easy detection of small HCC.[41–43] However, it is sometimes difficult to characterize small hepatic nodular lesions detected by these imaging modalities. Definitive diagnosis requires invasive methods such as US-guided liver biopsy. Hemodynamic evaluation of the nodule is also important to assess the biological behavior of HCC. The recent advances in MRI and computed tomography (CT) procedures, such as CT during hepatic arteriography (CTHA) and CT during arterial portography (CTAP), have enabled the detailed hemodynamic evaluation of small hepatic nodules.

Recently, liver-specific contrast agents such as superparamagnetic iron oxide particles (SPIO), which are taken up by Kupffer cells, and Gd-EOB-DTPA, which is taken up by hepatocytes, are frequently used in MRI for early diagnosis of HCC. Gd-EOB-DTPA is a superb agent because it provides dynamic and liver-specific MR images.[44–46] This contrast agent is highly liver specific; approximately 50% of the injected dose is taken up by functioning hepatocytes and is excreted in bile, compared with just 3–5% for gadobenate dimeglumine.[46] Early studies comparing Gd-EOB-DTPA-enhanced dynamic MRI with dynamic MDCT showed that Gd-EOB-DTPA-enhanced MRI is significantly more accurate, sensitive and specific than dynamic MDCT for the diagnosis of HCC in patients with cirrhosis.[47,48] In addition, Gd-EOB-DTPA-enhanced MRI has a high detection rate for early stage HCC nodules that are not enhanced in dynamic studies. However, although the differentiation of early HCC from dysplastic nodule by hepatobiliary phase images of Gd-EOB-DTPA MRI is promising, more data are still needed.

Informative statement 2. Gd-EOB-DTPA-enhanced MRI provides dynamic and hepatocyte-specific images and is more accurate than dynamic MDCT or SPIO-MRI for the detection and characterization of small HCC, including early HCC.

ABLATION THERAPIES

IMAGE-GUIDED PERCUTANEOUS ablation therapies have long played important roles in the treatment of HCC. Percutaneous ethanol injection has been used for unresectable, small HCC since the early 1980s[49–51] and offers us the potential to treat HCC using non-surgical means. Percutaneous microwave coagulation therapy became popular in Japan in the late 1990s.[52] However, since the introduction of radiofrequency ablation (RFA) into clinical practice around 1999, there has been a dramatic shift from ethanol injection or microwave coagulation to RFA.[53] RFA for HCC has been covered by public health insurance since April 2004 in Japan. Although more than 1700 institutions have experienced RFA in Japan, RFA is estimated to be performed routinely in approximately 1000 institutions throughout Japan at the present.

Radiofrequency ablation often seems to be performed with less than adequate treatment planning or preparation compared with surgical resection. RFA appears to be a very simple procedure. Thus, some physicians may perform RFA without adequate training or experience. In addition, RFA does not require expensive equipment. Thus, several hospitals have introduced RFA into clinical practice without high-performance US and CT.

However, RFA is indicated for malignant tumors and inadequate outcome should be avoided. Thus, only physicians with sufficient experience and appropriate skill should perform the procedure. Furthermore, only well-equipped hospitals should perform RFA because the outcomes of RFA are strongly influenced by the performance of the CT and US equipment available at each institution. It is crucial to offer consistent outcomes for RFA at all institutions and for all operators.

More importantly, before commencing RFA, the tumors should be evaluated by US, contrast-enhanced CT or MRI to determine tumor size, shape, number, presence or absence of extracapsular invasion, presence or absence of satellite lesions, location relative to Glisson's capsule or other critical structures, and to determine the optimal route to approach the tumor.

Within 1–3 days after RFA, contrast-enhanced CT or MRI is essential to objectively assess the treatment response. If the tumor is completely ablated with a sufficient safety margin, the treatment may be considered complete. However, if there is any residual cancer tissue or an insufficient safety margin, RFA should be repeated until complete tumor destruction with a sufficient ablative margin is achieved. The following recommendation was supported by 94% of the experts.

Recommendation 8. Imaging should be performed within 1–3 days after RFA to evaluate treatment response. It is essential that RFA is repeated until entire tumor destruction with a sufficient ablative margin is achieved.

For accurate tumor evaluation, CT and MRI performed before and after RFA should be done using a thin slice interval. The following recommendation was agreed by 94% of the experts.

Recommendation 9. CT and MRI before and after RFA should be done using a slice thickness and interval of 5 mm or less; slice thickness and interval of 10 mm or more is not adequate.

A histopathological study has revealed that, in cases with incomplete necrosis, viable cancer tissue remains around the main tumor, in portions isolated by the septa, or along the edge of the tumor after ablation therapies.[54] There may also be extranodular growth, satellite nodules or portal vein invasion, which cannot be detected by imaging modalities.[55,56] The incidence of satellite nodules and portal vein invasion is associated with the gross appearance of the main tumor. The single nodular type with extranodular growth and the confluent multinodular type both show satellite lesions more frequently than early HCC (vaguely nodular-type HCC showing preservation of the preexisting liver structure) and the single nodular type. Thus, it is important to determine the gross appearance of the tumor by imaging. It is also essential to ablate beyond the tumor border to achieve complete tumor necrosis and prevent local tumor progression (ablative margin or safety margin). Sonazoid-enhanced US in the Kupffer phase is useful to determine the gross tumor appearance.[57] The width of the safety margin should be modified based on the gross appearance of the tumor, the number of tumors, the initial tumor or recurrent tumor, the duration of time between the previous treatment and recurrence in recurrent cases, tumor location (particularly in relation to the Glisson's capsule), liver function, comorbid conditions and the patient's age.

Furthermore, the accuracy of contrast-enhanced CT or MRI for evaluating the extent of necrosis is limited because of the partial volume effect.[58] The following recommendation was agreed by 94% of the experts.

Recommendation 10. A safety margin completely surrounding the lesion should be achieved in cases in which RFA is performed as a locally curative treatment (level 6, grade A).

Ablation therapies, including RFA, are widely accepted as the preferred treatment for unresectable small HCC. On the other hand, it has been strongly debated whether ablation therapies can provide a treatment option for resectable HCC since the introduction of ethanol injection. Although the number of patients treated by RFA has steadily increased, the Clinical Practice Guidelines for Hepatocellular Carcinoma in Japan recommends surgery rather than ablation.[1] Their scientific statement recommends the following: "(i) if only one tumor is present, liver resection is recommended irrespective of the diameter of the tumor. Ablation therapy may also be selected if the severity of liver damage is class B and the diameter of the tumor is no more than 2 cm; (ii) if two to three tumors with diameters of no more than 3 cm are present, liver resection or local ablation therapy is recommended". This scientific statement is based on a cohort study of patients at clinical stage I (fair liver function), with a solitary tumor of less than 2 cm in diameter, patients across all clinical stages with a solitary tumor greater than 2 cm, and patients of clinical stage II (moderately impaired liver function) with two tumors greater than 2 cm. In that cohort, those who underwent hepatic resection showed higher survival rates than those who received non-surgical interventions.[59]

However, those findings were not based on randomized controlled trials (RCT) and the different survival rates may be subject to bias arising from the background characteristics of the patients. Of note, the hepatic resection group was younger than the ethanol injection group. Furthermore, even among patients at clinical stage I, most patients with normal liver or chronic hepatitis seemed to undergo resection while many with cirrhosis seemed to receive ethanol injection. This might reduce the recurrence rate because of multicentric carcinogenesis and less frequent development of liver failure in the resection group. Moreover, the trend that patients with severe comorbid conditions, such as cardiopulmonary diseases and others, received ethanol injection rather than resection might explain some of the disparity in survival. By contrast, in one RCT the recurrence and survival rates were comparable between surgical resection and ethanol injection.[60] In addition, other non-randomized trials have reported similar or better overall survival after ethanol injection than after resection.[61–63]

In addition, the findings described above only compared resection with ethanol injection. For example, our RCT showed that RFA had higher survival and lower recurrence rates than ethanol injection while the adverse events were similar between the two therapies.[64] Similarly, other RCT have shown that RFA is superior to ethanol injection in terms of treatment outcomes for HCC.[65–67] Another RCT has shown that there was no difference between resection and RFA in terms of overall and disease-free survival, while post-treatment complications occurred more frequently and were more severe after surgery.[68]

Hence, it is inappropriate to generalize the findings for ethanol injection to other percutaneous local ablation therapies such as RFA, and it should not be concluded that hepatectomy is recommended over percutaneous local ablation.

