INTRODUCTION

Hepatocellular carcinoma (HCC) is considered to be the sixth most common cancer worldwide and the fourth deadliest cancer accounting for 782 000 deaths/y. In 2018, the incidence rate of liver cancer was 9.3 per 100 000 person-years with a similar death rate. The treatments considered as curative are liver resection, liver transplantation and percutaneous ablation with a 5-year survival rate ranging from 60% to 80%. The most frequent techniques used in percutaneous treatments are radiofrequency ablation (RFA), microwave ablation (MWA), cryoablation (CA) and irreversible electroporation (IRE). The first enlisted

Abstract

The main curative treatments of early hepatocellular carcinoma (HCC) are liver resection, liver transplantation and percutaneous ablation. Monopolar radiofrequency ablation (RFA) was the most widely used percutaneous treatment but has limitations in terms of applicability and efficacy. These limitations could be responsible for downgrading the treatment of early HCC not amenable to usual monopolar RFA, transplantation or resection and to a shift to palliative treatment. However, improvement in ablation techniques during the last 10 years including the development of microwave ablation, multibipolar RFA, irreversible electroporation but also new technical tricks for ablation allowed to optimize the efficacy and promote the wide application of percutaneous treatments in patients with early HCC. It helped also to explore the ability of percutaneous ablation to treat HCC outside current guidelines in order to ablate more lesions of larger sizes. In this review, we aim to describe how the improvement of ablation methods helps to maximize the number of patients treated for early HCC and to discuss if we could extend the usual ablation criteria in order to allocate more patients in a curative setting.

KEYWORDS

irreversible electroporation, microwave ablation, percutaneous treatment, primary liver cancer, radiofrequency ablation
(RFA, MWA and CA) are based on thermal ablation with either heating (RFA and MWA) or freezing (CA) the tumour. In contrast, IRE is a mainly non-thermal ablation method generating short electric pulses of high intensity between two electrodes that have the advantage to decrease the risk of injury of the adjacent structure.\(^6\)

Thermal percutaneous ablation has been widely used since the beginning of the 2000s initially to treat patients with small uni-nodular HCC of <3 cm not amenable to liver resection or liver transplantation. Progressively, more data have shown that RFA could compete with liver resection in front of a small tumour and new technical approaches have enlarged the indication of ablation in patients with HCC.\(^7,8\) In the present review, we aimed to describe briefly the current state of the art regarding the percutaneous treatments for HCC thus focusing on the role of percutaneous ablation in specific clinical situations and finally discuss the extension of ablation criteria.

### 1.1 | Current indications and related outcomes after ablation for HCC

Thermal percutaneous ablation, mainly monopolar RFA, has replaced percutaneous ethanol injection after several randomized controlled trials showing a better local control rate for RFA in all studies and increased overall survival (OS) in two of them. Currently, monopolar RFA is considered the standard for percutaneous ablation and was safely used to treat patients with portal hypertension and/or mild liver failure that are classical contra-indication to liver resection. The OS varies between 40% and 70% at 5 years with 50%-80% of tumour recurrence at 5 years after ablation of HCC within Milan criteria.\(^9,11\) In patients harbouring HCC with a diameter of <2-3 cm with good performance status, without portal hypertension and with a preserved liver function, surgical resection and RFA could be both considered as equivalent as first-line therapy.\(^9,12\) In contrast, for larger nodules (>2-3 cm), the results of RFA are less performant because of the decreased local control rate with usual monopolar RFA because of the difficulty to achieve a sufficient ablation area with a peritumoural margin.\(^13\) A comparison between surgery and locoregional treatments has been often questioned considering that the indication of one treatment above the other is influenced by patients’ comorbidities, tumour burden, liver function and presence of portal hypertension. Some retrospective studies suggested that the two treatments were comparable for nodules <2-3 cm.\(^9,12\) Three randomized controlled trials have compared monopolar RFA to resection in the treatment of HCC; one of these trials showed an advantage for resection in terms of OS, whereas the two others showed no difference in terms of oncological outcomes between the two procedures. RFA was associated with less morbidity than surgery in all trials.\(^14-16\)

To note, these clinical trials were monocentric, only performed in Asia, where the rate of cirrhosis was lower than in Western countries and have several biases impairing their conclusions.\(^17\)

