment under general anesthesia is much higher than that of local anesthesia, which is unacceptable for ordinary patients. Third, although the local complications of the ablation process in patients under GA are less, the rate of the LTP between the two groups is equivalent, which should be an acceptable result. And could be provide a reference for the selection of anesthesia methods for ablation therapy under the guidance of magnetic resonance in the future. Finally, this is a single-center retrospective study involving a small number of cases, which may have led to biased results. Thus, further studies need to be combined with prospective multicenter studies and extend the follow-up period to reduce the risk of bias.

Conclusions

Different anesthesia methods seem to have no significant effect on treatment-related complications and LTP in HCC (≤ 5.0 cm). Secondly, the number of lesions(Single) and tumor location (regular locations) may be associated with favorable LTP. However, Prospective trials exploring the effects of different anesthetic methods on cancer outcome in these patients are warranted.

Abbreviations

LA Local anesthesia

GA General anesthesia

MR Magnetic resonance

CT Computed tomography

MWA Microwave ablation

HCC Hepatocellular carcinoma

PACU Post-Anaesthesia Care Unit

NSAIDs Non-steroidal antiinflammatory drugs

EASL European Association for the Study of the Liver

AASLD American Association for the Study of Liver Diseases

LTP Local tumor progression

RECIST Modified response evaluation criteria in solid tumours

CTCAE National Cancer Institute Common Terminology Criteria for Adverse Events

SIR Society of Interventional Radiology

RFA Radiofrequency ablation

CA Cryoablation

NKCC NK cell cytotoxicity

AFP Alpha-fetoprotein

Declarations

Ethics approval and consent to participate

This retrospective study was approved by the institutional review board of the First Affiliated Hospital of Zhengzhou University. All participants gave written informed consent that their data can be used for scientific purposes.

Consent for publication

Not applicable.

Availability of data and materials

The datasets generated for this study are available on request to the corresponding author.

Competing interests

The authors of this manuscript declare no relationships with any companies whose products or services may be related to the subject matter of the article.

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Author Contributions

ZL: primary investigator, involved in study planning, data collection, data analysis and interpretation, and manuscript writing. CW, XZ, GS, YL, and JL: involved in study planning, data collection, data analysis and interpretation, and proofreading of manuscript. DC and XH: involved in study planning, data collection, data analysis and interpretation, manuscript writing, and proofreading of manuscript. All authors provided approval for publication of the content.

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Figures

Figure 1

Magnetic resonance imaging and placement of anesthesia equipment during treatment

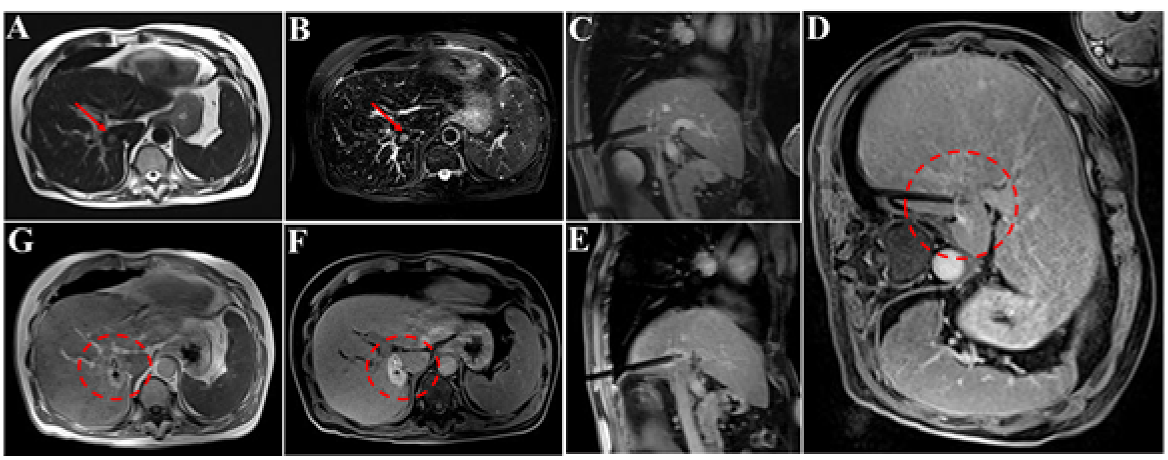

Figure 2

A patient completed MR-guided MWA treatment under general anesthesia. (A-B) The liver caudate lobe (red arrow) has a diameter of 17 mm and appears as hyper-intensity on T2-weighted transverse images before MWA. (C-E) The trajectory of the tilting puncture were adjusted gradually for the lesion target under the guidance of T1WI and the image shows precise insertion of the antenna into the target.(F) After one day of MWA, magnetic resonance reexamination found the treatment border covered the lesion completely as hyperintensity on T1WI (dashed circle). (G) Follow-up for 1 month, the lesion (red arrow) was completely ablated.