Further trials are needed to determine whether RFA can become a preferred treatment for "resectable HCC". In such trials, the primary end-point should be overall

survival.[69] The AASLD practice guideline clearly states the following: "although a treatment might be less active against the tumor than another treatment and thus result in a higher recurrence rate after initial treatment, the overall survival might not differ or may even be better".[3]

Recurrence-free survival can be misleading and should not be considered as a surrogate end-point for overall survival. In HCC, unlike other solid tumors, recurrence can still be treated, and the first recurrence does not cause death in most cases. Furthermore, surgery theoretically offers better disease-free survival than RFA because it removes larger liver tissue. However, the better curability associated with hepatectomy could be cancelled out by the surgical invasion and the potential deterioration in liver function. The following recommendation was agreed by 84% of the experts.

Recommendation 11. Overall survival should be the end-point to compare results between ablation and hepatectomy.

SURGICAL TREATMENT: RESECTION AND TRANSPLANTATION

A NATIONWIDE SURVEY by the Japanese Liver Transplantation Society found that a total of 4725 cases of living-donor liver transplantations (LDLT) were reported in Japan as of the end of 2007 since its initiation in 1989. By contrast, during the same period, only 46 cases of deceased-donor liver transplantation (DDLT) were documented. At the end of 2006, 778 patients with HCC had undergone an LDLT in Japan.[70] Because of the severe shortage of brain-dead donors and the extremely long waiting time for such organs, DDLT is not a realistic treatment option for HCC patients in Japan.

Algorithm for the treatment of patients with HCC in Japan

Figure 1 shows the treatment algorithm presented in the Japanese evidence-based guideline for the diagnosis and treatment of HCC.[1] Liver transplantation is recommended for HCC patients with liver damage C (similar to Child–Pugh C), but only when the patients meet the Milan criteria proposed by Mazzaferro.[71] In the revised version of the guidelines published at the end of 2009, an age limit of 65 years was added to the criteria for liver transplantation.

Can the indications for liver transplantation be expanded beyond the Milan criteria?

Until the mid-1990s, HCC was considered a contraindication for liver transplantation because of the extremely poor outcome of early series.[72,73] This pessimistic view was reversed by Mazzaferro *et al.* who conducted a prospective cohort study to identify subgroups of HCC patients who may benefit from DDLT. They presented clear eligibility criteria for transplantation, as follows: the presence of a solitary tumor of 5 cm or less in diameter and no more than three tumor nodules, each 3 cm or less in diameter, in patients with multiple tumors, and the absence of vascular invasion or extrahepatic disease. In their series, the overall and recurrence-free survival rates

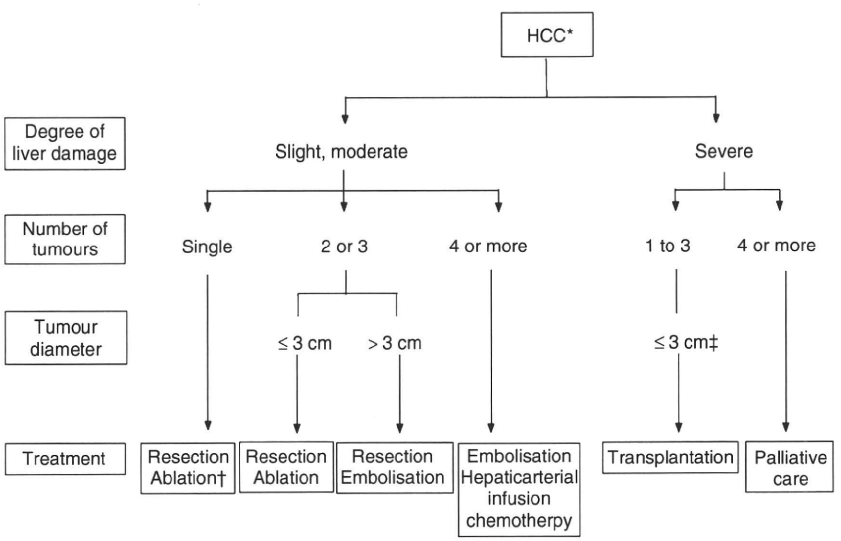

Figure 1 Japanese evidence-based treatment algorithm. HCC, hepatocellular carcinoma.

at 4 years for 35 patients who met the above criteria were as high as 85% and 92%, respectively. These criteria were named the "Milan criteria" and became the gold standard for patient selection for liver transplantation. The Milan criteria were also validated for LDLT using data from a nationwide survey in Japan.[74] Since 2004, LDLT for HCC has been covered by social medical insurance in Japan when the preoperative imaging studies indicate that the patient's condition meets the Milan criteria.

The Milan criteria have encouraged transplant surgeons to increase the number of liver transplantations performed in HCC patients, and the United Network for Organ Sharing (UNOS) has incorporated the Milan criteria as conditions for listing HCC patients. During the extensive application of liver transplantation for HCC, transplant surgeons have noticed that the outcomes of some patients who slightly exceeded the Milan criteria were also favorable. To expand the indications for liver transplantation, several groups from different countries have challenged these restrictive criteria (Table 1).[75–79] Yao *et al.* at the University of California at San Francisco (UCSF) proposed criteria consisting of a single tumor of less than 6.5 cm in diameter or two lesions of less than 4.5 cm in diameter, with a total tumor diameter of less than 8 cm; these criteria are known as the "UCSF criteria".[76] The utility of the UCSF criteria was subsequently confirmed by the University of California at Los Angeles.[80]

Regarding the indications for LDLT in HCC patients, several proposals from Asian centers have extended the eligibility criteria (Table 1). For example, a group at the University of Tokyo proposed the "5-5 rule", which allows up to five nodules with a maximum diameter of 5 cm.[77] The 3-year recurrence-free rate of 72 patients who met the Tokyo 5-5 rule was as high as 94%, which was comparable with that of patients within the Milan criteria. A group at the University of Kyoto subsequently proposed a further expansion of the criteria, increasing the upper limit of the number of tumors to 10.[79]

Because LDLT is not governed by an organ-sharing system, some authors have argued that the indications for LDLT in patients with HCC could be further extended. One might say that "If the patient (recipient) and his/her family (donor) strongly wish to undergo LDLT even in cases of very advanced HCC with full knowledge of potential for poor outcomes, there is no reason for transplant surgeons to reject their wish. The family members may accept the poor outcome after LDLT without doing any harm to the community." However, we should always remember that, while LDLT does not require a donor from the community, it does require extensive medical resources, including a large workload for surgeons and other hospital staff members, medical supplies, drugs and blood products. Furthermore, the premature death of the recipient is well known to cause severe emotional trauma to the living donors and their family members.

Based on an answer-pad vote at the consensus meeting of 45th JSH congress, 84% of the experts supported keeping the Milan criteria for DDLT, but only 25% supported keeping these criteria for LDLT. Although any expansion of the criteria should be modest, no consensus exists as to the extent to which the criteria can be extended.

Recommendation 12. For DDLT, the HCC status of the recipients should meet the Milan criteria.

Recommendation 13. For LDLT, the HCC status of the recipients does not need to be within the Milan criteria.

Which is better, liver resection or transplantation, for HCC patients who are eligible for either treatment?