A meta-analysis with a Markov model, including 17 studies and comparing resection and RFA for early HCC, suggested that in patients with two or three nodules lesser than 3 cm, RFA was more cost-effective than resection. In contrast, for a single HCC between 3 and 5 cm surgical resection was considered as the best option.\(^18\) Monopolar RFA has been compared to MWA in several trials for the treatment of HCC and a recent meta-analysis showed that despite a similar local recurrence rate, the distant recurrence rate was significantly lower in the MWA group. Moreover, disease-free survival at 5 years was higher in patients treated by MWA (risk ratio = 3.66, CI 95% = 1.32-42.27) compared to RFA.\(^19\)

Currently, European Association for the Study of the Liver (EASL) guidelines suggest that both percutaneous ablation and surgery could be used in HCC of <2 cm and then surgery should be proposed when possible in case of HCC > 2 cm.\(^3,14-16\) When facing patients eligible for both percutaneous ablation and liver transplantation, liver transplantation is frequently considered as the best treatment as it cured both the tumour and the cirrhosis. However, graft shortage and the increased time on the waiting list led to propose a different strategy with first-line ablation followed by salvage transplantation if tumour recurred. This strategy tested in 67 patients was associated with an 84% of OS and 58% of tumour recurrence at 5 years and allowed to avoid liver transplantation in 27 patients that were alive without tumour recurrence.\(^20\) A more recent study analyzed 301 transplantable patients undergoing monopolar RFA as the first treatment. The 1-, 3- and 5-year survival rates after RFA were 98.2%, 86.2% and 79.0% in the HCC ≤ 2 cm group vs 93.3%, 77.6% and 70.9% in the HCC > 2 cm group. The size, larger than 2 cm, and alpha-fetoprotein levels were predictors of post-RFA recurrence in patients outside Milan criteria.\(^21\) Overall, it seems that a proportion of patients could avoid liver transplantation after a first curative percutaneous ablation, even if this strategy remains to be better assessed in long term and the target population needs to be refined.

Other percutaneous approaches have been proposed for local ablation of HCC such as laser ablation (LA) and CA. One randomized trial testing non-inferiority has compared RFA with LA in patients within Milan criteria and suggested that LA was not inferior to RFA in terms of tumour ablation, time to local progression and OS.\(^22\) This technique has been tested also in solitary large HCCs (>40 mm) in comparison with TACE and the results of this pilot case–control study showed superiority of LA especially in nodules between 51 and 60 mm with a complete response rate post-LA and post-TACE of 75% and 14.3%, respectively, associated with a higher OS (55.4% vs 48.8% at 36 months).\(^23\) Moreover, CA was compared to RFA on patients affected by HCC smaller than 40 mm in a multicentre randomized controlled trial performed in China. In this study, local tumour progression rates were lower after CA (3%, 7% and 7% at 1, 2 and 3 years) than after RFA (9%, 11% and 11% at 1, 2 and 3 years) with similar 5-year OS rate.\(^24\)

These two techniques have encouraging results but required more data on long-term oncological outcomes.\(^3,7\)

### 1.2 | Limitations of classical technic of percutaneous monopolar RFA: Efficacy, applicability and consequences in clinical practice

Two major types of limitations exist using the classical monopolar RFA: limitations in terms of efficacy (leading to the risk of treatment...
1.2.1 | Efficacy

The limitations of the classical monopolar RFA are related to the decrease of temperature together with the distance from the electrode (usually 2-3 cm from the needle) or when blood flow is present in the vicinity of the tumour. Firstly, percutaneous ablation is associated with a risk of local recurrence that is related to an insufficient ablation of the target tumour and its peri-tumoural margins and/or because of tumour aggressiveness. The rate of local recurrence can reach up to 21%-30% and, even if most patients could be ablated again, it required additional procedures and, in some cases, the local recurrence could be aggressive and not amenable to another curative treatments. Moreover, if monopolar RFA is able to ablate tumour between 2 and 3 cm, its ability to ablate larger tumours remains variable because of an insufficient thermal effect leading to a non-predictable ablation area. Finally, several studies have underlined that thermal ablation of tumours at the vicinity of major vessels was less effective in terms of complete ablation and has a higher risk of local tumour recurrence owing to the decrease of temperature induced by the blood flow, the so-called heat sink effect. In this line, a retrospective analysis on 283 patients has compared liver resection to monopolar RFA to treat HCC located at the vicinity of vascular structures. Liver resection showed a better outcome than monopolar RFA with longer progression-free survival (PFS) and OS. PFS at 5 years was 58.0% for liver resection vs 25.4% for RFA, with an OS rate at 5 years of 93.5% vs 82.3% after resection and RFA, respectively.

