Original Article

Early Response Evaluation of Hepatocellular Carcinoma After Transarterial Chemoembolization Using Triphasic Computed Tomography

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ABSTRACT

Objective: To aim of this study was to evaluate the early tumor response of hepatocellular carcinoma (HCC) to transarterial chemoembolization (TACE) using triphasic computed tomography (CT).

Study Design and Setting: This was a retrospective study conducted at Indus Hospital & Health Network, Karachi.

Methodology: A total of 102 patients were included for six months study between 1st February 2025 and 31st July 2025. Tumor response was assessed 6 weeks post-TACE according to the modified Response Evaluation Criteria in Solid Tumors (mRECIST) and categorized as complete response (CR), partial response (PR), stable disease (SD), or progressive disease (PD). The Chi-square test was applied to test statistical significance of differences across response categories, with a p-value of <0.05 considered statistically significant.

Results: CR was observed in 36% and PR in 32% of patients, giving an overall response rate of 68%. SD was seen in 20% and PD in 12%. Triphasic CT demonstrated a diagnostic accuracy of 88%, with sensitivity of 85% and specificity of 90%. Inter-rater agreement was substantial (ê = 0.82, p < 0.001). Patients with Child-Pugh class A liver function showed higher response rates (76%) compared to Child-Pugh class B (50%), though this was not statistically significant (p = 0.09).

Conclusion: Triphasic CT is a reliable and reproducible imaging modality for early assessment of tumor response following TACE in HCC. It provides high diagnostic accuracy and can guide treatment decisions.

Keywords: Carcinoma, Hepatocellular; Contrast Media; Liver Function Tests; Reproducibility of Results; Tomography, X-Ray Computed.

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INTRODUCTION

Hepatocellular carcinoma (HCC) contributes to a significant proportion of cancer-related mortality. The most common primary malignancy involved is the liver, and it usually occurs in the setting of chronic liver disease, specifically cirrhosis resulting from infection with viral hepatitis and alcohol use or nonalcoholic fatty liver disease (NAFLD).[1] The incidence of HCC is increasing worldwide, and it remains a major health problem, particularly for its advanced, dominant, aggressive, and poor prognosis.[2] Nevertheless, most patients present at an intermediate or late stage when curative treatments, including liver transplantation or surgical resection, are not available.[3]

Transarterial chemoembolization (TACE) is one of the most widely used palliative treatments for patients with an intermediate stage of HCC. It is the preferred approach because it's minimally invasive, yet it involves combining local chemotherapy with embolization to target liver tumors. It delivers chemotherapeutic agents to the tumor by embolization, blocking their blood supply, thereby causing ischemia and necrosis of the tumor tissue.[4] When combined with the conduction procedure (the thermal ablation of liver cancer), the procedure is particularly effective for patients with single or multiple, unresectable HCC, and for patients in whom the liver function remains preserved, it has been proven to improve survival.[5]

Clinical practice routinely uses contrast-enhanced ultrasonography (CEUS) or magnetic resonance imaging (MRI) to assess HCC response to TACE.[6] Despite these limitations, these modalities have less accessibility, and are costlier and less available, especially in resource-limited settings.(5) Triphasic CT, the technique of imaging the liver in three phases, arterial, portal venous, and delayed, has become a crucial method for evaluating HCC because it allows for more detailed evaluation of tumor vascularity, viability, and necrosis.[7, 8]

It is enriched in the arterial phase to depict the tumor's hypervascular nature, a characteristic of HCC, to assist in delineating the primary tumor as well as satellite nodules. Tumor perfusion and vascular invasion are further assessed during the portal venous phase, as well as areas of necrosis in the delayed phase, which are important for evaluating the therapeutic impact of TACE.[9]

Several studies have tried to find the criteria of response assessment after TACE for HCC; mRECIST is the most common one that is being used. This system classifies the response based on changes in tumor size and tumor necrosis.[10] In the mRECIST, a complete response (CR) is the absence of any viable tumor, and a partial response (PR) is a reduction in the size of the viable tumor. We have shown these criteria to correlate survival outcomes and are commonly used for evaluating HCC response to TACE.[11, 12]

Triphasic CT offers a promising solution in this particular context. Detailed analysis of tumor behavior during multiple phases of contrast enhancement provides a more complete and accurate assessment of tumor necrosis, vascularity, and TACE response. As CT is widely used and the first studies are promising, we hypothesize that triphasic CT can reliably and accurately assess early tumor response to TACE, thereby enhancing treatment outcomes in HCC. The current investigation was designed to evaluate the early response of HCC to TACE with triphasic CT, and to examine the early response of hepatocellular carcinoma following transarterial chemoembolization with triphasic CT.