Because liver transplantation replaces the whole liver, removing the highly carcinogenic background and the cirrhotic liver can avoid multicentric or de novo cancer recurrence.[80] In contrast, liver resection is associated with a very high risk of tumor recurrence. Even after curative liver resection in patients with good liver function, the 5-year recurrence rate is as high as 70–79%.[80] Roughly half of these recurrences are multicentric or de novo recurrences. For this reason, liver transplantation

Table 1 Summary of proposed criteria for indication of liver transplantation for HCC

Criteria	Conditions	References
Milan criteria	Up to 5 cm for single nodule or up to 3 nodules with a maximum diameter of 3 cm	70
UCSF criteria	Up to 6.5 cm for single nodule or up to 3 nodules with a maximum diameter of 4.5 cm	76
Tokyo 5-5 rule	Up to 5 nodules with a maximum diameter of 5 cm	77
Asan criteria	Up to 6 nodules with a maximum diameter of 5 cm	78
Kyoto criteria	Up to 10 nodules with a maximum diameter of 5 cm and PIVKA-II <400 mAU/mL	79
Up-to-seven criteria	Up to seven as the sum of the size of the largest tumor [in cm] and the number of tumors	75

may be recommended for HCC patients with good liver function who are also eligible for liver resection, as in Western countries.

Another issue is the operative risk of the two treatments. In Japan, the operative mortality rates for LDLT and liver resection are estimated to be 4–10% and 0.8–1.2%, respectively. This striking difference in operative mortality rates might preclude LDLT for patients with good liver function.

Using two databases at the National Cancer Center Hospital in Japan and the University of Pittsburgh Medical Center in the USA, Yamamoto *et al.* compared the long-term outcome of liver resection and transplantation in cirrhotic patients with HCC.[81] The overall survival of Child–Pugh A patients who underwent liver resection was similar to that of the patients without vascular invasion or lymph node metastases who underwent transplantation (most cases with Child-Pugh C). The recurrence rate was significantly lower in the transplantation group. For cases in which either treatment can be performed, the outcome of liver transplantation might be better than that of hepatic resection, particularly in cases with only a few small lesions.[81,82] In cases with large lesions, superior outcomes are achieved with hepatectomy. Because some patients may withdraw from treatment during the pre-transplantation period,[83] the outcomes with resection are better than those for liver transplantation based on intention-to-treat analysis of patients who meet the criteria for resection.

The evidence-based guideline[1] recommends the following: considering the occurrence of dropouts during the pre-transplantation period, the outcome of resection is better than that of liver transplantation among patients who meet the criteria for resection (grade B).

According to a question and answer-analyzer vote at this consensus meeting, 83% of the HCC experts selected LDLT for Child–Pugh C patients meeting the Milan criteria, whereas only 15–19% of the audience selected LDLT for Child–Pugh A or B patients.

Recommendation 14. LDLT should not be recommended for HCC patients with Child–Pugh A or B liver function.

PALLIATIVE TREATMENTS: TRANSARTERIAL CHEMOEMBOLIZATION AND CHEMOTHERAPY

PALLIATIVE TREATMENTS FOR HCC include transarterial chemoembolization (TACE), hepatic arterial infusion chemotherapy (HAIC) and systemic chemotherapy.

Transarterial embolization/TACE

Transcatheter arterial embolization (TAE)/TACE is one of the treatment options to treat hypervascular HCC. The theoretical basis of embolization is to induce ischemic tumor necrosis by acute arterial occlusion in hypervascular classical HCC. Embolization may be done alone (TAE) or in combination (TACE) with antineoplastic agents such as doxorubicin, epirubicin or cisplatin and a contrast agent, lipiodol. TACE is more effective and, thus, more widely used than embolization alone.

The technique for TACE is well established. The subsegmental artery or a peripheral artery near the target tumor is selected by a micro-catheter technique, followed by selective injection of antineoplastic agents mixed with lipiodol (lipiodol emulsion). The artery is then selectively obstructed with gelatin sponge particles. For bi-lobular multiple HCC with moderately impaired hepatic function (Child–Pugh B), TACE might need to be performed twice with an interval of several weeks to avoid hepatic decompensation.

The survival benefit of TAE/TACE was controversial until the publication of two RCT in 2002, which showed that TACE improved the survival of selected patients (Child–Pugh A with no vascular invasion) compared with conservative treatment.[84,85] A subsequent meta-analysis of seven RCT comparing TAE/TACE as a primary treatment for HCC in comparison with conservative management and/or suboptimal therapies showed a significant improvement in the 2-year survival, favoring TAE/TACE (odds ratio [OR] = 0.53; 95% confidence interval [CI] = 0.32–0.89, $P = 0.017$).[86,87]

According to the Nationwide Follow-up Survey of Primary Liver Cancer in Japan, one-third of all patients with primary HCC were treated by TAE/TACE (Fig. 2). Thus, TAE/TACE, hepatic resection and local ablation therapy are commonly used in Japan. TAE/TACE is the most widely used treatment for unresectable HCC.

In two Japanese treatment guidelines for HCC, evidence-based[1,30,88] and consensus-based guidelines,[89] TACE is recommended for patients with the severity of the liver damage categorized into A or B, in whom there are two or three tumors with a diameter greater than 3 cm, or four or more tumors.

In early stages of HCC, TACE is not indicated as first-line treatment because the outcome review of the Nationwide Follow-up Survey by the LCSGJ reported worse results for TACE than surgery or percutaneous ablation. This survey revealed that the 5-year survival rates for resection, ablation and TACE were 59.2%,

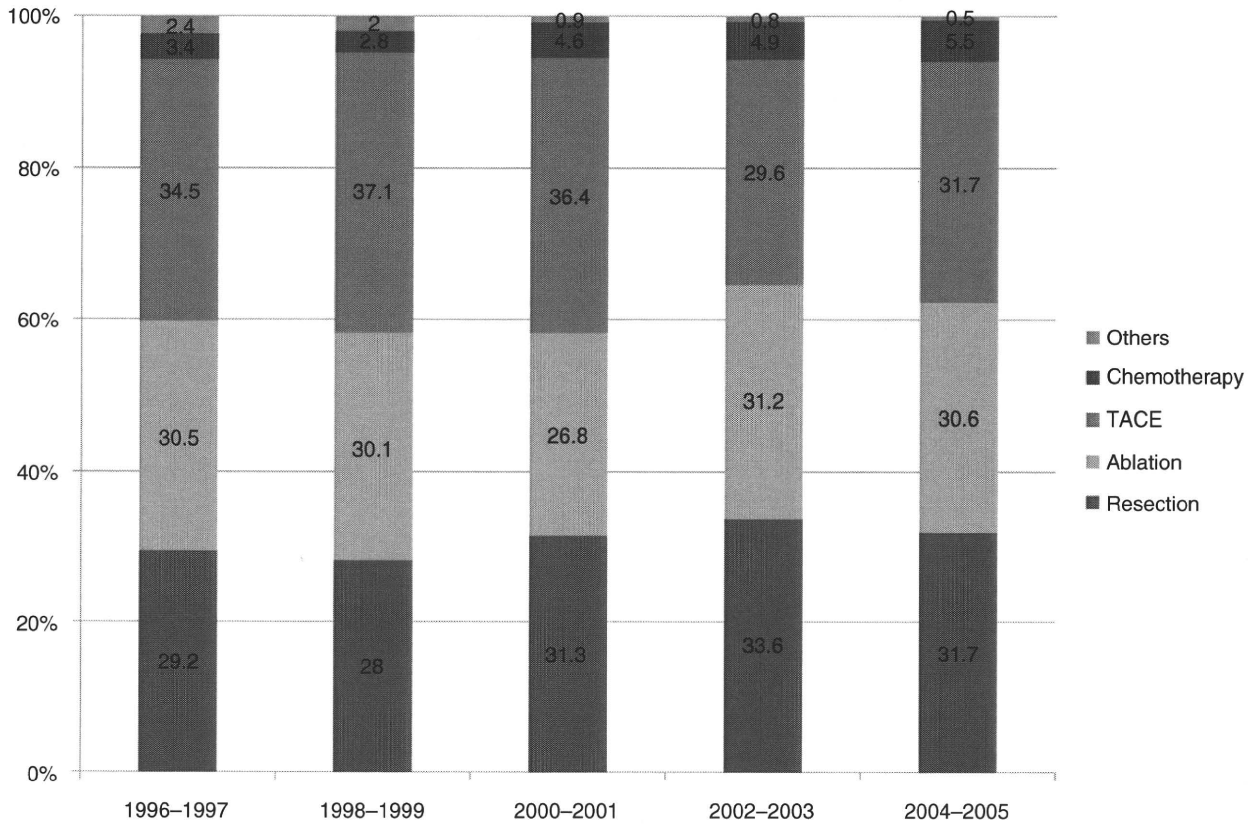

Figure 2 Change of treatment method for hepatocellular carcinoma in Japan. TACE, transcatheter arterial chemoembolization.