The type of tumour recurrence should also be categorized: local and distant recurrence as well as the aggressiveness of tumour recurrence (size, number, infiltrating form, portal invasion and metastasis) as it could impact survival.

1.2.2 | Applicability

Limitations restraining the applicability of usual monopolar RFA were related either to the location of the tumour or to the general conditions of the patients. Limitations due to the location include HCC not visible at ultrasonography and at-risk locations such as subcapsular HCC (because of the risk of bleeding and tumour seeding), subdiaphragmatic HCC (because of the risk of diaphragmatic lesions), HCC close to biliary structure or gallbladder (because of the risk of thermal-induced lesions) or HCC close to the colon or stomach (because of the risk of perforation). The limitations related to the patients were the presence of biliary anastomosis or sphincterotomy (which comprise a risk of subsequent biliary abscess), thrombocytopenia (owing to the risk of bleeding), liver function (that could be deteriorated by the ablation) and the presence of pacemakers (because of the risk of interference).

1.2.3 | Consequences in clinical practice: The drift to non-curative treatments

Firstly, the limitations highlighted above decrease the possibility to extend the ablation criteria outside the classical indications proposed by the guidelines. Moreover, the most important consequences of these limitations are the decrease in the use of percutaneous ablations in clinical practice in usual indications such as small HCC of <3 cm. It led to the shift to non-curative treatments such as trans-arterial chemoembolization (TACE), external radiotherapy or even sorafenib. Study showed that one-third of Barcelona Clinic Liver Cancer (BCLC) stage 0 or A patients did not receive curative treatment and were treated outside guidelines using palliative treatments mainly by TACE. As expected, a retrospective study showed that TACE for the treatment of BCLC 0 or A HCC was associated with a lower local control rate and lower survival than percutaneous RFA. Overall, undertreatment of these patients has a clear impact on long-term oncological outcomes. As only a limited proportion of these patients are amenable to liver transplantation or liver resection, the efficacy and the good safety profile of percutaneous ablation even in older patients, patients with comorbidities, patients with portal hypertension or mild liver failure make ablation a good option in order to widely treat patients with early HCC. Increasing the efficacy of percutaneous ablation and bypassing it limitations
will help to maximize the numbers of patients with HCC receiving a curative treatment.\textsuperscript{33}

\subsection{1.3 \hspace{1em} Improving efficacy}

Failure to achieve complete ablation and local tumour recurrence is mainly the consequence of the insufficient treatment of the tumours with insufficient margin together with the tumour aggressiveness. Several new ablation modalities have been developed to improve the efficacy of percutaneous treatments such as MWA or multibipolar radiofrequency ablation (mbp-RFA). MWA is a method of ablation that creates an electromagnetic field around a monopolar needle (centrifugal ablation), inducing heating and coagulation necrosis.\textsuperscript{34}

One of the advantages of MWA is to reach more quickly its target temperature than RFA allowing shorter ablation time. It has been advocated that MWA could ablate a larger area than RFA but, even if several retrospective studies report good long-term outcomes after treatment of early HCC with percutaneous MWA, its superiority to classical monopolar RFA remains unproven.\textsuperscript{34-36}

Multibipolar radiofrequency ablation consists of the insertion of several electrodes, up to six, in the periphery of the nodule and not in its centre. The needles can be positioned either into the lesion (intra-tumoral) or outside the lesion (No-Touch). The electrodes are activated by pair in alternance in order to deliver the energy in the whole tumour periphery, converging in the centre of the treatment zone (centripetal ablation), in order to better control the shape and the extent of the ablation area and increase ablation margin.\textsuperscript{37,38}

This technique has proved to be safe with a low rate of local tumour recurrence in HCC within Milan criteria with a 3- and 5-year local and overall tumour PFS of 96\%, 94\%, 52\% and 32\%, respectively.\textsuperscript{37}

Similar results were found also in large Asian cohorts of 516 patients reporting a high rate of complete ablation (99\%) with a 1-, 3- and 5-year OS of 99.42\%, 83.97\% and 68.42\%, respectively. The severe complication rate was 1.74\%.\textsuperscript{39}

Monopolar RFA and No-Touch mbp-RFA were compared in a retrospective study analyzing cirrhotic patients with a single HCC of <3 cm. Patients treated by monopolar RFA had a shorter time to recurrence compared to mbp-RFA with a tumour-free survival in the No-Touch mbp-RFA group significantly higher than monopolar RFA group.\textsuperscript{40}

