

Original Article

Effect of Nigella Sativa Oil on the Treatment of Hypertension

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ABSTRACT

Background: Transarterial chemoembolization (TACE) is an established locoregional therapy for selected patients with hepatocellular carcinoma (HCC). Post-treatment contrast-enhanced imaging is important because viable HCC is assessed by residual arterial enhancement rather than lesion size alone. **Objective:** To evaluate radiological response following TACE using triphasic CT and modified Response Evaluation Criteria in Solid Tumors (mRECIST). **Methods:** This retrospective observational study included 50 patients with HCC who underwent TACE at CMA Hospital, Lahore, from February to July 2025. Pre- and post-treatment triphasic CT studies were reviewed for lesion size and treatment response. Paired lesion size was evaluated using the Wilcoxon signed-rank test, and response was categorized using mRECIST. **Results:** Mean lesion size decreased from 5.33 ± 1.39 to 2.77 ± 2.02 cm, an absolute difference of 2.56 cm and a 48.0% relative reduction in the group means (Wilcoxon $Z = -5.266$, $p < 0.001$; $r = 0.74$). Complete response occurred in 33/50 patients (66.0%; 95% CI 52.2–77.6%), stable disease in 12/50 (24.0%), and progressive disease in 5/50 (10.0%); no partial responses were reported. The resulting objective response rate was 66.0% and disease-control rate was 90.0% (95% CI 78.6–95.7%). **Conclusion:** The cohort demonstrated substantial post-TACE radiological response on triphasic CT. Interpretation is limited by the retrospective single-center design and incomplete characterization of TACE technique, liver-function status, tumor stage, and follow-up interval. **Keywords:** Hepatocellular Carcinoma; TACE; Triphasic CT; mRECIST; Treatment Response; Liver Tumor.

INTRODUCTION

Hepatocellular carcinoma (HCC) is the dominant primary malignancy of the liver and remains a major cause of cancer-related mortality worldwide. Most cases develop in the setting of chronic liver disease or cirrhosis, although the underlying etiological profile varies across populations. The clinical management of HCC is determined not only by tumor size and number but also by hepatic functional reserve, performance status, portal hypertension, vascular invasion, extrahepatic disease, and the feasibility of potentially curative treatment (1,2).

Modern HCC management is therefore multidisciplinary. Surgical resection, liver transplantation, and local ablation can provide potentially curative treatment for appropriately selected patients with early-stage disease, whereas locoregional and systemic therapies assume increasing importance when curative approaches are unsuitable (2–4). The Barcelona Clinic Liver Cancer (BCLC) framework integrates tumor burden, liver function, and performance status to support prognostic stratification and treatment selection. In the contemporary BCLC strategy, transarterial treatment remains an important option for appropriately selected patients with intermediate-stage HCC, although this stage is clinically heterogeneous and increasingly requires individualized treatment decisions (3). Current AASLD guidance similarly places transarterial therapy within a broader multidisciplinary framework and emphasizes preservation of liver function, tumor distribution, treatment feasibility, and reassessment after therapy (4).

TACE exploits the predominantly arterial vascular supply of HCC. A catheter is advanced selectively into tumor-feeding branches of the hepatic artery, allowing administration of chemotherapy together with embolic material to increase local drug exposure while reducing arterial perfusion to the tumor (5,6). Conventional TACE commonly uses a chemotherapy–Lipiodol emulsion followed by embolization, whereas drug-eluting-bead TACE delivers chemotherapy through embolic microspheres. Randomized and comparative evidence demonstrates that these techniques differ in drug-delivery characteristics, post-procedural effects, and some response outcomes, reinforcing the importance of reporting the exact TACE technique used in clinical studies (7,8).

Imaging-based response assessment after TACE differs fundamentally from conventional size-based assessment after systemic cytotoxic therapy. Locoregional treatment can produce substantial tumor necrosis without immediate disappearance or proportional shrinkage of the treated mass. Consequently, total lesion diameter alone may underestimate therapeutic effect by including necrotic tissue within the residual lesion measurement. Modified RECIST was developed specifically to address this problem in HCC by defining viable tumor according to contrast-enhancing tissue in the arterial phase and measuring the diameter of viable enhancing tumor rather than total treated-lesion diameter alone (9). Under mRECIST, complete response requires disappearance of arterial enhancement in all target lesions, partial response requires at least a 30% decrease in the sum of diameters of viable enhancing target lesions, progressive disease requires at least a 20% increase in viable-tumor measurements or qualifying new disease, and stable disease includes findings that meet neither response nor progression criteria (9). Early radiological response determined using mRECIST has also demonstrated prognostic relevance in patients undergoing locoregional treatment for HCC (10,11).