48.4% and 29.7%, respectively, for single tumors, and 46.4%, 37.3% and 23.0%, respectively, for two tumors.[90]

In contrast, in a large prospective cohort study of 8510 patients who received TACE for unresectable HCC, according to the LCSGJ, the median survival was 34 months with 1-, 2-, 3-, 5- and 7-year survival rates of 82%, 63%, 47%, 26% and 16%, respectively.[91] In patients with early stage HCC, single tumors of 2 cm or more and preserved liver function (clinical stage I and liver damage A according to the LCSGJ),[92] the median survival was 62 months with 1-, 2-, 3-, 5- and 7-year survival rates of 98%, 92%, 73%, 52% and 38%, respectively.[91] These results for TACE with early stage HCC seem comparable with those for surgery or ablation. Thus, although curative therapies are highly recommended for patients with early stage HCC, TACE can be applied in these patients contraindicated for curative therapies.

Transcatheter arterial chemoembolization can be used in combination with percutaneous ablation, including RFA. A meta-analysis of four RCT comparing combination therapy (TACE plus percutaneous ethanol injection [PE]) or RFA) versus monotherapy (TACE alone, PEI or RFA alone) showed a significant decrease in mortality favoring combination therapy versus monotherapy in patients with small (<3 cm) or large (>3 cm) HCC (OR = 0.534; 95% CI = 0.288–0.990; $P = 0.046$).[93]

In RFA treatment, as the tumor size increases, the therapeutic response decreases because of the limited volume of coagulation necrosis induced by the electrode. Blood flow also promotes heat loss to result in insufficient necrosis; therefore, reducing blood flow during RFA increases the ablation volume. Therefore, it seems to be reasonable to perform RFA after reducing blood flow by preceding RFA with TACE. Several cohort studies have shown that performing TACE before RFA is feasible and safe, and offers a useful treatment in compensated cirrhosis (Child–Pugh A or B) with relatively small HCC nodules (20–50 mm).[94–97] RFA in combination with preceding TACE is already recommended in the consensus-based treatment algorithm proposed by the JSH[89].

In the current consensus meeting, for hypervascular HCC of 2 cm in size, 51% of the experts used TACE

before RFA treatment. By contrast, for hypervascular HCC of 3 cm in size, 81% of the experts performed TACE before RFA. This is theoretically reasonable because the possibility of incomplete ablation is greater for tumors of 2–3 cm in size, compared with tumors of less than 2 cm in size, based on the limited volume possible with a single ablation procedure. Additionally, the accumulation of lipiodol in the tumor should facilitate the decision on whether additional RFA treatment is required following the response evaluation by dynamic CT scan. However, the survival benefit of TACE in combination with RFA should be verified by well-designed RCT.

Transcatheter arterial chemoembolization is performed in various stages in the clinical management of HCC, not only for the initially detected HCC, but also for recurrent HCC. TACE has been shown to be valuable for improving the overall survival of HCC patients, although it is difficult to assess its clinical efficacy as second- or third-line therapy.

Informative Statement 3. TACE performed before RFA is favorable for the curative treatment of hypervascular HCC of 2–3 cm in size.

Recommendation 15. TACE performed before RFA is recommended for curative treatment of hypervascular HCC larger than 3 cm in size.

Chemotherapy

Chemotherapy for HCC is divided into two types according to the route of administration; the first is systemic chemotherapy and the second is hepatic arterial infusion chemotherapy (HAIC). Systemic chemotherapy can also divided into two types: intravenous and oral chemotherapy.

According to the Nationwide Follow-up Survey of Primary Liver Cancer by the LCSGJ, chemotherapy is used in 3.4–5.5% of primary HCC patients (Fig. 2). HAIC is theoretically more favorable for HCC than systemic chemotherapy because hepatic arterial infusion of anticancer drugs enables the delivery of high doses of drugs directly to the hypervascular HCC. In addition, HAIC provides a lower systemic level of the drugs than systemic administration, because the first-pass effect in the liver, and thus reduces toxicity and side-effects. Because of these advantages, HAIC is frequently used in Japan for intrahepatic advanced HCC with portal vein tumor thrombosis and/or intrahepatic multiple HCC. A recent report from the Japanese Nationwide Survey revealed that almost 90% of the chemotherapeutic regimens for HCC are done by hepatic arterial infusion. Thus, HAIC has become widely used in Japan, despite there being no solid evidence for a survival benefit of HAIC compared with systemic chemotherapy or best supportive care (Fig. 3).

Recommendation 16. HAIC is recommended for advanced HCC with major portal vein tumor thrombi with preserved liver function.

Various anticancer drugs and treatment regimens are used for HAIC in Japan. Two regimens in particular are widely used for HAIC. The first is interferon (IFN) in combination with 5-fluorouracil (5-FU); the second is low-dose cisplatin (CDDP) in combination with 5-FU. For IFN plus 5-FU, the response rate was reported to be 52.6%, with 16.4% achieving complete response (CR) and 36.2% achieving partial response (PR) among 116 patients with tumor thrombosis of the major portal vein or first branches of the portal vein. The survival rates at 6, 12 and 24 months were 53%, 34% and 18%, respectively, with a median survival of 6.9 months, compared with survival rates of 40%, 15% and 5%, respectively, in the historical control group.[98] The survival was significantly different between the two groups ($P < 0.01$). For low-dose CDDP plus 5-FU, the response rate was 48%, including 8% with CR and 40% with PR among 48 patients with portal vein tumor thrombosis. The 1-, 2-, 3- and 5-year cumulative survival rates were 45%, 31%, 25% and 11%, respectively, with a median survival of 10.2 months.[99]

In a review of previously reported small-size phase II studies of HAIC for advanced HCC,[10,17,98–108] the response rate varied from 14% to 71%. The mean survival duration also varied from 2.6 months to 32.4 months. However, few reports have compared systemic chemotherapy or HAIC using cytotoxic agents with placebo or best supportive care (Table 2).

The results of a randomized placebo-controlled double-blind phase III study with the multikinase inhibitor sorafenib were recently reported, representing a breakthrough in the chemotherapy for advanced HCC. Sorafenib is an oral drug that inhibits the platelet-derived growth factor (PDGF)-R, vascular endothelial growth factor (VEGF)-R, c-Kit-R and raf signaling pathways in tumor cells and in surrounding endothelial cells. In that study, 602 patients with advanced HCC, who were not indicated for other loco-regional treatments such as hepatic resection, who had not received prior systemic treatment and who had good liver functional reserve (Child–Pugh A) were randomized to sorafenib (400 mg b.i.d.) or placebo. Sorafenib was well tolerated and yielded a statistically significant improvement (44%) in overall survival. The median survival increased from 7.9 to 10.7 months (hazard ratio, 0.69;