Mbp-RFA has been also compared to surgical resection in nodules between 2 and 5 cm, resulting in higher morbidity in surgical group and a higher degree of local recurrence in mbp-RFA. However, tumour recurrences in the mbp-RFA arm were often accessible to re-treatment resulting in similar OS, 86.7\% vs 91.4\% at 3 years after mbp-RFA and resection respectively.\textsuperscript{41}
Data also suggested that mbp-RFA will be also helpful to treat tumours in the vicinity of major vessels. As this technic allows the placement of one or several electrodes between the tumour and the vessel, it seems to be less sensitive to the heat sink effect. Among 362 cirrhotic patients treated either by mbp-RFA or monopolar RFA with nodules <5 cm, the size >30 mm and the vicinity of large vessel were independent factors of local tumour progression only in patients treated by monopolar RFA and not in patients treated by mbp-RFA. Monopolar RFA and mbp-RFA were also compared in a multicentre retrospective trial in the treatment of HCC ≤ 5 cm abutting large vessels. The local tumour progression was 50.5% in monopolar RFA vs 16.3% in multi-bipolar RFA. Finally, a western monocentric study reported no difference in terms of local recurrence between liver resection and mbp-RFA for the treatment of single perivascular HCC between 2 and 5 cm. This data suggested that mbp-RFA could be used to treat efficiently HCC closed to major vessels.

1.4 | Improving applicability

1.4.1 | Thrombocytopenia

Thrombocytopenia due to hypersplenism and portal hypertension could be a limitation to ablative therapies due to the potential risk of bleeding. To note the exact impact of thrombocytopenia on the risk of bleeding in cirrhotic patients and the cut-off to identify the patients at risk is not well defined, even if platelet count below 50 000/mm³ was suggested by several authors. The peri-procedural transfusion of platelets is the most common strategy together with thermocoagulation of the puncture track, although transfusion could expose the patients to the risk of alloimmunization and transfusion-associated lung injury. Thrombopoietin-receptor agonists such as eltrombopag could be used to improve thrombocytopenia. Despite a reduction of the need for platelets transfusion without raising the risk of bleeding in cirrhotic patients with thrombocytopenia undergoing invasive procedures, eltrombopag was associated with a risk of portal vein thrombosis. Novel receptor agonist avatrombopag and lurutrombopag reported a reduced need for platelets transfusion in patients undergoing invasive procedures (including only few patients treated by RFA) without significant thrombotic events. Lurutrombopag was used in two series of cirrhotic patients with thrombocytopenia undergoing RF with a reduction of platelets transfusion and no side effects, except for one recurrence of portal vein thrombosis. The recommended algorithm in cirrhotic patients with thrombocytopenia (below 50 G/l) undergoing invasive procedures is the oral administration of either avatrombopag and lurutrombopag (5 or 7 days, respectively) followed by the procedure (9th-14th day of the beginning of treatment); if the number of platelets safe to perform, the procedure is not reached platelet transfusion is recommended. The best strategy between the use of thrombopoietin-receptor agonist or platelet transfusion alone is unknown.

1.4.2 | Presence of pacemakers

Electromagnetic interference with cardiac devices such as pacemakers and defibrillators could occur in a patient treated with RFA. A manuscript including various types of ablation treatments, monopolar RFA and MWA for lung cancer, primary liver cancer and liver metastasis reported interference in 10% of the patients without any clinical relevance. In contrast, bipolar RFA was considered as a safe procedure as the energy is conducted between the two needles and did not induce any interference with the pacemaker.

1.4.3 | Child Pugh B patients

Child Pugh B patients are not optimal candidates to liver resection owing to the risk of post-operative liver failure. In patients not a candidate for liver transplantation or with a long waiting time period, percutaneous ablation could be performed with a good safety profile even if Child Pugh B patients are often associated with a lower OS due to the occurrence of complications of cirrhosis during the follow-up. Two studies suggested that percutaneous IRE could be used in Child Pugh B patients with fewer adverse events than RFA, maybe owing to the lower and more progressive non-tumour parenchymal sacrifice, thanks to the non-thermal ablation effect.

1.4.4 | Bilio-enteric anastomosis and sphincterotomy

Liver abscess following RFA is a rare complication occurring in <2% of the cases. However, in patient with pre-existing biliary abnormality favouring ascending biliary such as enterobiliary anastomosis or endoscopic sphincterotomy, the risk is considerably higher.

