

Year in Review: Top Papers in Interventional Oncology

A summary of four recent studies evaluating locoregional therapies for hepatocellular carcinoma and percutaneous ablation for non–small cell lung cancer and their potential impact on the field.

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Transarterial Chemoembolization Plus Thermal Ablation in Unresectable Hepatocellular Carcinoma: The Phase 3 TORCH Randomized Clinical Trial

Lyu N, Yi J, Wu X, et al. *JAMA Oncol*. Published online July 30, 2026. doi: 10.1001/jamaoncol.2026.2366

SUMMARY

The TORCH trial was a phase 3, open-label, randomized clinical trial evaluating transarterial chemoembolization (TACE) followed by thermal ablation compared with TACE alone in patients with liver-confined, unresectable hepatocellular carcinoma (HCC). The study was conducted at two tertiary centers in China and enrolled 241 patients with Barcelona Clinic Liver Cancer (BCLC) stage B disease, who were randomized 1:1 to TACE followed by selective radiofrequency ablation or TACE alone.

The rationale for the combination was to address some of the limitations of TACE alone. Although TACE can achieve substantial tumor necrosis, residual viable tumor may remain, particularly in larger or more complex lesions. Selective ablation of residual viable disease following embolization may offer a means of obtaining more complete local tumor control.

The primary endpoint was progression-free survival (PFS) by Response Evaluation Criteria in Solid Tumors (RECIST) version 1.1. Secondary endpoints included overall survival (OS), tumor response and PFS by modified RECIST, untreatable PFS, and safety. Median PFS was 17.7 months in the TACE/ablation group compared with 7.3 months with TACE alone (hazard ratio [HR], 0.47; 95% CI, 0.34-0.65; $P < .001$). Untreatable PFS was also substantially prolonged, from 12.3 months with TACE alone to 35.1 months with combination therapy (HR, 0.40; 95% CI, 0.27-0.58; $P < .001$).

Most importantly, the improvement in disease control translated into a significant OS benefit. Median OS was 88.6 months in the TACE/ablation group compared with 35.1 months in the TACE alone group (HR, 0.50; 95% CI, 0.34-0.73; $P < .001$). Grade 3 or 4 treatment-related adverse events were reported in 23.2% of patients receiving TACE/ablation compared with 18.3% receiving TACE alone.

WHY THIS ARTICLE IS IMPORTANT

The TORCH trial is particularly notable because it is a well-designed randomized phase 3 trial demonstrating that combining two established locoregional therapies can produce not only improved tumor control but also a substantial OS benefit. The magnitude of the reported OS difference (88.6 vs 35.1 months) is striking and makes this an important interventional oncology study.

However, an important consideration is which patients with intermediate-stage HCC these results apply to. The investigators characterized tumor burden using the 6-and-12 score, a simple metric calculated by adding the diameter (in centimeters) of the largest tumor to the total number of tumors. Patients were divided into three groups— ≤ 6 , > 6 to ≤ 12 , and > 12 —with increasing scores representing increasing intrahepatic tumor burden. For example, a patient with a single, 5-cm tumor would have a score of 6, as would a patient with three tumors whose largest tumor measures 3 cm.

This is useful because BCLC B encompasses an extremely heterogeneous group of patients. A patient with a few relatively small tumors and a patient with extensive multifocal bilobar disease may both be classified as BCLC B but are very different candidates for combined TACE and ablation. In TORCH, approximately 90% of patients had a 6-and-12 score ≤ 12 , whereas relatively few had a score > 12 . Thus, the trial primarily studied patients with low-to-moderate rather than extremely high intrahepatic tumor burden.

This distinction also makes intuitive sense from an interventional oncology perspective. The rationale for sequential TACE and ablation is strongest when TACE can treat the arterialized tumor burden and the remaining viable tumors are sufficiently limited in size, number, and location to permit complete thermal ablation. The results therefore should not be interpreted as demonstrating that all patients with BCLC B HCC should undergo TACE followed by ablation. Rather, they suggest that a selected subset of patients with intermediate-stage HCC and a technically ablatable tumor burden may derive substantial benefit from combining the two modalities.

The applicability of TORCH to contemporary United States practice is also somewhat limited. Although TACE remains widely used worldwide, yttrium-90 (Y90) radioembolization has become an increasingly dominant transarterial treatment strategy in United States interventional oncology practice. Contemporary United States transplant data, for example, demonstrate that transarterial radioembolization (TARE) has surpassed TACE as the most frequently used bridging locoregional therapy before liver transplantation. Consequently, the specific question of adding thermal ablation after TACE may be encountered less frequently in many United States practices.