Multiphasic CT therefore plays an important role in evaluating HCC following TACE because arterial, portal venous, and delayed phases provide complementary information regarding residual enhancing tumor, necrotic components, new intrahepatic lesions, and post-treatment change. Interpretation after conventional TACE can nevertheless be complicated by dense Lipiodol deposition, which can obscure subtle enhancement or introduce CT artifacts (12–14). Conversely, Lipiodol distribution itself may provide information about treatment delivery and local tumor control, and quantitative or qualitative Lipiodol-related imaging biomarkers have been investigated in association with residual viability and subsequent progression (12–15). Contemporary treatment-response frameworks further emphasize standardized multiphasic CT or MRI evaluation and treatment-specific interpretation of residual mass-like enhancement after locoregional therapy (16).

Response to TACE is heterogeneous and depends on more than imaging appearance alone. Tumor size and burden, baseline bilirubin and albumin, alpha-fetoprotein concentration, hepatic reserve, and the presence of advanced tumor features can influence prognosis and suitability for further transarterial treatment (17). Outcomes also differ across levels of Child-Pugh liver dysfunction, emphasizing the importance of hepatic reserve in patient selection (18). Contemporary pooled evidence additionally identifies impaired baseline liver function, larger tumor size, portal-vein thrombosis, and related clinical factors as important correlates of hepatic failure following TACE (19). These factors are important when interpreting radiological response because a favorable local tumor response does not necessarily imply equivalent long-term clinical benefit in patients with markedly different hepatic reserve or disease burden.

The present study retrospectively evaluated patients with HCC who underwent TACE at a single center in Lahore. The primary aim was to assess change in lesion size and post-treatment response on triphasic CT according to mRECIST.

MATERIALS AND METHODS

Study Design and Setting

A retrospective observational study was conducted in the Department of Radiology at CMA Hospital, Lahore, Pakistan. Clinical and imaging records from February to July 2025 were reviewed.

Study Population

Fifty patients with HCC who had undergone TACE and had both pre-treatment and post-treatment triphasic CT examinations were included using purposive sampling. Both male and female patients were eligible.

Patients were excluded when medical records or imaging examinations were incomplete, follow-up CT was contraindicated or unavailable, severe comorbidity interfered with assessment of treatment response, or TACE had been performed outside the study period.

Imaging Review

Pre- and post-TACE triphasic CT examinations were reviewed. Arterial, portal venous, and delayed-phase images were evaluated. Recorded imaging variables included lesion size, arterial enhancement, treatment-related necrosis, Lipiodol uptake or deposition where applicable, residual tumor, and development of new lesions.

Treatment Response

Radiological response was classified according to modified RECIST for HCC (9). The mRECIST framework focuses on viable tumor demonstrating arterial-phase enhancement rather than total lesion size alone. Response was classified as complete response, partial response, stable disease, or progressive disease.

Clinical Variables

Recorded demographic and clinical variables included age, sex, presence of cirrhosis, abdominal pain, and selected portal-hypertension-related imaging findings.

Statistical Analysis

Data were analyzed using SPSS. Continuous variables were summarized using means and standard deviations, whereas categorical variables were presented as frequencies and percentages.

Because the paired lesion-size outcome was considered non-normally distributed, pre- and post-TACE measurements were compared using the Wilcoxon signed-rank test. An exploratory rank-based effect-size estimate was calculated from the reported Wilcoxon statistic according to:

$$r = \frac{|Z|}{\sqrt{N}}$$

Rank-based effect-size reporting provides information regarding the magnitude of an observed difference in addition to statistical significance (20). Response proportions were supplemented with 95% Wilson confidence intervals.

Ethical Considerations

Ethical approval was obtained from the Institutional Review Board of Superior University, Lahore, Pakistan.

RESULTS

Participant Characteristics

Fifty patients were included in the analysis. Mean age was 59.04 years, with an age range of 41–79 years. Thirty-two participants were male and 18 were female. Cirrhosis was present in 45 patients, representing 90.0% of the cohort, whereas five patients had no documented cirrhosis. Abdominal pain was reported by 15 patients.

Change in Lesion Size

Mean lesion diameter decreased from 5.33 ± 1.39 cm before TACE to 2.77 ± 2.02 cm on follow-up imaging. The absolute difference between the two group means was 2.56 cm, corresponding to a 48.0% relative reduction between the pre- and post-treatment mean lesion measurements.