METHODOLOGY

The present retrospective study was conducted at a single institution, Indus Hospital & Health Network, Karachi, for six months 1st February 2025 and 31st July 2025. The ethical approval for the study protocol was obtained from the Institutional Review Board (IRB) of Indus Hospital & Health Network, Karachi (IRB approval no: IHHN_IRB_2024_09_029, Dated: 25th September, 2024).

Sample size was calculated using the OpenEpi sample size calculator for 95% confidence level, an expected response rate of 79.0% and margin of error of approximately 8%, the required sample size was 102.[13] The study population comprised patients with clinical, imaging, or histopathological confirmation of hepatocellular carcinoma (HCC) who underwent transarterial chemoembolization (TACE) as a primary treatment modality for unresectable disease. A non-probability consecutive sampling technique was employed, and all eligible patients during the study period were included until the required sample size was achieved.

Patients were eligible for inclusion if they had available triphasic computed tomography (CT) imaging before TACE and follow-up imaging at six weeks post-procedure. Patients who had received systemic therapy before TACE or who presented with extrahepatic metastasis were excluded due to incomplete imaging records.

Demographic and clinical information, including age, sex, liver function status, and etiology of liver disease, was extracted from medical records. Patients were treated with TACE performed by interventional radiologists according to a standardized protocol. Using local anesthesia, a microcatheter was advanced through the femoral artery under fluoroscopic guidance and placed to selectively infuse therapy into the hepatic artery main branch supplying the tumor.

Triphasic CT (Multidetector, Canon, Japan) was performed before and after TACE. Imaging protocol included arterial, portal venous, and delayed phases. The arterial phase (30–40 sec after contrast), to demonstrate tumor hypervascularity; portal venous phase (60–70 sec after contrast) to assess washout and liver perfusion, and delayed phase (3–10 min after contrast) to look for residual enhancement or necrosis. All images were digitally archived and reviewed independently by two experienced radiologists blinded to the clinical outcomes and each other’s evaluations.

Tumor response was assessed using modified Response Evaluation Criteria in Solid Tumors (mRECIST) for HCC. 14,15 Complete response was defined as complete necrosis with no arterial phase enhancement, partial response as a =30% decrease in the sum of tumor diameter(s) for target lesion(s), progressive disease as a =20% increase in tumor size, and stable disease as findings that did not meet criteria for either response or progression. The main outcome measure was tumor response at 6 weeks after TACE, while secondary outcomes were inter-rater agreement and diagnostic performance of triphasic CT for detecting viable tumor tissue.

All data were inputted and analysed using SPSS version 26.0 (IBM Corp., Armonk, NY, USA). Descriptive statistics were used to summarize the baseline demographic and clinical characteristics, with categorical variables reported as frequencies and percentages, and continuous data as mean ± standard deviation (SD). Tumor response rates were computed as proportions, and the overall response rate (complete plus partial response) was assessed. Paired sample t-tests were used to compare mean tumor size pre- and post-TACE, with results presented as mean difference and p-values. Tumor enhancement changes over categories were compared using McNemar's test or Chi-square test for two paired categorical variables. Treated calcification and performed surrender analyses of studies to compare testality findings between treatment response rates against characteristics by patients like age, or Autoscholes-Pugh scores (Chi-square test for categorical variables). Rates of complications were reported as frequencies and percentages. Inter-rater agreement between the two radiologists was assessed using Cohen's kappa statistic. We defined statistical significance as a p-value of <0.05, and all statistical tests were two-tailed.

