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Original Article

Comparison of LI-RADS Scores Before and After Transarterial Chemoembolization (TACE) in Hepatocellular Carcinoma Patients

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Abstract

Hepatocellular carcinoma (HCC) is the most frequent primary liver malignancy, notorious for its elevated mortality. In intermediate-stage HCC where surgical resection is contraindicated, transarterial chemoembolization (TACE) is the primary treatment modality. Accurate evaluation of therapeutic response is essential to guide ongoing patient management. The Liver Imaging Reporting and Data System (LI-RADS), particularly its Treatment Response (LI-RADS TR) criteria, provides a validated radiographic method for assessing lesions before and after locoregional interventions. This study compared LI-RADS scores before and after TACE in patients at Dr. Soetomo Regional General Hospital, Surabaya. A retrospective observational design was employed, involving 37 HCC patients who underwent TACE and abdominal CT between January 2024 and July 2025. Statistical analysis used the paired t-test or Wilcoxon test ($p < 0.05$). The majority of patients were male (67.6%) with a mean age of 55.3 years. Before TACE, the most common categories were LR-5 (51.4%) and LR-4 (48.6%). Following TACE, 78.4% of tumors were classified as viable and 21.6% as non-viable by LI-RADS TR. No significant difference in tumor size was observed, but tumor-to-liver ratio was significantly reduced ($p < 0.001$). No significant association was identified between pre-TACE LI-RADS characteristics and post-TACE LI-RADS TR categories, except for the pre-treatment tumor-to-liver ratio. TACE significantly reduced the tumor-to-liver ratio; however, most lesions remained viable by LI-RADS TR. LI-RADS and LI-RADS TR are important tools for evaluating treatment response and guiding further management in HCC patients.

Keywords: Abdominal CT Scan, Hepatocellular Carcinoma, LI-RADS, LI-RADS Treatment Response, TACE.

1. Introduction

Hepatocellular carcinoma (HCC) is the most frequently diagnosed primary hepatic tumor, responsible for over 90% of all liver malignancies. Globally, it stands as the fifth most common cancer, with a particularly strong correlation to cirrhosis, as it is found in approximately 85% of patients with this underlying condition. When examining cancer-related fatalities in men, HCC ranks as the second leading cause, preceded only by lung cancer. Reflecting its high lethality, the five-year survival rate for HCC is a mere 18%, a figure that makes it the second most fatal cancer, with pancreatic cancer being the sole malignancy associated with a higher mortality rate (Sung et al., 2021). The high mortality of HCC is attributed to delayed detection, resulting in patients being diagnosed with advanced-stage HCC upon their first medical visit. Only 40% of patients are diagnosed in a timely manner (Akbulut et al., 2022). Approximately 68.9% of patients are diagnosed with HCC at an incurable stage (BCLC stage B/C/D) (Albrecht et al., 2021). Patients at this stage can only receive palliative therapy aimed at reducing symptoms and prolonging survival (Alhasan et al., 2019).

A variety of treatment strategies are currently employed in clinical settings for hepatocellular carcinoma (HCC), with recommendations stratified by tumor stage. These include surgical options, chemical and energy-based ablation techniques, transcatheter interventions, radiation therapy, and systemic therapies. For patients with intermediate-stage HCC who are ineligible for surgery, transcatheter therapy is recommended as a palliative approach that is typically well tolerated (Amalia et al., 2020). The appropriate candidates for this modality are those presenting with either large uninodular or multinodular disease, provided they maintain adequate liver function (Child-Pugh class A or B) and show no evidence of vascular invasion or extrahepatic metastases (Asafo-Agyei & Samant, 2023). TACE is a dual procedure involving the superselective transarterial placement of chemotherapy agents through the hepatic artery supplying the tumor, followed by the administration of an embolization agent. This mechanism delivers a “double attack” on the tumor by producing cytotoxic damage through chemotherapy drugs and additional embolization that prevents washout of the chemotherapy agent from the tumor and causes ischemic necrosis of the tumor (Asayama et al., 2016).