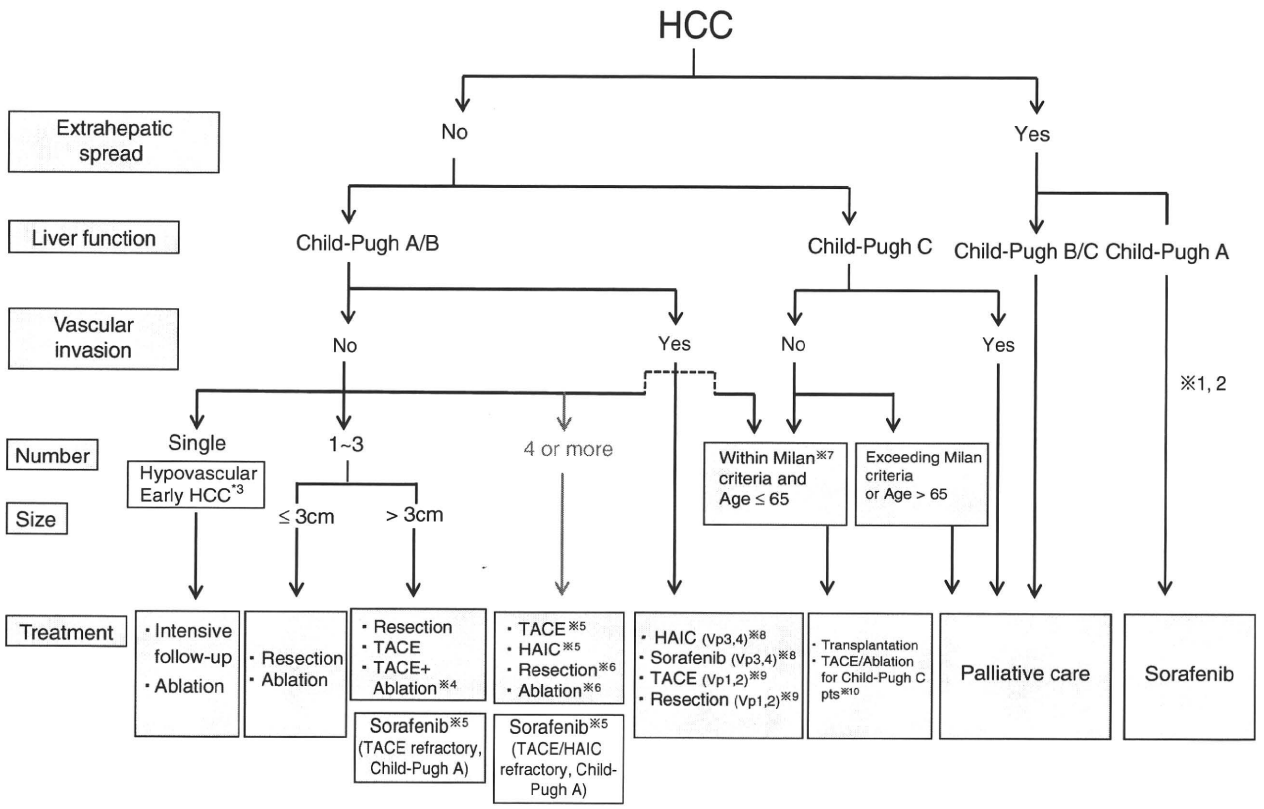

Figure 3 Consensus-based treatment algorithm for hepatocellular carcinoma proposed by the Japan Society of Hepatology (JSH) revised in 2010. (1) Treatment should be performed as if extrahepatic spread is negative, when extrahepatic spread is not regarded as a prognostic factor. (2) Sorafenib is the first choice of treatment in this setting as a standard of care. (3) Intensive follow-up observation is recommended for hypovascular nodules by the Japanese Evidence-Based Clinical Practice Guidelines. However, local ablation therapy is frequently performed in the following cases: (i) when the nodule is diagnosed pathologically as early hepatocellular carcinoma (HCC); (ii) when the nodules show decreased uptake on gadolinium ethoxybenzyl magnetic resonance imaging (Gd-EOB-MRI); or (iii) when the nodules show decreased portal flow by computed tomography during arterial portography (CTAP), because these nodules are known to frequently progress to the typical advanced HCC. (4) Even for HCC nodules exceeding 3 cm in diameter, combination therapy of transcatheter arterial chemoembolization (TACE) and ablation is frequently performed when resection is not indicated. (5) TACE is the first choice of treatment in this setting. Hepatic arterial infusion chemotherapy (HAIC) using an implanted port is also recommended for TACE refractory patients. The regimen for this treatment is usually low-dose FP (5-fluorouracil [5-FU] + cisplatin [CDDP]) or intra-arterial 5-FU in fusion combined with systemic interferon therapy. Sorafenib is also a treatment of choice for TACE/HAIC refractory patients with Child–Pugh A liver function. (6) Resection is sometimes performed even when numbers of nodules are over 4. Furthermore, ablation is sometimes performed in combination with TACE. (7) Milan criteria: tumor size ≤ 3 cm and tumor numbers ≤ 3; or solitary tumor ≤ 5 cm. Even when liver function is good (Child–Pugh A/B), transplantation is sometimes considered for relatively younger patients with frequently or early recurring HCC after curative treatments. (8) HAIC or sorafenib is recommended for HCC patients with Vp3 (portal invasion at the 1st portal branch) or Vp4 (portal invasion at the main portal branch). Sorafenib is only recommended for HCC patients with Child–Pugh A liver function. (9) Resection and TACE is frequently performed when portal invasion is minimal such as Vp1 (portal invasion at the 3rd or more peripheral portal branch) or Vp2 (portal invasion at the 2nd portal branch). (10) Local ablation therapy or subsegmental TACE is performed even for Child–Pugh C patients when transplantation is not indicated when there is no hepatic encephalopathy, no uncontrollable ascites and a low bilirubin level (<3.0 mg/dL). However, it is regarded as an experimental treatment since there is no evidence of its survival benefit in Child–Pugh C patients. A prospective study is necessary to clarify this issue. Even in Child–Pugh A/B patients, transplantation is sometimes performed for relatively younger patients with frequently or early recurring HCC after curative treatments.

Table 2 Response rates and survival periods in studies of intrahepatic arterial infusion chemotherapy for advanced hepatocellular carcinoma

	Drugs	No. of Patients	Response rate (CR + PR, %)	Median survival time (months)	References
Single	Doxorubicin (IHAC)	72	60	7.0	Tzoracoleftherakis *et al.*[102]
	Doxorubicin (systemic)		44.1	6.5	
	CDDP	67	37	10.7	Court *et al.*[103]
Multiple	CDDP, 5-FU (low FP)	52	71	ND	Okuda *et al.*[104]
	CDDP, 5-FU (low FP)	48	48	10.2	Ando *et al.*[99]
	CDDP, 5-FU (low FP)	37	56.3	32.4	Sumie *et al.*[101]
	CDDP, 5-FU (low FP)	38	47	6.2	Tanioka *et al.*[105]
	CDDP, 5-FU	41	22	12.0	Park *et al.*[106]
	CDDP, Mitomycin C, 5-FU, LV	53	28.3	13.2	Lin *et al.*[100]
	IFN, CDDP	68	33	4.4	Chung *et al.*[107]
	CDDP		14	2.6	
	BSC			1.2	
	IFN, CDDP, 5-FU, MTX, LV	34	45	ND	Kaneko *et al.*[108]
	IFN, 5-FU	116	52	6.9	Obi *et al.*[98]

IHAC, intrahepatic arterial chemotherapy; CDDP, cisplatin; 5-FU, 5-fluorouracil; low FP, 5-fluorouracil + cisplatin. BSC, best support care; IFN, interferon; LV, leucovorin; MTX, methotrexate.

95% CI = 0.55–0.87). Side-effects included hand–foot skin reaction, diarrhea and fatigue, but sorafenib was not found to be toxic to the liver.[109] Similar findings were reported in a subsequent Asia–Pacific RCT.[110]

Based on the results of these RCT, sorafenib has become the first-line therapy for advanced HCC worldwide. Some Japanese experts for HCC are claiming low response rates, although the survival was significantly prolonged compared with placebo. This phenomenon could be explained by a longer period with stable disease with sorafenib than with placebo, or the necrotic change in the tumor is present without size reduction.

In Japan, sorafenib was approved for the treatment of HCC on 20 May 2009. In the consensus meeting held in June, 35% of the Japanese experts agreed that sorafenib should be selected as the first-line therapy for advanced HCC considered unsuitable for resection, RFA or TACE. A further 36% of the experts were undecided because they did not have enough experience with using sorafenib.

Informative Statement 4. Sorafenib is the first-line therapy for advanced HCC with major vascular invasion and/or extrahepatic spread and good liver function. However, further studies are needed to compare the overall efficacy of HAIC and sorafenib.