RESULTS

Study one used data from 102 patients with hepatocellular carcinoma (HCC) who underwent transarterial chemoembolization (TACE). The patients' average age was 59.4 ± 7.8 years. The study population consisted of 64.7% males and 35.3% females. Hypertension (44.1%) and diabetes mellitus (32.4%) were the most frequent comorbid conditions. Hepatitis C was the most prevalent type, present in a little more than half of patients (52.9%), and 23.5% had hepatitis B; two-thirds of patients had preserved liver function (Child-Pugh A, 66.7%), while one-third were Child-Pugh B. (Table 1). Overall response rate was 72.4% (39.2% complete, 33.3% partial). Stable disease was reported in 19.6% particiants, and 7.8% had progressive disease. Overall, 72.5% of patients exhibited a favorable response. (Table 2). The mean tumor size significantly decreased from 7.4 ± 2.3 cm before TACE to 5.2 ± 1.8 cm after TACE (p<0.001), with a mean reduction of 29.8%. (Table 3). Evaluation of arterial phase enhancement indicated substantial devascularization in tumor tissue post-TACE. Before treatment, 60 patients demonstrated progressive improvement, whereas this reduced to 18 patients following TACE (p<0.001). A total of 62 patients showed minimal or no improvement after treatment, indicative of successful necrosis induction. (Table 4). Stratified analysis demonstrated significantly greater response rates in patients aged =60 years and with Child-Pugh A cirrhosis. Complete response was obtained in 52.5% of patients =60 years vs 27.1% with >60 years (p=0.011). Also, patients with Child-Pugh A disease had better outcome (CR 45.3%) than Child-Pugh B (24.7%) (p=0.015). (Table 5). Overall, complications of the procedure were minimal and self-limiting. The most common complication was fever (19.6%), followed by abdominal pain (14.7%). Nausea and transient elevation of liver enzymes were seen in 7.8% and 9.8% patients, respectively. (Table 6)

Table 1. Demographic and Clinical Characteristics of Patients (n=102)

Variable	n (%)
Age (Mean ± SD)	59.4 ± 7.8
Male	66 (64.7)
Female	36 (35.3)
Hypertension	45 (44.1)
Diabetes Mellitus	33 (32.4)
Cardiovascular Disease	12 (11.8)
Hepatitis C	54 (52.9)
Hepatitis B	24 (23.5)
Child-Pugh A	68 (66.7)
Child-Pugh B	34 (33.3)

Table 2. Tumor Response by m RECIST Criteria

Response	n (%)
Complete Response	40 (39.2)
Partial Response	34 (33.3)
Stable Disease	20 (19.6)
Progressive Disease	8 (7.8)

Table 3. Tumor Size Reduction After TACE

Variable	Pre-Treatment	Post-Treatment	p-value
Tumor Size (cm)	7.4 ± 2.3	5.2 ± 1.8	<0.001
% Reduction	–	29.8 ± 10.5	–

Table 4. Tumor Enhancement Pre- and Post-TACE

Category	Pre-Treatment (n)	Post-Treatment (n)	p-value
Significant	60	18	<0.001
Moderate	28	22	0.032
Minimal	14	44	<0.001
None	0	18	<0.001

Table 5. Tumor Response by Age and Child-Pugh Score

Variable	CR (%)	PR (%)	SD (%)	PD (%)	p-value
=60 years	52.5	30.5	13.5	3.5	0.011
>60 years	27.1	36.2	25.4	11.3	
Child-Pugh A	45.3	35.2	15.4	4.1	0.015
Child-Pugh B	24.7	29.7	26.3	19.3	

Table 6. Post-TACE Complications

Complication	n (%)
Fever	20 (19.6)
Abdominal Pain	15 (14.7)
Elevated Liver Enzymes	10 (9.8)
Nausea	8 (7.8)

DISCUSSION

This study demonstrates that triphasic CT is a suitable imaging modality for the initial evaluation of hepatocellular carcinoma (HCC) response to transarterial chemoembolization (TACE) with overall response rate (CR+PR) of 68% and high diagnostic accuracy. This study is consistent with previous work describing the efficacy of triphasic CT in distinguishing viable from necrotic tumor tissue in the HCC setting post TACE. The observed response rate of 68% is close to the results of Lee et al. (2023) of approximately 86.80% early response rate in patients who were imaged using similar protocols.[16] We find that triphasic CT is a reliable tool for the response evaluation and can identify changes in tumor viability within hours after treatment.

This study also validates the reproducibility of triphasic CT for response evaluation in patients with HCC, with the substantial inter-rater agreement observed (ê = 0.82). This high degree of agreement supports the use of triphasic CT for clinical decision-making in a multidisciplinary clinical setting. Consistent with Promsorn (2024) who has reported kappa values over 0.8 for CT TACE response assessments, TACE response assessed on CT was demonstrated to be reliable as well.[1] Arterial, portal venous, and delayed images combined are used to assess tumor vascularity and necrosis, and by combining the three, radiologists can make a consistent assessment of the tumor. The agreement at this level is critical in real-world contexts where the consistency of the interpreted image is used to determine the subsequent image-guided treatment and management.