The persistence of residual tumor fractions can stimulate neovascularization, leading to continued tumor growth even after an initial response to TACE. Consequently, repeated treatment sessions are frequently necessary to sustain adequate tumor control. In this context, reliable assessment of treatment response becomes essential for guiding subsequent therapy, particularly within “on-demand” TACE strategies. Dynamic imaging techniques capable of detecting tumor vascularity and viability are therefore of critical importance (Maimunah et al., 2020). Various parameters have been reported to be useful in evaluating the success of locoregional therapy, including TACE, such as tumor size, number of tumors, mRECIST, and LI-RADS Treatment Response (TR). Tumor size and number of lesions based on abdominal CT scan results have been studied as post-TACE evaluation parameters at RSUD Soetomo Surabaya (Amalia et al., 2020). Choi et al. (2020) used mRECIST criteria to evaluate tumor recurrence after TACE. LI-RADS Treatment Response (LR-TR) criteria can be used for post-TACE tumor evaluation and have been reported to have better specificity and sensitivity than mRECIST (Awadh et al., 2024).

It is important to note that two distinct LI-RADS systems are applied in this study. The standard LI-RADS system is used prior to treatment to categorize untreated liver observations according to their probability of representing HCC (LR-1 through LR-5). The LI-RADS Treatment Response (LR-TR) algorithm, in contrast, is applied exclusively to previously treated observations, categorizing findings as LR-TR Nonviable, LR-TR Equivocal, or LR-TR Viable to reflect the likelihood of residual or recurrent tumor activity. Established by the American College of Radiology in 2011, the LI-RADS Treatment Response (LI-RADS-TR) criteria provide standardized categories for assessing treated liver observations. These categories reflect the likelihood of tumor viability or recurrence following locoregional therapy. These criteria are still rarely used in Indonesia to evaluate locoregional therapy response despite having good diagnostic accuracy. This study was conducted to determine the comparison of LI-RADS and LI-RADS-TR scores before and after TACE in HCC patients, thereby providing a reporting system that meets international guideline standards. Good reporting is expected to facilitate planning of subsequent management for HCC patients after locoregional therapy at Dr. Soetomo Regional General Hospital Surabaya. Based on the above background, this study aims to determine the LI-RADS scores before and after TACE in hepatocellular carcinoma patients at Dr. Soetomo Regional General Hospital Surabaya.

2. Methods

This study is an observational analytic study with a retrospective approach. The scope of the research is in the field of radiology, conducted at the Radiology Installation of Dr. Soetomo Regional General Hospital Surabaya, with a study period from January 2024 to December 2025. The target population was patients with suspected hepatic abnormalities who underwent transarterial chemoembolization (TACE) procedures and abdominal CT scan examinations. The accessible population was hepatocellular carcinoma patients who underwent TACE procedures and abdominal CT scans at Dr. Soetomo Regional General Hospital during the period January 1, 2024 to July 31, 2025. The study population comprised hepatocellular carcinoma patients who underwent TACE procedures and abdominal CT imaging between January 1, 2023, and July 31, 2025. Eligible participants met predefined inclusion and exclusion criteria and received ethical approval from the Research Ethics Committee of the Faculty of Medicine, Universitas Airlangga-Dr. Soetomo Regional General Hospital Surabaya. Consecutive sampling was employed until the required sample size was achieved. The sample size was determined using the paired numeric analytic test formula, incorporating an α of 0.05 ($Z\alpha = 1.96$), β of 0.20 ($Z\beta = 0.84$), the minimum meaningful mean difference ($X1 - X2$), and the pooled standard deviation (Sg). Based on the calculation, Sg was 5.24 and the minimum sample size was 34 subjects.