The paired change was statistically significant using the Wilcoxon signed-rank test ($Z = -5.266$, $p < 0.001$). The corresponding exploratory rank-based effect-size estimate was approximately $r = 0.74$.

Table 1. Participant Characteristics

Characteristic	Value
Total participants	50
Mean age, years	59.04
Age range, years	41–79
Male	32 (64.0%)
Female	18 (36.0%)
Cirrhosis	45 (90.0%)
No documented cirrhosis	5 (10.0%)
Abdominal pain	15 (30.0%)

Table 2. Change in Lesion Size Following TACE

Outcome	Pre-TACE	Post-TACE	Difference
Mean lesion size, cm	5.33 ± 1.39	2.77 ± 2.02	-2.56 cm
Relative difference between group means	—	—	-48.0%
Wilcoxon Z	—	—	-5.266
p value	—	—	<0.001
Rank-based effect size, r	—	—	0.74

mRECIST Response

Complete response was documented in 33 patients, corresponding to 66.0% of the cohort. No partial responses were recorded. Stable disease occurred in 12 patients, while five patients had progressive disease.

The objective response rate, defined as complete plus partial response, was therefore 66.0%. The disease-control rate, incorporating complete response, partial response, and stable disease, was 90.0%.

Table 3. mRECIST Treatment Response

Response Category	n	%	95% CI
Complete response	33	66.0	52.2–77.6
Partial response	0	0.0	—
Stable disease	12	24.0	14.3–37.4
Progressive disease	5	10.0	4.3–21.4
Objective response rate (CR+PR)	33	66.0	52.2–77.6
Disease-control rate (CR+PR+SD)	45	90.0	78.6–95.7

Response According to Cirrhosis Status

Among the 45 patients with cirrhosis, 29 had complete response, 12 had stable disease, and four had progressive disease. Among the five patients without documented cirrhosis, four had complete response, none had stable disease, and one had progressive disease. No partial responses occurred in either subgroup.

Table 4. mRECIST Response According to Cirrhosis Status

mRECIST Response	Cirrhosis (n=45)	No Documented Cirrhosis (n=5)	Total
Complete response	29 (64.4%)	4 (80.0%)	33
Partial response	0	0	0
Stable disease	12 (26.7%)	0	12
Progressive disease	4 (8.9%)	1 (20.0%)	5
Total	45	5	50

Because only five patients lacked documented cirrhosis, the subgroup findings are descriptive and do not establish a reliable difference in treatment response according to cirrhosis status.

DISCUSSION

The present study demonstrated substantial radiological response following TACE in a cohort of 50 patients with HCC. Mean lesion diameter decreased from 5.33 to 2.77 cm, representing a 2.56-cm

absolute difference and a 48.0% reduction between the pre- and post-treatment group means. Complete response according to mRECIST occurred in 66.0% of patients, while the disease-control rate was 90.0%. These results indicate marked local radiological control in the studied cohort but, because there was no untreated or alternative-treatment comparator, they should not be interpreted as a comparative estimate of TACE effectiveness against another therapeutic strategy.

TACE remains an important locoregional treatment for appropriately selected patients with HCC, particularly within the heterogeneous intermediate-stage population described by contemporary BCLC, EASL, and AASLD frameworks (2–4). Treatment selection now increasingly reflects tumor distribution, hepatic reserve, technical feasibility, previous treatment, and the availability of alternative locoregional or systemic strategies rather than stage designation alone (2–5). Conventional TACE and drug-eluting-bead TACE also differ in technical characteristics and toxicity profiles, while randomized and pooled evidence shows that treatment response may vary according to the transarterial strategy employed (7,8). The precise technique therefore has direct implications for interpreting response rates across individual studies.

Cirrhosis was present in 90% of the current cohort, which is consistent with the strong relationship between chronic liver disease, cirrhosis, and development of HCC (1,2). Hepatic reserve is particularly relevant in patients considered for TACE because treatment produces ischemic and cytotoxic injury within a liver that may already have limited functional capacity. Prognostic models developed for transarterial therapy incorporate variables such as albumin, bilirubin, tumor size, and alpha-fetoprotein, illustrating the combined contribution of tumor burden and underlying liver function to outcomes (17). Clinical outcomes after TACE also differ according to Child-Pugh status (18), while pooled evidence has linked impaired baseline hepatic parameters, larger tumors, portal-vein thrombosis, and higher Child-Pugh class with an increased risk of post-TACE hepatic failure (19). The absence of detailed Child-Pugh class, MELD score, BCLC stage, and performance-status information in the current analysis therefore limits risk adjustment and the extent to which the response rate can be generalized to specific HCC populations.