TREATMENT ALGORITHM

TO TREAT HCC, the most appropriate therapeutic option needs to be selected among the available treatment modalities, including resection, percutaneous ablation, TACE and transplantation, but few evidence-based guidelines have been developed to aid decision-making.[1,28,29,88,89,111] Recently, two treatment algorithms for HCC have been proposed in the Japanese guidelines. The profile of these algorithms is briefly described here, in addition to the results of two questions and answers at the JSH Consensus Meeting for HCC at Kobe.

Evidence-based treatment algorithm

The Clinical Practice Guidelines for HCC was established in 2005 based on evidence-based methodology, and covers six topics including prevention, diagnosis, surgery, chemotherapy, TACE and percutaneous ablation. To develop these guidelines, a systematic review of the English medical published work was performed and a total of 7118 articles on HCC were identified, mainly from MEDLINE (1966–2002), of which 334 were selected based on the evidence level to form 58 pairs of clinical questions and recommendations.[1,88] For convenience in clinical use, two algorithms were created for the surveillance and treatment of HCC. A full English version was uploaded to the website of the JSH (www.jsh.or.jp/) in 2006.

The treatment algorithm for HCC was made on the basis of three independent factors: degree of liver damage, tumor number and tumor size. For the resulting six patients' subgroups, the first- and second-line therapies were recommended as objectively as possible (Fig. 1). The degree of liver damage is a modified system based on the Child–Pugh classification: "encephalopathy" was replaced by $ICGR_{15}$, to provide an accurate evaluation of liver functional reserve, particularly in surgical candidates.

Patients with mild (class A) or moderate (class B) liver damage are subject to the following recommendations: (i) in patients with a single tumor, liver resection is recommended, irrespective of the tumor size (percutaneous ablation may be performed if liver damage is of class B and the tumor is no more than 2 cm in size); (ii) for patients with two or three tumors smaller than 3 cm, resection or ablation are recommended; (iii) for patients with two or three tumors larger than 3 cm, resection or TACE are recommended; and (iv) for patients with more than four tumors, TACE or HAIC is recommended. The recommendations for patients with severe (class C) liver damage are as follows: (v) in patients with tumor(s) meeting the Milan criteria, liver transplantation is recommended; and (vi) for patients with more than four tumors, palliative treatment is recommended. For patients with extrahepatic metastasis, chemotherapy may be performed.

The rationale for selecting resection or ablation in patients with class A or B liver damage is based on the outcome of the largest multicenter study involving 12 888 patients in Japan.[59] The recommendation for TACE is based on the findings of two RCT showing a significant improvement in the survival of patients with multiple tumors and class A or B liver damage.[84,85] The indication for liver transplantation is derived from a prospective cohort study using the Milan criteria,[71] and a nationwide survey of Japan justifying the criteria in living donor transplantation.[74]

Consensus-based treatment algorithm

An expert panel of the JSH established a consensus-based treatment algorithm based on the therapeutic policies that are widely used in Japan.[89,111] This algorithm categories the patients on five clinical variables (extrahepatic spread, liver function, vascular invasion, tumor number and tumor size), and it divides the treatment options into resection, ablation, TACE, HAIC, liver

transplantation and palliative treatment (Fig. 3).[89,111] Because of the recent introduction of sorafenib in Japan, this consensus-based treatment algorithm was further revised and approved by the experts at the consensus meeting.[111,112]

Essentially, the consensus-based algorithm follows the evidence-based algorithm, but the treatments widely used in Japan were included by consensus, even though the evidence may be weak. The major differences in the consensus-based algorithm include: (i) ablation is sometimes performed in patients with a single, hypovascular early HCC; (ii) sorafenib is recommended for use in Child–Pugh A patients with vascular invasion, TACE failure or extrahepatic spread of HCC;[109,112] and (iii) liver transplantation is recommended, even for Child–Pugh A/B patients, if the Milan criteria are met.

The consensus-based algorithm based on the consensus of a large number of specialists, and a treatment strategy for management of HCC in Japan is important, and should be revised based on prospective trials for aspects of the algorithm lacking sufficient evidence.[111,112]

Informative statement 5. RFA might be recommended as a first-line treatment option in patients with a single, hypervascular HCC of less than 2 cm in size and with preserved liver function (Child–Pugh A or Liver Damage Class A). However, there was a discrepancy between surgeons and non-surgeons for this statement. This statement is strongly supported by non-surgeons (68%), whereas 80% of the surgeons favor resection rather than RFA. Recommendation 17. Resection should be considered as the first-line treatment option for patients with a single, hypervascular HCC of 3 cm or more in size and with preserved liver function (Child–Pugh A or Liver Damage Class A).

The revised version of the consensus-based treatment algorithm for HCC proposed by the JSH (Fig. 3) should aid decision-making at every stage in clinical practice. By sharing the information contained within the treatment algorithm chart, the physicians can offer recommended treatment options to the patient who can then choose one based on their preference (Fig. 3).

CONCLUSIONS

THIS CONSENSUS STATEMENT is a conclusion of the consensus meeting of HCC, which was held at the 45th JSH meeting, Kobe, Japan on 4–5 June 2009 (Congress President: Professor Masatoshi Kudo). This manuscript and recommendations largely reflect the daily practice in the real world carried out throughout Japan. The biggest difference of Japan's HCC practice from Western countries are pathological assessment issue, prognostic staging system, surveillance and diagnostic strategy, treatment strategy including role of HAIC, and method of RFA procedure, and treatment algorithm shown in Figure 3.

We believe every reader of this manuscript will well understand the real Japanese HCC practice much better than the other already published arterial articles. It is needless to say that consensus statements like this article should be regularly revised every 3–4 years because solid evidence or new diagnostic and treatment tool/drug or concept will be published and then established in clinical practice every year.

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Special Report

Response Evaluation Criteria in Cancer of the Liver (RECICL) proposed by the Liver Cancer Study Group of Japan (2009 Revised Version)

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The World Health Organization (WHO) criteria and Response Evaluation Criteria in Solid Tumors (RECIST) are inappropriate to assess the direct effects of treatment on the hepatocellular carcinoma (HCC) by locoreginal therapies such as radiofrequency ablation (RFA) and transcatheter arterial chemoembolization (TACE). Therefore, establishment of response evaluation criteria solely devoted for HCC is needed urgently in the clinical practice as well as in the clinical trials of HCC treatment, such as molecular targeted therapies, which cause necrosis of the tumor. Response Evaluation Criteria in Cancer of the Liver (RECICL) was revised in 2009 by Liver Cancer Study Group of Japan based on the 2004 version of RECICL, which was commonly used in Japan. Major revised points of the RECICL 2009 is to provide TE4a (Complete response with enough ablative margin) and TE4b (complete response without enough ablative margin) for local ablation therapy. Second revised point is that setting the timing at which the overall treatment effects are assessed. Third point is that emergence of new lesion in the liver is regarded as progressive disease, different from 2004 version. Finally, 3 tumor markers including alpha-fetoprotein (AFP) and AFP-L3 and des-gamma-carboxy protein (DCP) were also added for the overall treatment response. We hope this new treatment response criteria, RECICL, proposed by Liver Cancer Study Group of Japan will benefit the HCC treatment response evaluation in the setting of the daily clinical practice and clinical trials as well not only in Japan, but also internationally.

Key words: Response Evaluation Criteria, hepatocellular carcinoma, WHO criteria, RECIST, Liver Cancer, Liver Cancer Study Group of Japan

INTRODUCTION

THE WORLD HEALTH Organization (WHO) criteria[1] and Response Evaluation Criteria in Solid Tumors (RECIST),[2] which are response evaluation criteria for solid tumors after chemotherapy, are commonly used for the evaluation of liver cancer treatment in Western countries. However, it is well known and obvious that both the WHO criteria and RECIST are inappropriate to assess the direct effects of treatment on the liver cancer lesions by ablative treatment and transcatheter arterial chemoembolization (TACE). Although effective treatments may exhibit a necrotizing effect on hepatocellular carcinoma (HCC) with deprivation of its blood flow, the WHO criteria and RECIST do not consider such necrotizing effects to be "effective"; instead, both criteria use only tumor size reduction as measures of effect. It has been shown that the tumor size reduction rate according to the WHO criteria and RECIST following TACE with lipiodol (Lip-TACE) is not correlated with the pathological necrosis rate.[3] When lipiodol is accumulated densely within the tumor, the early arterial staining is masked, and tumor size is not increased, the tumor is completely necrotized as confirmed by histology.[3] Even though the tumor is completely necrotized, it takes a long time to result in reduction of size. The nodule with complete necrosis after Lip-TACE can be seen for several years as a lipiodol more densely

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accumulated nodules than 2 weeks after the intervention. In case of radiofrequency ablation (RFA), the phenomenon is the same with Lip-TACE, though lipiodol accumulation is not seen.