The study's inclusion criteria encompassed several key requirements. Participants had to be at least 18 years of age with a diagnosis of hepatocellular carcinoma confirmed via European Association for the Study of the Liver (EASL) criteria and classified as BCLC stage B or C. Additionally, eligible subjects must have undergone TACE and received a subsequent abdominal CT scan evaluation more than one month after the procedure. The availability of complete three-phase abdominal CT images (arterial, venous, and delayed) was mandatory, as was access to full medical records containing subject identity, physical examination results, and blood laboratory data. Exclusion criteria included unavailability of abdominal CT scan results, secondary metastatic hepatic nodules, hepatic masses with abscess appearance, patients who had previously undergone resection, ablation, transplantation, or TACE therapy, and patients with a history of malignancy other than hepatocellular carcinoma or hepatocellular carcinoma with metastasis.

Research variables included LI-RADS-TR, TACE, and hepatic nodules. The research instrument used a 128-slice CT scan machine, Philips Siemens Somatom Emotion 16 VB40B, Model No. 989000086371; Serial No. 145872; Tube MRC 880. Data collection was performed through abdominal CT scan examination more than 1 month after TACE by the researcher, who is an advanced-level Radiology resident under the supervision of two abdominal consultant radiologists with approximately 10 years of work experience. CT scan results data were collected in a case report form and then analyzed using the Statistical Programme for Social Sciences (SPSS) version 25.0. Descriptive analysis was performed to classify data based on age, gender, and research variables to assess frequency and distribution. Quantitative analysis was performed through bivariate testing to compare LI-RADS values before and after TACE using paired T-test or Wilcoxon test as an alternative. The p-value was considered significant if $p < 0.05$ with a 95% confidence interval, and the results of the analysis are presented in tabular form. This study has been submitted for ethical approval from the Ethics Committee of the Faculty of Medicine, Universitas Airlangga Surabaya / Dr. Soetomo Regional General Hospital Surabaya.

3. Results and Discussion

3.1. Research Results

3.1.1. Characteristics of Research Subjects

This study was conducted on 37 patients diagnosed with hepatocellular carcinoma (HCC) who underwent TACE procedures at the Radiology Installation of Dr. Soetomo Regional General Hospital Surabaya during the period January 1, 2024 to July 31, 2025. Table 1 below shows the characteristics of subjects in the study. The collected research subjects consisted of 25 males (67.6% of total research subjects) and 12 females (32.4%). The mean age was 55.3 years with a median age of 57.0 years. Regarding hepatitis B status, 48.6% of subjects had positive test results, while 51.4% had negative results. As for hepatitis C status, 18.9% of subjects were detected positive and the remaining 81.1% had negative results.

Table 1. Characteristics of research subjects

Variable	N	%	Mean	S.D.	Median
Gender					
Male	25	67.6			
Female	12	32.4			
Age (years)			55.3	12.1	57.0
Hepatitis B					
Positive	18	48.6			
Negative	19	51.4			
Hepatitis C					
Positive	7	18.9			
Negative	30	81.1			

3.1.2. LI-RADS Examination Before TACE

Table 2 presents data related to various parameters in the pre-TACE (transarterial chemoembolization) assessment. On arterial phase examination, 97.3% of cases showed non-rim hyperenhancement, while only 2.7% showed iso/hypoenhancement. In terms of non-peripheral washout appearance, 56.8% of cases did not show any washout and 43.2% showed washout appearance. The next examination relates to the enhancing capsule appearance. A total of 86.5% of cases showed no enhancement, and 13.5% showed enhancing capsule appearance. All tumors (100%) in this study had a size greater than 20 mm; no research subjects had tumors smaller than 10 mm or between 10 and 20 mm.

The research data also provides an overview of tumor size, tumor-to-liver ratio, and final LI-RADS (Liver Imaging Reporting and Data System) score. The mean tumor size before TACE was 10.2 cm with a standard deviation of 4.6 cm. The tumor-to-liver organ ratio showed that 51.4% of cases had a ratio less than 50% and the remaining 48.6% had a ratio of 50% or more. For pre-TACE LI-RADS, 48.6% of cases were categorized as LR-4 and 51.4% as LR-5.