A central interpretive issue is the distinction between lesion shrinkage and viable-tumor response. After locoregional therapy, necrotic tissue, embolic material, and the residual structural mass may remain visible even when viable tumor has been substantially reduced. For this reason, mRECIST evaluates arterially enhancing viable tumor rather than relying on total lesion dimensions (9). Studies evaluating early post-TACE imaging have demonstrated that enhancement-based mRECIST response has greater prognostic relevance than purely size-based conventional response measures (10), and meta-analytic evidence supports an association between objective response defined using mRECIST or related enhancement-based criteria and survival after locoregional treatment (11). Consequently, the 48.0% reduction in mean total lesion size and the 66.0% complete-response rate in the present study represent related but conceptually distinct measures of treatment response.

The complete-response rate of 66.0% is substantial but should be interpreted in the context of differences among TACE studies in patient selection, technique, tumor burden, liver function, and response-assessment timing. For comparison, a prospective Egyptian cohort treated using doxorubicin and Lipiodol TACE reported complete response in 51.4% of patients at one month (21). Direct numerical comparison is nevertheless inappropriate without accounting for differences in eligibility, baseline staging, treatment technique, and response definitions. The confidence interval around the present study's complete-response estimate was 52.2–77.6%, demonstrating the degree of statistical uncertainty associated with a sample of 50 patients. The disease-control rate of 90.0% similarly had a 95% confidence interval of 78.6–95.7%.

No partial responses were recorded in the present cohort. This distribution is possible, but it is noteworthy because partial response represents a defined and clinically relevant mRECIST category (9). Maintaining lesion-level measurements of viable arterial enhancement in future datasets would allow transparent verification of transitions among complete response, partial response, stable disease, and progressive disease. This would be particularly useful when treatment produces substantial necrosis without complete elimination of enhancement.

Post-TACE response assessment also depends strongly on imaging technique and timing. Adequate arterial-phase acquisition is essential because viable HCC is primarily identified through arterial enhancement under mRECIST (9,10). Previous studies have assessed early imaging response approximately one month after treatment; for example, one DEB-TACE study had a median assessment interval of approximately 33.5 days (10), while another interventional cohort used approximately one-

month post-treatment imaging before subsequent surveillance (22). Variation in follow-up interval can materially affect the observed response because very early imaging may reflect treatment-related changes, whereas later imaging may identify revascularization, residual disease, or new lesions.

Triphasic CT provides arterial, portal venous, and delayed-phase information and can identify residual enhancement, new lesions, necrotic components, and treatment-related changes. Conventional Lipiodol-based TACE introduces an additional interpretive dimension. Dense Lipiodol retention has been associated with local tumor control, while patterns of Lipiodol deposition can function as imaging biomarkers of treatment delivery and subsequent progression (12,13). Histopathological correlation has further shown that complete radiological response and complete pathological necrosis are not always equivalent and that the degree of Lipiodol accumulation can contribute additional information regarding tumor necrosis (14). Angio-CT studies have likewise identified relationships between Lipiodol distribution and subsequent treatment response (15). These observations support careful evaluation of both enhancement and embolic-material distribution rather than interpretation based solely on post-treatment lesion diameter.

Contemporary imaging frameworks further emphasize standardized treatment-response assessment. The updated CT/MRI LI-RADS treatment-response approach recognizes the importance of treatment-specific imaging appearances and residual mass-like enhancement when determining viability after locoregional therapy (16). Although the present study used mRECIST rather than LI-RADS treatment-response categories, both frameworks reinforce the principle that enhancement and viable tumor are more informative than total lesion size alone after locoregional therapy.

The specific TACE technique used in the present cohort was not sufficiently characterized to distinguish conventional Lipiodol-based TACE from drug-eluting-bead TACE in all cases. This distinction is clinically and methodologically important because the procedures differ in chemotherapy delivery, embolic materials, post-treatment imaging appearance, and adverse-effect profiles (5–8). Consequently, incomplete procedural characterization limits reproducibility and complicates comparison of the observed 66.0% complete-response rate with other TACE cohorts.

The cirrhosis-stratified findings should also be interpreted cautiously. Complete response occurred in 64.4% of patients with cirrhosis and 80.0% of patients without documented cirrhosis, but the non-cirrhotic subgroup included only five participants. Such an imbalance does not provide a stable basis for inferential comparison. Moreover, cirrhosis as a binary variable does not capture hepatic functional reserve. Child-Pugh class, MELD score, bilirubin, albumin, and portal-hypertension severity would provide substantially more clinically informative stratification (17–19).