Moreover, the WHO criteria are originally based on bi-dimensional measurement, which was changed to a uni-dimensional measurement in RECIST. Even if tumor necrosis is considered in the response evaluation criteria, uni-dimensional measurement is inappropriate for assessment of the direct treatment effect. Therefore, establishment of response evaluation criteria solely devoted for HCC is needed urgently in the clinical practice as well as in the clinical trials of HCC. The current report describes the newly established response evaluation criteria for HCC by revising the previously existing criteria established by the Liver Cancer Study Group of Japan.

CONCEPT OF THE RESPONSE EVALUATION CRITERIA IN CANCER OF THE LIVER (RECICL)

THE FIRST EDITION of Criteria for the Evaluation of Direct Treatment Effects in Hepatocellular Carcinoma was published in 1994.[4] The revised edition was published in 2004,[5] and is commonly used in Japan, but several problems remained in the revised criteria. Thus, a third revision was carried out before publishing the English edition of the General Rules for the Clinical and Pathological Study of Primary Liver Cancer edited by the Liver Cancer Study Group of Japan (third edition).

Current response evaluation criteria focuses on the following points: (i) development of simple criteria that are sufficiently applicable in routine clinical practice centering on local treatment (ethanol injection therapy, microwave coagulation therapy, RFA) and transcatheter arterial therapy, radiotherapy and systemic chemotherapy can also be included; (ii) assessment of direct treatment effects on intrahepatic target lesions and overall effects are described separately; and (iii) the criteria follow the fifth edition of the General Rules for the Clinical and Pathological Study of Primary Liver Cancer edited by the Liver Cancer Study Group of Japan.[6]

Considering the biological characteristics of HCC, high frequencies of "intrahepatic metastatic recurrence" and "multicentric carcinogenesis", it may not necessarily be appropriate for liver cancer to be indiscriminately diagnosed as "progressive disease" based on the appearance of "a new lesion" alone because such "a new lesion" has not been treated by ablation or TACE when the recurrent nodule exists outside of the treated area. Thus, evaluation of the direct effects of treatment on target lesions should focus on the direct therapeutic effect on the target lesions, and the overall evaluation should be investigated with close association with the prognosis.

Although the chemotherapeutic agent permeates through the liver in chemotherapy, the therapeutic effect of TACE and ablative treatments is limited only to the target lesion or the area fed by embolized artery with the tumor. Treatment is not done for the new lesions appearing outside the area where the ablation or TACE are performed. After the same treatment is carried out on the targeted new lesion, a similar treatment effect may be expected on the formerly treated lesion. Accordingly, when "a new lesion" appears in a region outside the treatment area, the new lesion (intrahepatic metastasis or multicentric carcinogenesis) may not directly indicate the prognosis. The basic concept of the 2004 version of the Japanese response evaluation criteria[5] was to exclude the new lesions from the evaluation of treatment effect on the formerly treated lesions. In other words, the emergence of a new lesion is regarded as out of the evaluation of the treatment effect for the former lesions, which is the most marked difference from the WHO criteria or RECIST.

Therefore, these criteria established by the Liver Cancer Study Group of Japan are exclusively specified for the Evaluation of Therapeutic Effects on Liver Cancer, and differ from other evaluation criteria for solid tumor regarding the various points described above.

The 2004 version of the Criteria for the Evaluation of Direct Treatment Effects in Hepatocellular Carcinoma are superior to the WHO criteria or RECIST because it considers the biological characteristics of HCC as follows: (i) tumor necrosis is regarded as a direct effect of treatment on the target lesion as well as tumor size reduction even though it is minimal; (ii) tumors are measured in two dimensions; (iii) the dense accumulation of lipiodol is regarded as necrosis;[3] and (iv) the emergence of a new lesion is not regarded as a "progressive disease" in evaluation of the treated nodule.

However, several problems remained in the 2004 version: (i) assessment of direct treatment effects was performed at 3 months, while the overall evaluation was performed at 6 months; and (ii) even though the direct effects on target nodules varies among treatment methods, the timing of assessment was not described. To overcome these limitations, some minor changes were made in this 2009 revised version. These criteria may be suitable mainly for local treatment and transcatheter arterial therapy, but are also applicable for radiotherapy and chemotherapy in combination with

the WHO criteria and RECIST. Whether or not some criteria are superior to others will be investigated in future studies. We expect that the 2009 revised edition of Response Evaluation Criteria in Cancer of the Liver (RECICL), will be widely used in clinical practice as well as in the clinical trial settings, not only in our country but also worldwide, as the criteria are clearer and may be more suitable in response evaluation for liver cancer than WHO criteria or RECIST.

MAJOR REVISED POINTS OF THE RESPONSE EVALUATION CRITERIA IN THE 2009 VERSION

FIRST, WE HAVE clarified the direct effect of local treatments on target nodules. When the non-stained low-density area in local ablation therapy such as ethanol injection therapy, microwave coagulation therapy and RFA covers all parts of the low-density area in the late phase of dynamic computed tomography (CT) scan before treatment, the lesion is regarded as 100% necrotized and described as treatment effect 4 (TE4), even though the size of the nodule does not decrease in the follow-up CT scan or multiple resonance imaging (MRI). However, when the non-stained low-density area does not cover the low-density area before the treatment, the risk of local recurrence is high.[7–9] Therefore, for ethanol injection therapy, microwave coagulation therapy and RFA, when the non-stained low-density area is slightly wider across the entire circumference than the low-density area in the late phase of dynamic CT scan before treatment, the lesion is regarded as 100% necrotized (TE4a). When only hypervascularity has disappeared without a slightly wider non-stained region than the low-density area on dynamic CT scan, the condition is judged as TE4b (Table 1).

Second, we have settled the timing at which the overall treatment effects are assessed: (i) the maximum response within 3 months is regarded as the overall treatment effect; (ii) for transcatheter arterial therapy with lipiodol, it is desirable to assess the effect after at least 1 month; (iii) local ablative treatment can be assessed immediately after the treatment; and (iv) for radiotherapy, the maximum response within 6 months may be regarded as the overall effect.

Third, regarding the criteria for "progressive disease" in the overall evaluation, the emergence of a new lesion is regarded as "progressive disease", similar to that advocated in the WHO criteria or RECIST, as shown in the Appendix. However, new lesions are separately described in consideration of the biological characteristics of HCC and the description may contribute to a future review of the criteria, particularly for: (i) intrahepatic solitary lesions (whether it is in the treated area or outside of the treated area by ablation or TACE); (ii) intrahepatic multiple lesions; and (iii) vascular invasion/extrahepatic spread.

Fourth, the RECIST and WHO criteria may be appropriate for radiotherapy and systemic chemotherapy including molecular targeted agents because these are currently used internationally,[10–13] however, we recommend evaluation using the RECICL criteria in combination with the WHO criteria or RECIST in order to clarify which criteria among the three are the most appropriate in future studies. This point is described in the detailed regulation section.

Fifth, in the detailed regulation section, the lowest levels of three tumor markers (α-fetoprotein [AFP], AFP-L3 and Protein induced by vitamine K absence or antagonist [PIVKA-II] or des-gamma-carboxy prothrombin [DCP]) should be measured and described within 3 months and considered with reference to the overall evaluation. It may be useful to prospectively investigate whether there is a difference in the prognosis between complete response (CR) based on imaging alone and CR on imaging in combination with response of tumor markers.