Table 2. Characteristics of LI-RADS examination findings before TACE from research subjects

LI-RADS Pre-TACE Evaluation Features	N (n=37)
Arterial Phase	
Iso/hypo-enhancement	1 (2.7%)
Non-rim hyperenhancement	36 (97.3%)
Non-peripheral Washout	
Absent	21 (56.8%)
Present	16 (43.2%)

LI-RADS Pre-TACE Evaluation Features	N (n=37)
Enhancing Capsule	
Absent	32 (86.5%)
Present	5 (13.5%)
Largest Tumor Size Category	
<10 mm	0 (0%)
10 - 20 mm	0 (0%)
>20 mm	37 (100%)
Pre-TACE Tumor Size (cm)	
(Mean)	10.2 cm
Pre-TACE Tumor/Liver Ratio	
<50%	19 (51.4%)
≥50%	18 (48.6%)
Pre-TACE LI-RADS	
LR 4	18 (48.6%)
LR 5	19 (51.4%)
TACE: transarterial chemoembolization	

3.1.3. LI-RADS Examination After TACE

Table 3 presents data on tumor mass size and tumor characteristics post-TACE. A total of 100% of cases from the collected research subjects showed tumor size greater than 20 mm, with no cases recorded in the 10-20 mm or less than 10 mm categories after TACE. The mean post-TACE tumor size was 9.2 cm with a standard deviation of 5.7 cm, and a median of 8.4 cm. A total of 91.9% of cases had a tumor-to-liver ratio of <50%, while the remainder had a ratio of ≥50%. The final category of LI-RADS TR (Liver Imaging Reporting and Data System for Tumor Response) assessment showed that 78.4% of cases had tumors that were still viable (still alive and active), while 21.6% of cases showed non-viable tumors (inactive or dead) after TACE.

Table 3. Characteristics of LI-RADS-TR examination findings after TACE from research subjects

LI-RADS Post-TACE Evaluation Features	N (n=37)
Embolic Agent Used	
Cisplatin	12 (32.4%)
Doxorubicin	24 (64.9%)
Epirubicin	1 (2.7%)
Largest Tumor Size Category Post-TACE	
<10 mm	0 (0%)
10 - 20 mm	0 (0%)
>20 mm	37 (100%)
Post-TACE Tumor/Liver Ratio	
<50%	34 (91.9%)
≥50%	3 (8.1%)
Post-TACE LI-RADS-TR	
Non-viable	8 (21.6%)
Viable	29 (78.4%)
Equivocal	0 (0%)
TACE: transarterial chemoembolization	

Table 4 presents a comparison of the types of chemoembolization agents used in the transarterial chemoembolization (TACE) procedure against the final LI-RADS Treatment Response (LI-RADS TR) category after the procedure. The total number of samples analyzed in this table was 37 cases. In the group of patients categorized as non-viable based on post-

TACE LI-RADS TR, 6 cases (16.2%) used doxorubicin and 2 cases (5.4%) used cisplatin, while there were no non-viable cases using epirubicin. Conversely, in the viable group, patients used doxorubicin in 18 cases (48.6%), followed by cisplatin in 10 cases (27.0%), and epirubicin in 1 case (2.7%). Statistical comparison was performed using Fisher's exact test due to the presence of cells with expected counts fewer than 5 (notably the epirubicin subgroup, n=1).

Table 4. Comparison of embolization agents used against the final category of LI-RADS TR after TACE

Embolic Agent Used	N (n=37)	Post-TACE LI-RADS TR Final Category		p-value
		Non-Viable	Viable	
Cisplatin	12	2 (16.66%)	10 (83.33%)	0.737
Doxorubicin	24	6 (25%)	18 (75%)	
Epirubicin	1	0 (0%)	1 (100%)	

Fisher's exact test; p-value < 0.05 is considered statistically significant

3.1.4. Comparison of Parameters Before and After TACE

Table 5 presents a comparison between tumor conditions before and after the TACE procedure in two main categories, namely tumor size and tumor-to-liver ratio. All patients (100%) had tumors greater than 20 mm both before and after TACE. This comparison shows that there was no difference in tumor size category after the TACE procedure, with statistically non-significant results (p-value could not be assessed).