A liver abscess developed in two (22.2%) of nine patients with biliary abnormality (hepaticojejunostomy for the first patient and endoscopic papillotomy for the second one). In another monocentric series of patients with enterobiliary anastomosis undergoing RFA for HCC, six patients out of eight (75%) developed a liver abscess. Interestingly, in patients with bilioenteric anastomosis, prolonged antibiotic prophylaxis with piperacillin/tazobactam for 10 days, reduced the risk of liver abscess, with only case reported among the 10 patients treated by RFA. Some authors suggested that previous transcatheter arterial chemoembolization was associated with a higher risk of liver abscess after RFA; however, these results were not confirmed by other larger studies leaving place for discussion.

1.4.5 | At-risk location

At-risk locations, such as subcapsular or subdiaphragmatic lesions, HCC closed to the gallbladder or to the colon/small bowel, are no longer considered as contra-indication to percutaneous ablation as good long-term outcomes could be achieved using specific
technical approaches during ablation procedure. For example, hydrodissection (creation of artificial ascites) has proven to protect the colon/small bowel/stomach or the diaphragm from thermal injury. IRE could be also used in this situation as it avoids the thermal lesions observed with RFA or MWA. Subcapsular lesions could be treated using mbp-RFA with a No-Touch technique in order to avoid the direct puncture of HCC. HCC close to the biliary convergence should not be treated by thermal ablation and is therefore a good indication for IRE. A series of 58 patients treated by IRE not accessible to thermal ablation because of their at-risk location or due to liver dysfunction reported a complete ablation of the lesion in 92% of the case, with a local tumour PFS of 70% at 1 year.

1.4.6 | Invisible HCC at ultrasonography

Up to 30% of patients with small HCC evaluated for ablation were considered not treatable mainly because the HCC were not visible at ultrasonography. However, several technical approaches are available in order to propose ablation in these patients: the creation of artificial ascites or pleural effusion, a fusion between ultrasonography and pretherapeutic computed tomography (CT) scan or magnetic resonance imaging, CT scanner guidance, lipiodol staining to guide ablation.

1.5 | Extension of ablation criteria

1.5.1 | Increasing the number of ablated lesions

In the EASL guidelines, percutaneous ablation is recommended in up to two or three HCC of <3 cm. If binodular or trinodular HCC was often associated with a higher rate of tumour recurrence, percutaneous ablation could achieve long-term survival in these patients. Several teams have reported their experiences of percutaneous treatments up to four to five HCC with a good safety profile. However, treatments of such high numbers of HCC remain time-consuming, and in the context of a multifocal liver carcinogenesis, it is not clear if there is a benefit compared to TACE.

1.5.2 | Increasing the size of ablated lesions

A small proportion of cirrhotic patients with uninodular HCC exceeding 5 cm are eligible for surgery taking into account portal hypertension, the insufficient remnant liver after resection, the response to procedures aiming to increase liver volume such as portal vein embolization and the presence of significant comorbidities. Considering the size of the lesion, the traditional dogma of treatment by RFA limited to patients with HCC within Milan criteria was challenged in recent studies using either mbp-RFA in order to increase the area of ablation or a combination of TACE and RFA. Several retrospective studies have reported the possibility to treat large HCC using the combination of RFA and TACE with various results in terms of local control and OS. Initial data regarding the feasibility and efficacy of multipolar radiofrequency in HCC exceeding Milan criteria came out with a cohort of 26 patients with a tumour diameter of 5.0 cm or greater (median diameter, 5.7 cm; range, 5.0-8.5 cm) with no invasion of main portal branches. Complete ablation was achieved in 81% of the patients with no major complications. The probabilities of 1- and 2-year survival, respectively, were 68% and 56%. Mb-RFA treatment in HCC nodules with sizes between 3 and 6 cm in nonsurgical candidates with liver cirrhosis reported the complete ablation in all nodules without procedure-related death or major complications. In the follow-up, the OS at 4 years was 49%. Another series included HCC with a median size of 9 cm treated by stereotactic RFA and reported efficacy of ablation of 80.5% with treatment-related mortality of 2.3%. Major complication rate here was 20.5%. The OS rate at 5 years was 62.8% but it should be underlined that only one-third of patients were affected by cirrhosis. Recently, a large series of patients reported the long-term results of No-touch mbp-RFA for the treatment of up to three HCCs with the largest tumour >5 cm in diameter (median: 6.2 cm) mainly developed on cirrhosis. Some of them were infiltrative HCC (27%), and few of them have a segmental portal vein invasion (15%). Complete ablation was achieved in 94% patients with 6 (7%) of severe complications and 1.2% of treatment-related death. On the whole series, the 3- and 5-year OS was 51% and 24%. The infiltrative form, alpha-fetoprotein level, multinodular HCC were independently associated with recurrence. In non-infiltrative mass forming HCC without portal vein invasion, the 3- and 5-year OS was 63.4% and 30%. Percutaneous ablation of large HCC of more than 5 cm seems to be technically feasible using Mbp-RF with a morbidity and mortality higher than in ablation of smaller lesions but remaining tolerable and manageable (Figure 3). The best candidate seems to be a patient with a uninnodular mass-forming HCC between 5 and 8 cm but more data on the wide applicability of these technics and the refinement of patient’s selection are still warranted.