Nonetheless, this remains an important and interesting paper. Randomized phase 3 trials of interventional oncology therapies with an OS endpoint remain relatively uncommon. TORCH provides high-level evidence that thoughtfully combining locoregional modalities can meaningfully alter oncologic outcomes. Perhaps the broader message is not simply that TACE should be followed by ablation, but that selected patients with intermediate-stage HCC may benefit from a multimodality locoregional strategy rather than treatment with a single modality alone.

Yttrium-90 Radioembolization Is Associated With a Lower Risk of Liver Transplant Waitlist Dropout Than Chemoembolization in Hepatocellular Carcinoma

Kim NG, Yao FY, Kwong AJ, Mehta N. *J Hepatol.* 2026;84:1112-1120. doi: 10.1016/j.jhep.2026.01.008

SUMMARY

This retrospective study compared TARE with TACE as first-line locoregional therapy in patients with HCC awaiting liver transplantation. The investigators used the United Network for Organ Sharing (UNOS)/Organ Procurement and Transplantation Network database to examine outcomes during the contemporary MMaT-3 (median model for end-stage liver disease at transplant minus 3 points) era. The study included 5,677 adult liver transplant candidates with an approved HCC exception who received first-line treatment with either TACE or TARE between May 2019 and October 2024. The cohort was almost exactly divided between TACE ($n = 2,839$) and TARE ($n = 2,838$).

The primary endpoint was waitlist dropout, with liver transplantation treated as a competing event. Because this was an observational study and treatment selection was not randomized, the authors used inverse probability of treatment weighting and competing-risk analyses to adjust for differences in patient, liver disease, tumor, and transplant center characteristics.

Several findings favored TARE. Patients initially treated with TARE were considerably more likely to require only one locoregional treatment than those initially treated with TACE (80.6% vs 57.8%). Correspondingly, the likelihood of requiring a second locoregional treatment by 1 year was lower following TARE. These differences suggest that TARE may provide more durable tumor control and reduce the treatment burden for patients during what can be a prolonged period on the transplant waitlist.

Most importantly, TARE was associated with improved waitlist outcomes. After weighted competing-risk analysis, TARE was associated with a 22% lower likelihood of waitlist dropout compared with TACE (HR, 0.78; 95% CI, 0.69-0.89; $P < .001$). Waitlist dropout rates were consistently lower with TARE than with TACE at 1 year (8.9% vs 11.4%), 2 years (14.2% vs 19.0%), and 3 years (16.8% vs 22.1%).

Explant pathology provided additional evidence of improved tumor control. Complete tumor necrosis was observed in 35.3% of patients treated with TARE compared

with 20.2% after TACE, and patients treated with TARE were less likely to have tumor burden beyond Milan criteria on explant. Thus, the association between TARE and reduced waitlist dropout was accompanied by both a decreased need for repeat locoregional treatment and more favorable pathologic findings at transplantation.

WHY THIS ARTICLE IS IMPORTANT

Over the past several years, there has been a major shift in the United States from TACE toward Y90 radioembolization for the treatment of HCC, including as bridging therapy before liver transplantation. TACE was historically the dominant transarterial treatment, whereas TARE has now become the most frequently used locoregional therapy in patients with HCC awaiting transplantation. This change in practice has occurred despite relatively limited high-level comparative data demonstrating that TARE produces better, clinically meaningful transplant outcomes.

There have been data supporting advantages of TARE over TACE, including improved tumor response and time to progression. However, prior randomized trials comparing the two modalities have been relatively small, making it difficult to determine whether improved tumor control actually translates into a greater likelihood of successfully reaching transplantation.

This study is particularly important because it provides strong contemporary evidence supporting a change in practice that has, to some extent, already occurred. In > 5,600 patients from the national UNOS database, first-

line TARE was associated with a 22% lower hazard of waitlist dropout compared with TACE. The findings were also internally consistent: Patients treated with TARE were substantially more likely to require only a single locoregional treatment and had higher rates of complete tumor necrosis on explant.

Waitlist dropout is also a particularly meaningful endpoint. For a patient being bridged to liver transplantation, the purpose of locoregional therapy is ultimately not simply to produce a favorable radiographic response but to maintain tumor control long enough for the patient to reach transplantation. Demonstrating an association between TARE and a reduced risk of waitlist dropout provides clinically relevant support for the increasing use of Y90 in this setting.