A significant change in the tumor/liver ratio occurred after TACE. Before the procedure, 48.6% had a tumor-to-liver ratio greater than 50% and the remaining 51.4% had a tumor ratio less than 50%. After TACE, 91.9% of patients had a tumor-to-liver ratio less than 50%, and only 8.1% had a ratio greater than 50%. This change was statistically significant with a p-value of <0.001. This indicates that there was a significant decrease in the tumor-to-liver ratio in hepatocellular carcinoma patients after the TACE procedure.

Table 5. Comparison of Tumor Size Before and After TACE

Variable	Pre-TACE	Post-TACE	p-value
Largest Tumor Size Category, n (%)			_*
<10 mm	0 (0.0)	0 (0.0)	
10 - 20 mm	0 (0.0)	0 (0)	
>20 mm	37 (100)	37 (100)	
Tumor/Liver Ratio, n (%)			<0.001**
<50%	19 (51.4)	34 (91.9)	
≥50%	18 (48.6)	3 (8.1)	

Cannot be assessed as the variable is constant (unchanged)
***Chi-square test, p-value < 0.05 is considered statistically significant*

Table 6 presents a comparison between the features evaluated on LI-RADS before patients underwent the transarterial chemoembolization (TACE) procedure against the final category results of LI-RADS Treatment Response (LI-RADS TR) assessment after patients underwent the TACE procedure. Since no patients in this study fell into the LI-RADS TR equivocal category, the comparison was narrowed to viable and non-viable.

Based on this comparison, it was found that of the 37 patients evaluated, 8 (21.6%) patients showed non-rim hyperenhancement and also fell into the non-viable category. There were 5 (13.5%) patients who previously did not show non-peripheral washout and then fell into the non-viable category. There were 7 (18.9%) patients who previously did not show a non-enhancing capsule and then fell into the non-viable category after the TACE procedure.

There were 4 (10.8%) patients each who before TACE fell into the LI-RADS 4 and 5 categories and after TACE fell into the non-viable category. No statistically significant difference was found (p-value > 0.05) from the comparison of the above categories. This finding is not unexpected, as pre-treatment enhancement features primarily reflect the tumor's vascular architecture rather than its biological susceptibility to TACE-induced ischemia and cytotoxicity; they are therefore not reliable predictors of treatment response.

Meanwhile, in the comparison of the tumor size/liver ratio before TACE, patients who had a ratio of <50% before the TACE procedure showed a higher number falling into the non-viable category after the TACE procedure (7 patients, 18.9%, out of a total of 19 patients with a ratio <50%, accounting for 51.4%) compared to patients who had a ratio >50% before the TACE procedure (1 patient, 2.7%, out of a total of 18 patients with a ratio >50%, accounting for 48.6%); this difference appeared statistically significant with a p-value <0.05.

Table 6. Comparison of LI-RADS examination findings before TACE against the final category of LI-RADS TR after TACE

	N (n=37)	Post-TACE LI-RADS TR Final Category		p-value
		Non-Viable	Viable	
Pre-TACE LI-RADS Evaluation Features				
Arterial Phase				
Iso/hypo-enhancement	1 (2.7%)	0 (0%)	1 (2.7%)	0.784
Non-rim hyperenhancement	36 (97.3%)	8 (21.6%)	28 (75.7%)	
Non-peripheral Washout				
Absent	21 (56.8%)	5 (13.5%)	16 (43.2%)	0.517
Present	16 (43.2%)	3 (8.1%)	13 (35.1%)	
Enhancing Capsule				
Absent	32 (86.5%)	7 (18.9%)	25 (67.6%)	0.708
Present	5 (13.5%)	1 (2.7%)	4 (10.8%)	
Largest Tumor Size Category				
<10 mm	0 (0%)	0 (0%)	0 (0%)	-
10 - 20 mm	0 (0%)	0 (0%)	0 (0%)	
>20 mm	37 (100%)	8 (21.6%)	29 (78.4%)	
Pre-TACE Tumor/Liver Ratio				
<50%	19 (51.4%)	7 (18.9%)	12 (32.4%)	0.025
≥50%	18 (48.6%)	1 (2.7%)	17 (45.9%)	
Pre-TACE LI-RADS				
LR 4	18 (48.6%)	4 (10.8%)	14 (37.8%)	0.621
LR 5	19 (51.4%)	4 (10.8%)	15 (40.5%)	