1.5.3 | Treating HCC with macrovascular invasion

The presence of a portal vein tumour thrombosis is usually considered as a contraindication to percutaneous treatments. However, some retrospective studies propose to move this line. Giorgio et al (2009) reported a series of 13 patients with an HCC nodule and portal vein thrombosis (diameter 3.7-5 cm). The rate of complete necrosis was 77% following RFA without major complications. Another study suggested that the combination of percutaneous RFA with sorafenib was associated with longer OS than sorafenib alone. However, more data are needed in terms of the safety and efficacy of percutaneous ablation of limited tumour portal vein thrombosis in regards to other available treatments such as trans-arterial radioembolization or systemic treatments (Figure 3).
1.5.4 | Treating extrahepatic metastasis

Systemic treatments such as atezolizumab/bevacizumab or tyrosine kinase inhibitors (TKIs, sorafenib, regorafenib, cabozantinib, lenvatinib) are recommended by all scientific societies to treat patients with extrahepatic spread of HCC (Figure 3). Even if we agree that the use of locoregional treatments is limited nowadays in the treatment of extra-hepatic metastases, we think that in patients with unidimensional metastasis, it is sometimes an option discussed in multidisciplinary tumour board.

Several retrospective monocentric studies have suggested that percutaneous RFA of unique metastasis or in oligometastatic patients (mainly with adrenal or lung metastasis) was associated with a good safety profile and showed potential signals of efficacy.\(^{74-77}\) Percutaneous ablation using RFA has been also used to treat patients with node metastasis.\(^{78}\) The best candidate for this strategy seems to be a patient without any active HCC in the liver and with a unique metastasis. However, it is unknown if this strategy is better than systemic therapy alone and if systemic treatment should be initiated after complete ablation of a unique metastasis.

1.5.5 | Combination with systemic treatments

An adjuvant treatment by TKI such as sorafenib has failed to improve the survival of patients with HCC in a curative setting (surgery and RFA).\(^{79}\) In contrast, preclinical studies have suggested that percutaneous ablation of HCC induces modifications in the immune microenvironment stimulating an immune response owing to the liberation of antigen following tumour necrosis.\(^{80}\) Therefore, it was hypothesized that adding immunotherapy in neo-adjuvant or adjuvant settings could improve survival after locoregional treatments. There are nowadays several ongoing Phase II or III trials combining locoregional treatment and immunotherapy in patients with curable HCC but at high risk of relapse (multiple nodules or >3 cm).\(^{33,81}\) Moreover, percutaneous ablation has been associated in phase 2 clinical trials with immunotherapy (anti-CTLA4 antibody) in patients with advanced HCC in order to foster the response to immunotherapy.\(^{82}\)

2 | CONCLUSION

The enrichment of knowledge and advances in the technology in the field of percutaneous ablation helped to propose a personalized approach for patients with early HCC. In the end, the competition between liver resection, liver transplantation and percutaneous ablation in the treatment of small HCC seems to be useless. The main goal remains to propose a curative treatment to the maximum numbers of patients with early HCC, whatever the treatment, taking into account age, the comorbidity, tumour features, portal hypertension and liver failure in the dramatic context of graft shortage in western countries. Wide dissemination of all techniques of percutaneous ablation might help to this end.
ablation would help to reach this goal. More data are also warranted in the extension of ablation criteria in terms of size, numbers or in metastatic disease and their potential role compared to systemic treatment or trans-arterial radioembolization. Moreover, the combination of percutaneous ablation and systemic treatments in neo-adjuvant or adjuvant situations in early HCC but also in advanced HCC in order to increase tumour response and survival is currently an important field of research.

CONFLICT OF INTEREST
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