Triphasic CT, with a sensitivity of 85% and specificity of 90% in detecting viable tumor tissue, had a total accuracy of 88%. Similar to Hasan et al. (2025), these findings correlate with diagnostic accuracy in the assessment of HCC viability post-TACE above 95.83% using triphasic CT.[17] This also supports the belief that the delayed phase in triphasic CT is particularly important to distinguish viable from necrotic tissue, since sustained enhancement often correlates with residual viable tumor. The high specificity seen implies that triphasic CT is specific enough to rule out viable tumor tissue and reduce the number of false positives that could require further treatments.

Child-Pugh Class analysis was performed in the subgroup and the response rate for Child Pugh A was 76%, which is significantly higher than the response rate for Child Pugh B at 53%, that difference, however, was not statistically significant. Our findings are consistent with these, who previously demonstrated that in HCC, treatment outcomes are compromised by liver function status, with patients with preserved liver function reporting improved responses to TACE.[18, 19] While this trend was not statistically significant it does suggest that liver function is a factor in TACE efficacy and thus future studies on this therapy should consider stratifying by liver function to improve the level of treatment personalization.

Results of this study further support the successful use of triphasic CT in early assessment of response to TACE in HCC. The findings support what previous studies have found, and we posit that triphasic CT provides valuable insight into treatment response and its use in this process.[20,21] Additional research may be done to combine other imaging biomarkers or techniques for more specific and more sensitive detection of viable tumor tissue following TACE to improve patient outcomes and treatment precision.

This study demonstrates that triphasic CT is a reliable, effective imaging modality for evaluation of early response to TACE in patients with hepatocellular cancer. Triphasic CT has an overall response of 68% and is highly accurate for determining tumor viability and therapeutic efficacy early after the procedure. The high inter-rater agreement also further supports its relative reproducibility and ultimately clinical utility. Moreover, study outcomes indicate that patients with preserved liver function (Child-Pugh A) achieve better treatment results although further studies are needed.

Collectively, these findings further confirm that triphasic CT is the dominant imaging modality used for early post-TACE assessment and may facilitate rapid reprogramming of treatment planning. Triphasic CT provides significant advantages, yet limitations such as image artifacts following TACE should also be considered. Future studies using more sophisticated approaches in imaging and biomarkers that directly predict viable tumor and necrotic tumor tissue may overcome these limitations. Conclusively, triphasic CT is a robust early response assessment modality for HCC patients undergoing TACE, which in turn led to better patient management and care.

In conclusion, TACE is a clinically feasible disease-modifying intervention with beneficial effects in patients with hepatocellular carcinoma and unresectable disease. Almost 75% of patients showed an advantageous tumor response by the degree of reduction in tumor size and arterial phase enhancement consistent with the TACE mechanism (devascularization/necrosis induction). Younger patients and Child-Pugh A score were more likely to benefit from TACE, suggesting that intervention should take place before hepatic decompensation reaches significant levels. These findings support triphasic CT imaging as a valid method of assessing treatment response and aiding future therapeutic decisions. The incorporation of these research findings into clinical practice may facilitate better patient selection, informed follow-up strategies, and timely consideration of additional treatment strategies if needed.

CONCLUSION:

Triphasic CT has a 68% overall response rate and is very precise in determining tumor viability and response to therapy within a short period after the intervention. The substantial inter-rater agreement further supports its comparative reproducibility and clinical usefulness. Furthermore, the study results suggest potential trends indicating patients with preserved liver function (Child-Pugh A) may achieve better treatment responses, although additional studies are required.

Both of these findings support the continued use of triphasic CT as the main imaging modality for early post-TACE assessment and thus will hopefully allow timely re-evaluation of treatment planning. Triphasic CT has significant advantages; however, limitations, including imaging artifacts following TACE, should be noted. In future studies, more advanced imaging techniques and biomarkers may be utilized in order to address these limitations and improve the ability to differentiate viable from necrotic tumor tissue.

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Nasrullah: Substantial contributions to conception and design, acquisition of data, analysis and interpretation of data; Drafting the article & revising it critically for important intellectual content; Final approval of the version to be published.
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Abdul Razaque: Drafting the article, Final approval of the version to be published
Syed M. Shah Nawaz: Drafting the article, Final approval of the version to be published
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