An important limitation is that this is a retrospective analysis rather than a randomized trial. Treatment selection may reflect tumor location, center expertise, patient characteristics, and other factors that cannot be completely accounted for in the UNOS database. Detailed information regarding TACE technique, Y90 dosimetry, radiographic response, and the reasons for choosing one treatment over another were also unavailable. Nevertheless, performing a randomized trial of this size with transplant waitlist dropout as an endpoint would be extremely difficult. In that context, the size of this contemporary national cohort and the consistency of the waitlist, treatment burden, and explant pathology findings provide important evidence supporting the shift from TACE toward TARE that has already occurred in United States practice.

Ablation Plus Immunotherapy Versus Immunotherapy Alone in Patients With Advanced NSCLC Who Develop Oligo-Residual Disease After Anti-PD-1/L1 Therapy (BOOSTER): A Randomized Phase 2 Trial

Yang S, Liu X, Yu J, et al. *Signal Transduct Target Ther*. 2025;10:365. doi: 10.1038/s41392-025-02460-z

SUMMARY

The BOOSTER trial was a randomized phase 2 study evaluating whether ablation of oligoresidual disease (ORD) could improve outcomes in patients with advanced non-small cell lung cancer (NSCLC) who had already benefited from first-line anti-PD-1/PD-L1 (programmed death-1/programmed death-ligand 1) therapy. Patients had achieved partial response or stable disease after immunotherapy, with or without chemotherapy, and had no evidence of disease progression before randomization. ORD was defined as residual disease limited to no more than five lesions involving no more than three organs.

Sixty-five patients were randomized 2:1 to ablation followed by continued immunotherapy or continued immunotherapy alone. After three patients withdrew consent before treatment, the final analysis included 42 patients in the ablation group and 20 in the immunotherapy alone group. In patients assigned to ablation, technically amenable residual pulmonary lesions were treated using either cryoablation or thermal ablation (microwave and radiofrequency).

At a median 17.8-month follow-up, median PFS measured from initiation of immunotherapy was 26.7 months with ablation plus continued immunotherapy compared with 11.7 months with immunotherapy alone (HR,

0.213; 95% CI, 0.099-0.461; $P < .001$). When PFS was measured from randomization, the benefit remained significant at 17.1 versus 4.4 months (HR, 0.198; 95% CI, 0.090-0.432; $P < .001$). OS also favored ablation, although median OS had not been reached.

Ablation also appeared to influence subsequent patterns of progression. Progression involving both preexisting and new lesions occurred in 7% of patients undergoing ablation versus 36% receiving immunotherapy alone, while extensive progression occurred in 27% versus 43%, respectively. An exploratory analysis suggested longer PFS with cryoablation than with thermal ablation, although only 13 patients underwent cryoablation, and this comparison was not powered to establish differences between ablation modalities.

The addition of ablation was generally well tolerated. Pneumothorax was the most common ablation-related adverse event, occurring in 35.7% of patients, but only one grade 3 pneumothorax occurred and there were no unexpected safety signals.

WHY THIS ARTICLE IS IMPORTANT

The most interesting aspect of BOOSTER may be when ablation was performed. Traditionally, interventional oncologists have been asked to treat oligoprogressive disease—one or several tumors that begin growing despite otherwise effective systemic therapy. BOOSTER evaluates a different and potentially broader strategy: planned consolidation of residual disease before progression occurs.

In these patients, immunotherapy had already demonstrated effectiveness and reduced the overall disease burden. Rather than waiting for the remaining tumors to progress, the investigators ablated residual pulmonary disease while continuing the same immunotherapy. The more than doubling of median PFS suggests that eliminating these residual sites may substantially extend the duration of benefit from systemic treatment.

This concept could have important implications for the role of interventional oncology in multidisciplinary cancer care. Ablation would no longer be reserved primarily for treating isolated sites after systemic therapy begins

to fail. Instead, interventional oncologists could become involved earlier in the treatment course, identifying patients with a favorable systemic response but limited residual disease who may benefit from consolidative local therapy. In that sense, BOOSTER supports a model in which ablation and systemic therapy are planned as complementary components of cancer treatment.

The change in subsequent patterns of progression is also intriguing. Patients undergoing ablation were less likely to develop simultaneous progression in existing and new lesions and less likely to develop extensive progression. One possible explanation is that residual tumors represent reservoirs of resistant clones, and eliminating them delays subsequent systemic progression. The authors also raise the possibility of immunologic effects from ablation, including antigen release and alterations in the tumor immune environment. However, the study does not establish that the benefit resulted from immune synergy rather than simply improved control of residual disease.

The exploratory cryoablation findings are particularly interesting for interventional oncologists. Patients undergoing cryoablation appeared to have longer PFS than those treated with thermal ablation, accompanied by a trend toward increased interferon- α . However, only 13 patients underwent cryoablation, and the study was neither designed nor powered to compare ablation modalities. These findings should therefore be viewed as hypothesis-generating rather than evidence that cryoablation is superior.