Fisher's exact test used for all comparisons given small cell counts; p-value < 0.05 is considered statistically significant

3.2. Discussion

3.2.1. Subject Characteristics

1) Gender

The study cohort demonstrated a male predominance, with 67.6% of hepatocellular carcinoma (HCC) patients being male. This finding aligns with the broader epidemiological literature, which consistently reports higher HCC incidence in men, with male-to-female ratios typically ranging from 2:1 to 4:1 in high-prevalence regions, attributable to greater exposure to risk factors such as hepatitis B and C infection and alcohol consumption (Kern et al., 2017; Rahadiani et al., 2021). Multivariate analysis has further identified male gender as an independent predictor of survival following TACE, alongside tumor-related variables such as location, number, and Child-Pugh score, which are also known to influence treatment response (Amalia et al., 2020; Maimunah et al., 2020). The underlying biological basis involves sexual dimorphism in hepatic physiology, wherein testosterone accelerates hepatocyte carcinogenesis while estradiol confers a protective effect, collectively modulating HCC aggressiveness, therapy response, and prognosis (Lonardo et al., 2020; Nevola et al., 2023; Pham, 2019).

2) Age

Based on the data from this study, the majority of patients who underwent TACE procedures had a mean age of 55.3 years with a median of 57.0 years, indicating that hepatocellular carcinoma (HCC) more frequently affects the elderly adult population, consistent with previous reports finding a median diagnosis age of 61 years with a median survival of 15.7 years (Kanneganti et al., 2025; Kern et al., 2017). Age is an independent risk factor for HCC development, with the highest incidence in the 50-69 age group, although patients above 70 years are also found (Shawon et al., 2020). Geographic variation is also evident, for example a mean diagnosis age of 58 years in Egypt and 46 years in other African countries (Martani et al., 2022), and 55-59 years in China and 63-65 years in Europe/North America (Louisa et al., 2023; Miyaaki, 2011; Montalvo-Javé et al., 2020; Motola-Kuba et al., 2006; Pham, 2019).

In elderly patients, radical therapy tends to be performed less frequently due to comorbidities, although some studies show good clinical responses despite older age (Fernández-Ruiz et al., 2008; Macias et al., 2021). Biological factors related to aging, such as genomic instability and mitochondrial dysfunction, also increase hepatic susceptibility to carcinogenesis (H. Guo et al., 2017; Macias et al., 2021). Elderly patients are often diagnosed with larger single nodules, lower fibrosis, and well-differentiated tumor cells, so the biological characteristics of HCC may differ and influence treatment choices (E. Cho et al., 2019; Macias et al., 2021). An individualized approach that takes into account organ function, life expectancy, and patient preference becomes key in selecting therapy, including TACE, radiofrequency ablation, or surgical resection in early stages (Brozzetti et al., 2018; E. Cho et al., 2019).