Finally, we include a comparison between the WHO criteria, RECIST[14,15] and RECICL established by the Liver Cancer Study Group of Japan.

Table 1 Treatment effect (TE) on the target nodule

TE4:	The tumor-necrotizing effect is 100% or the tumor size reduction rate is 100%.*
TE4a:	Necrotized area with larger ablated area than original nodule.*
TE4b:	Necrotized area of same size with original nodule.
TE3:	The tumor-necrotizing effect or tumor size reduction rate is between 50% and <100%.*
TE2:	Effects other than TE3 and TE1.
TE1:	The tumor enlarged by >25% regardless of the necrotizing effect.

*For ethanol injection therapy, microwave coagulation therapy, and radiofrequency ablation, when the non-stained low-density area is slightly wider across the entire circumference than the low-density area in the late phase of dynamic computed tomography (CT) scan before treatment, the lesion is regarded as 100% necrotized (TE4a). When only hypervascularity has disappeared without a slightly wider non-stained region than the low-density area on dynamic CT scan, the condition is judged as TE4b. In transcatheter arterial chemoembolization (TACE), the tendency of reduction of tumor size, without tumor staining by CT scan with contrast enhancement, and denser uniform accumulation of lipiodol than just after lipiodol TACE when lipiodol is used, are classified to be TE4.

DESCRIPTION OF RECICL PROPOSED BY LIVER CANCER STUDY GROUP OF JAPAN

Subjects

THE SUBJECTS ARE patients who are treated initially and for recurrence. Because responses to treatment are evaluated, as a rule, by dynamic CT, intrahepatic lesions with hypervascular tumors are the principle targets of the RECICL criteria. It is essential that tumors can be clearly visualized using an imaging technique.

Detailed description

Description of past medical history

1 Methods and date when definitive diagnosis of liver cancer was made.
2 Previous treatment modality (as described in "c. Description of treatment modalities").
3 Dates of initiation and completion of previous treatment.
4 Methods and date when recurrence was diagnosed.

Descriptions of liver cancer at the time of the initiation of treatment

These issues are based on the second English Edition of the General Rules for the Clinical and Pathological Study of Primary Liver Cancer (edited by the Liver Cancer Study Group of Japan).[16] The following items should be noted:

1 Tumor location.
2 Tumor size, number, and vascular invasion. The tumor size is presented as the major axis and maximum diameter crossing the major axis at a right angle.
3 Macroscopic types.[16,17]
4 Macroscopic staging. Even for tumors that are only assessable by imaging, staging should be described following the rules for surgical findings and the resected specimen.[16,17]
5 Histological grading when biopsy is performed.[16,17]

Description of treatment modalities

1 Name of treatment: transcatheter hepatic arterial therapy (transcatheter arterial infusion chemotherapy, transcatheter arterial embolization, TACE), local treatment (ethanol injection therapy, microwave coagulation therapy, RFA), radiotherapy such as Liniac, γ-knife, or proton beam line, systemic chemotherapy.
2 Details of treatment: for treatments using drugs, the name of drugs* (anticancer drugs, Lipiodol, etc.), route of administration, treatment interval and single dose, and the total number of administrations and total dose should be described. For other treatment methods, the details should be described appropriately. When the treatment is discontinued, the reason for discontinuation and the presence or absence of adverse effects should be described. (*In addition to the chemotherapeutic drugs, any drugs directly injected into the tumor to necrotize it, such as ethanol, and/or embolizing materials, should be described.)
3 Dates of initiation and completion or termination of treatment.

Assessment of direct treatment effect on target nodule

1 On assessment of the direct effect of treatment on the target nodule, the tumor-necrotizing effect and tumor size reduction rate are calculated based on the size reduction or disappearance of hypervascularity of the nodule on dynamic CT. Findings of dynamic MRI, and/or contrast-enhanced ultrasonography can substitute dynamic CT.
2 The necrotizing effect is assessed by imaging. The percent ratio of the necrotized area to the cross-sectional area of the tumor should be calculated.* (*When various cross-sections are obtained for a single tumor, the total sum of the necrotic area should be used; however, when the maximum cross-section represents the entire findings of the tumor, assessment may be made based on the maximum cross-sectional area.)
3 The size reduction rate is calculated using the equation below, after calculating the product of the major axis of the maximum cross-section by the maximum diameter crossing the major axis at a right angle: size reduction rate = ([product before treatment] – [product after treatment]) / (product before treatment) × 100.
4 Direct treatment effect (TE) on target nodule: effects on individual lesions are categorized into four degrees based on the tumor-necrotizing effect observed within a fixed term* after the initiation of treatment or the maximum tumor size reduction rate, as shown in Table 1. (*For local treatments [such as ethanol injection therapy, microwave coagulation therapy, RFA], the effects are assessed immediately after treatment. For transcatheter arterial chemotherapy using lipiodol, transcatheter arterial embolization and transcatheter arterial chemoembolization, it is desirable to assess the effect after at least 1 month. For radiotherapy, the effect assessed based on the maximum response within 6 months.)
5 When multiple lesions are present in the liver, TE is determined in individual lesions.

Table 2 Overall response evaluation (effect of treatment on all intrahepatic lesions at 3 months; radiotherapy can be evaluated at 6 months)

Overall evaluation of treatment effect	Effect of treatment on the tumor
CR (complete response)	100% tumor-necrotizing effect or 100% tumor size reduction rate
PR (partial response)	The tumor-necrotizing effect or tumor size reduction rate is between 50% and <100%
SD (stable disease)	Effects other than PR and PD
PD (progressive disease)	The tumor growth >25% regardless of the necrotizing effect, or emergence of a new lesion*

*With regard to the emergence of new lesions, the lesion should be classified as either: (i) intrahepatic solitary lesion (within or outside the treatment area); (ii) intrahepatic multiple lesions (within or outside the treatment area); or (iii) vascular invasion (the portal vein, hepatic vein, bile duct)/extrahepatic spread.

OVERALL EVALUATION OF THE TREATMENT RESPONSE

1 The overall evaluation is determined, based on the effect in the entire liver and its persistence, and categorized as CR, partial response (PR), stable disease (SD) and progressive disease (PD), as defined in Table 2.
2 To use this method to predict the prognosis, TE is determined and recorded at 3 months when retreatment is not performed after the initiation of treatment, as an overall response evaluation, except for radiotherapy, in which the overall evaluation is performed at 6 months.
3 When multiple lesions are present, but the assessment of all of the lesions is difficult, evaluation of the five largest lesions may be considered to represent the overall evaluation of the entire liver, but it is not regarded as CR. In addition, CR should not be given when the findings of the maximum cross-section is regarded to represent the entire tumor. Tumors may only be described as CR when all of the intrahepatic lesions are assessable as well as the effect shown in Table 2 (100% tumor-necrotizing effect or 100% tumor size reduction rate) is obtained.

DETAILED REGULATIONS

THE NECROTIZING EFFECT is assessed based on the response evaluation criteria of treatment on target nodules.

1 The presence, on dynamic CT with an i.v. bolus injection, of a non-stained low-density area after treatment is regarded as a necrotizing effect. A non-stained low-density area represents an apparently lower level than that in the surrounding liver parenchyma in the early and late phases* of dynamic CT with an i.v. bolus injection. Usually, the CT attenuation value of a non-stained low-density area does not increase on dynamic imaging. (*The early phase represents the arterial dominant phase of dynamic CT. The late phase represents the equilibrium phase of dynamic CT.)
2 When lipiodol is used, the presence of a region retaining lipiodol homogeneously and densely in the tumor shown on CT 1 month after therapy is regarded as a necrotizing effect. Dynamic MRI, Doppler ultrasonography and contrast-enhanced ultrasonography can be also used.
3 The effects of radiotherapy, systemic chemotherapy (including treatment with molecular targeted agents) and hepatic arterial chemotherapy should be described by both RECIST and present criteria, RECICL.
4 The lowest levels of three tumor markers (AFP, AFP-L3 fraction, PIVKA-II or DCP) should be recorded as reference values for the overall response evaluation.

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