BOOSTER remains a relatively small phase 2 trial, and larger multicenter, randomized studies will be needed before consolidative ablation becomes a standard component of treatment for advanced NSCLC. Nevertheless, the trial raises an important question for interventional oncology: Rather than waiting for oligoprogression to occur, should we be treating limited residual disease while systemic therapy is still working? If validated, this could represent a meaningful expansion of the role of percutaneous ablation in patients with metastatic cancer.

Lung Ablation Outcomes for Inoperable Stage IA Non–Small Cell Lung Cancer

Rehman S, Naidu S, Mehdi RS, et al. *J Vasc Interv Radiol.* 2026;37:107974. doi: 10.1016/j.jvir.2025.107974

SUMMARY

This retrospective, single-institution study evaluated the safety and effectiveness of percutaneous cryoablation as definitive therapy for medically inoperable patients with biopsy-proven stage IA NSCLC. A total of 176 con-

secutive patients underwent CT-guided cryoablation between July 2020 and July 2025. Eligible tumors measured ≤ 3 cm, and patients were medically inoperable or had declined surgery, had an ECOG (Eastern Cooperative Oncology Group) performance status < 2 , and had signif-

icant underlying pulmonary disease. Of the 176 patients, 170 had follow-up data available for survival analysis.

All procedures were performed under general anesthesia by a thoracic interventional radiologist using a standardized cryoablation technique. Probe number and configuration were determined by tumor size and geometry, with approximately 2-cm interprobe spacing. The investigators used a triple freeze-thaw protocol consisting of sequential 3-, 7-, and 10-minute freeze cycles, with the ice ball monitored to obtain approximately a 1-cm margin around the tumor. Patients subsequently underwent structured imaging surveillance with CT and positron emission tomography/CT.

The primary endpoint was local PFS (LPFS), with secondary outcomes including OS, locoregional and distant progression, and adverse events. LPFS was 91.8% at 1 year and 89.4% at 3 years, with an overall tumor progression rate of 10.6%. OS was 100% at 1 year and 94.7% at 3 years. These outcomes were achieved in an elderly and medically high-risk population; 82.9% of patients were aged ≥ 70 years and 71% had a smoking history of at least 30 pack-years.

Tumor size was an important determinant of outcome. Stage IA3 tumors measuring > 2 to 3 cm had a significantly greater risk of local progression than stage IA2 tumors measuring > 1 to 2 cm (adjusted HR, 4.71; 95% CI, 1.84-12.06; $P = .001$). Three-year LPFS was 95.9% for stage IA2 tumors compared with 80.8% for stage IA3 tumors. Central tumor location demonstrated a trend toward increased local progression but was not independently significant after adjustment for tumor size.

The safety profile was favorable given the patients' underlying pulmonary disease. Pneumothorax requiring chest tube placement occurred in 17.6%, and hemothorax occurred in 2.3%. There were no grade 4 or 5 adverse events or procedure-related deaths. Twelve patients underwent repeat cryoablation, which was also well tolerated.

WHY THIS ARTICLE IS IMPORTANT

Surgical resection remains the standard treatment for operable stage I NSCLC, while stereotactic body radiation therapy (SBRT) is commonly used in patients who are medically inoperable. Percutaneous thermal ablation is another minimally invasive treatment option, but its role as definitive therapy for early stage primary lung cancer continues to evolve.

This study represents a large experience with percutaneous cryoablation specifically in a medically high-risk population with stage IA NSCLC. The reported local control and survival outcomes are impressive, particularly for tumors ≤ 2 cm, and the treatment was performed with acceptable morbidity and no procedure-related mortality.

The study also reinforces an important principle of percutaneous lung ablation: Tumor size matters. Local

control was substantially better for stage IA2 tumors than for tumors measuring > 2 cm, emphasizing the importance of patient selection and adequate ablative margins. The standardized triple freeze-thaw technique used in this series may also be relevant, because durable local control after cryoablation is likely dependent not simply on performing an ablation but on achieving appropriate probe geometry, ice ball coverage, and margins.

The limitations of this study should be noted. This was a retrospective, single-center study without a comparator group, and therefore these results cannot establish equivalence or superiority to SBRT or surgery. Nonetheless, as lung cancer screening identifies increasing numbers of small peripheral tumors in older patients with significant pulmonary and cardiovascular comorbidities, the population potentially suitable for percutaneous ablation is likely to increase. These data provide further support for including interventional oncology in multidisciplinary discussions of medically inoperable patients with early stage NSCLC and provide additional justification for prospective comparisons of percutaneous ablation with other definitive local therapies. ■

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