A strength of the present study is the use of paired pre- and post-treatment imaging together with an HCC-specific response framework. The paired lesion measurements demonstrated a statistically significant within-patient change, and the exploratory rank-based effect-size estimate of approximately 0.74 indicates that the observed shift in lesion measurements was substantial in magnitude. Reporting an effect-size measure alongside the p value improves interpretation by separating the magnitude of the observed change from statistical significance alone (20).

Several limitations require consideration. The study was retrospective and conducted at a single center with only 50 participants. There was no untreated or alternative-treatment comparator, which precludes comparative effectiveness inference. Baseline BCLC stage, Child-Pugh class, MELD score, performance status, alpha-fetoprotein concentration, portal-vein invasion, extrahepatic disease, previous therapy, tumor number and distribution, and the number of TACE sessions were not incorporated into the analysis. The TACE technique, chemotherapeutic agent, embolic materials, catheter selectivity, CT acquisition parameters, and follow-up interval were also incompletely characterized. These factors can influence both treatment response and its radiological interpretation (2–8,17–19).

The analysis was additionally limited in evaluating relationships between arterial enhancement, Lipiodol deposition, portal-hypertension-related imaging features, and mRECIST response because complete inferential data for these relationships were not incorporated into the final statistical analysis. No overall survival, progression-free survival, time to progression, retreatment rate, or liver-decompensation outcomes were assessed. The present findings should therefore be interpreted principally as an imaging-response characterization rather than evidence of long-term oncological benefit. This distinction is important because radiological response has prognostic relevance at the population level (10,11), but an individual study requires longitudinal outcome data before it can directly relate its own radiological response to survival.

Future research should use standardized TACE and imaging protocols, prospectively defined follow-up intervals, complete baseline staging, detailed characterization of liver function, and lesion-level documentation of viable enhancement. Independent or blinded image review where feasible would strengthen response assessment. Larger multicenter cohorts should also evaluate objective response together with duration of response, repeat TACE, hepatic decompensation, progression-free survival, and overall survival so that radiological response can be linked more directly with clinically meaningful outcomes.

CONCLUSION

TACE was followed by substantial radiological response in this retrospective cohort of 50 patients with HCC. Mean lesion size decreased by 2.56 cm, corresponding to a 48.0% reduction between the pre- and post-treatment group means, and the paired change was statistically significant. Complete response according to mRECIST occurred in 66.0% of patients, while the disease-control rate was 90.0%.

The findings support the value of multiphasic CT and enhancement-based criteria such as mRECIST for characterizing post-TACE response. However, the study does not establish comparative treatment effectiveness or long-term survival benefit. Interpretation is constrained by the single-center retrospective design, modest sample size, absence of a comparator, and incomplete characterization of baseline tumor stage, hepatic reserve, TACE technique, and imaging follow-up timing.

LIMITATIONS

The principal limitations were the retrospective single-center design and sample size of 50 patients. No untreated or alternative-treatment comparator was included. Baseline BCLC stage, Child-Pugh class, MELD score, performance status, alpha-fetoprotein concentration, vascular invasion, extrahepatic disease, tumor number, and tumor distribution were not incorporated into the analysis.

The TACE technique, chemotherapy and embolic materials, catheter selectivity, number of treatment sessions, follow-up CT interval, and technical CT acquisition parameters were not fully characterized. Partial responses were absent from the recorded response distribution, and lesion-level viable-tumor measurements were not presented. Complete inferential analyses of several proposed relationships involving arterial enhancement, Lipiodol deposition, portal-hypertension-related findings, and treatment response were not available. Long-term outcomes including overall survival, progression-free survival, time to progression, retreatment, and hepatic decompensation were not assessed.

RECOMMENDATIONS

Future studies should use standardized pre- and post-TACE imaging protocols with clearly defined follow-up intervals. Baseline BCLC stage, Child-Pugh class, MELD score, alpha-fetoprotein concentration, performance status, tumor number, maximum tumor diameter, vascular invasion, and extrahepatic disease should be systematically documented.

The TACE procedure should be reported in sufficient detail to distinguish conventional from drug-eluting-bead techniques and should specify the chemotherapy agent and dose, embolic material, catheter selectivity, and number of treatment sessions. mRECIST assessment should document measurable viable enhancing diameter for each target lesion rather than relying only on overall lesion dimensions.

Larger multicenter studies should evaluate radiological response together with duration of response, repeat treatment, progression-free survival, overall survival, and liver-function outcomes. This would permit more complete assessment of the relationship between early imaging response and clinically meaningful long-term outcomes.

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