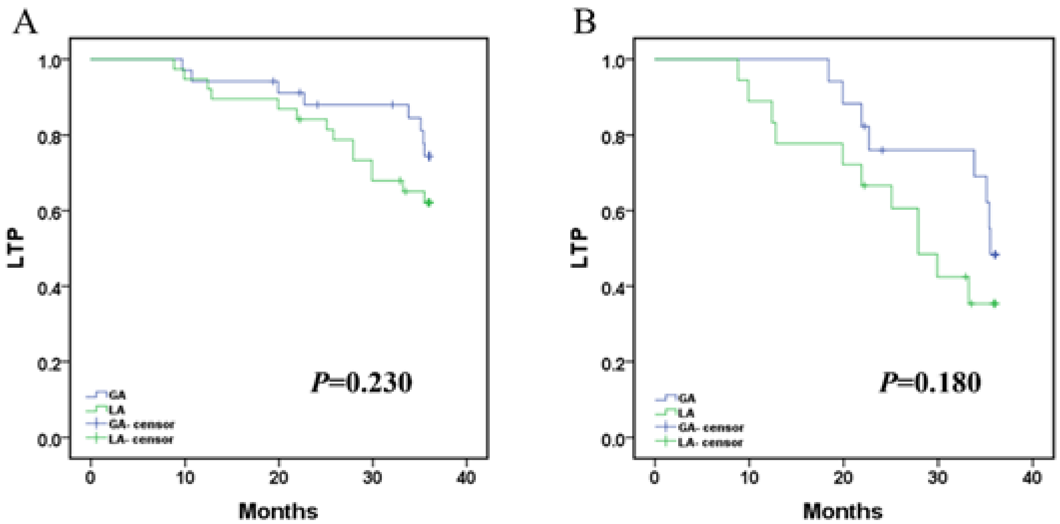

Figure 3

A. Comparison of local tumor progression (LTP) after ablation under local anesthesia(LA) and general anesthesia(GA). The mean LTP was 33.434 months (95% CI: 31.133, 35.734) in GA versus 31.132 months (95% CI: 28.535, 33.730) in LA (p = 0.230, log-rank test). The 12-, 24-, and 36-month LTP rates in GA were 94.1%, 87.9% and 74.4% , respectively, and the 12-, 24-, and 36-month LTP rates in LA were 94.7%,84.2% and 62.1% , respectively. B. Comparison of different anesthesia methods on LTP of tumour in challenging locations. The mean LTP was 32.055 months (95% CI: 28.973, 35.138) in GA versus 26.551 months (95% CI: 22.049, 31.053) in LA (p = 0.180, log-rank test). The 12-, 24-, and 36-month LTP rates in GA were 100.0%, 76.0% and 48.4% , respectively, and the 12-, 24-, and 36-month LTP rates in LA were 88.9%,66.7% and 35.4% , respectively.(Note: challenging locations–Hepatic dome, close to the heart/diaphragm/hepatic hilum).

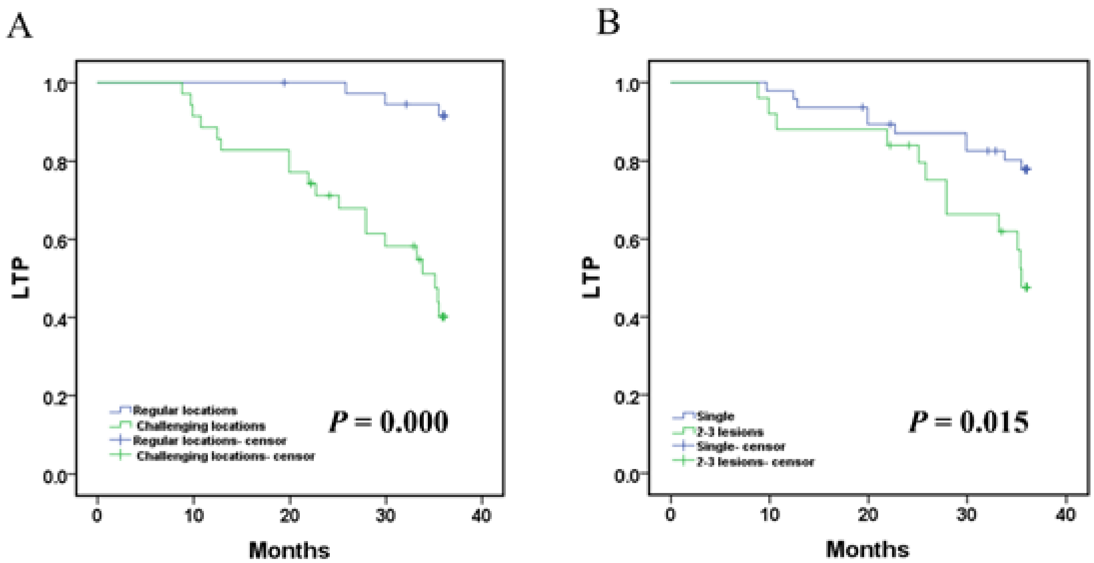

Figure 4

A. Comparison of local tumour progression (LTP) between tumour in regular locations and challenging locations after MR-guided MWA treatment. The mean LTP was 35.533 months (95% CI:34.903, 36.162) in regular locations versus 28.607 months (95% CI: 25.423, 31.792) in challenging locations (p = 0.000, log-rank test). The 12-, 24-, and 36-month LTP rates in tumor with regular locations were 100.0%, 100.0% and 91.6% , respectively, and the12-, 24-, and 36-month LTP rates in tumor with challenging locations were 88.6%,71.2% and 40.2% , respectively; B. Comparison of local tumour progression (LTP) between single tumours and multiple tumours (2-3 lesions) after MR-guided MWA treatment. The mean LTP was 33.111 months (95% CI: 31.147, 35.075) for procedures with a single lesion versus 30.424 months (95% CI: 26.992, 33.855) for procedures with 2-3 lesions (p = 0.015, log-rank test). The 12-, 24-, and 36-month LTP-free survival rates in patients with a single lesion were 97.9%, 87.0% and 77.8% , respectively, and the 12-, 24-, and 36-month LTP-free survival rates in patients with 2-3 lesions were 88.0%,84.0% and 47.6% , respectively. (Note: challenging locations–Hepatic dome, close to the heart/diaphragm/hepatic hilum)