TACE has proven to be safe and effective in elderly patients, including those above 85 years of age, although the risk of complications increases due to comorbidities and reduced functional organ reserves (Macias et al., 2021). Response to TACE is more influenced by tumor stage, tumor markers, and hepatic functional reserve than by age alone (Nishikawa et al., 2013). In this study, a TACE regimen combining Cisplatin, Doxorubicin, and Epirubicin was used to maximize cytotoxic effects on tumor cells while minimizing damage to healthy tissue, with dose adjustments and close monitoring in the geriatric population (Federico et al., 2021; Fite & Makary, 2024; Rabei et al., 2023). Each agent has its advantages and limitations, with Doxorubicin being most commonly used, but there is no clear superiority between single agents or combinations (Behnagh et al., 2017; Y. Cho et al., 2023; de Baere et al., 2022; Hui et al., 2022; Kotsifa et al., 2022).

Side effects of TACE that need attention include post-embolization syndrome, hepatic decompensation, elevated liver enzymes, ascites, fever, pain, hepatic abscess, and biliary infarction, although advanced age is not a contraindication (Brozzetti et al., 2018; Chui et al., 2020; Qi et al., 2025). Studies show no significant difference in survival success and adverse event rates between patients above and below 70 years of age, although elderly patients have more comorbidities (E. Cho et al., 2019; Elkadeem, 2018; Lawson et al., 2023; Liu et al., 2023;

Papis et al., 2020). This emphasizes the importance of individual evaluation of hepatic functional reserve and comorbidity status to determine the eligibility and type of TACE intervention in the elderly population.

3) Risk Factors

The majority of patients tested positive for hepatitis B ((Goh et al., 2023), 6%) and hepatitis C (18.9%). Corroborating the work of Awadh et al. (2024) which highlight hepatitis B and C infections, along with excessive alcohol consumption, diabetes, and nonalcoholic steatohepatitis, as principal risk factors for hepatocellular carcinoma. Notably, hepatitis B and C infections account for 30% and 21% of liver cancer mortality, respectively. These observations reinforce the imperative of early identification and comprehensive management of such risk factors to mitigate HCC incidence. Furthermore, effective control of chronic viral hepatitis through screening and antiviral intervention holds significant potential for reducing HCC risk among susceptible populations (Nishikawa et al., 2013).

Nevertheless, the global prevalence of hepatocellular carcinoma continues to rise, largely due to other risk factors such as excessive alcohol consumption and nonalcoholic fatty liver disease, indicating an epidemiological shift of HCC in some regions (Dorochowicz et al., 2023; Septiarini et al., 2024). Interestingly, HBV-related hepatocellular carcinoma tends to occur at a younger age compared to HCV-related HCC, demonstrating differences in disease onset timing (H. Guo et al., 2017). This epidemiological shift also includes an increasing incidence of HCC associated with obesity and diabetes, particularly in Western countries, indicating that metabolic factors now play an increasingly dominant role in the pathogenesis of this disease (Dorochowicz et al., 2023).

These factors contribute to the increasing cases of hepatocellular carcinoma caused by nonalcoholic steatohepatitis, particularly in elderly patients (Macias et al., 2021). Several other risk factors that also contribute to the development of hepatocellular carcinoma include advanced age, family history of HCC, as well as certain environmental and clinical factors (Fernandes et al., 2022). Among these factors, excessive alcohol consumption has long been recognized as a significant contributor to the risk of HCC, primarily through induction of hepatic cirrhosis, and its synergistic effect with hepatitis virus infection further exacerbates this risk (Nordenstedt et al., 2010).

Geographic variations exist in the contribution of viral hepatitis to hepatocellular carcinoma, with HBV responsible for 60% of cases in Asia and Africa compared to 20% in Western nations. Notably, HBV confers an increased risk of HCC even in non-cirrhotic individuals. Conversely, chronic HCV infection constitutes the leading etiology of HCC across North America, Europe, and Japan, with carcinogenic risk extending beyond the point of virological cure. Janevska et al. (2015) report that HCV-infected patients demonstrate a 17-fold elevation in HCC risk relative to uninfected populations, a phenomenon that persists following sustained virological response. Additionally, Greten et al. (2013) established that elevated serum HBV-DNA, specifically concentrations above 2000 IU/ml, functions as a critical determinant of HCC development in HBV-infected patients, independent of cirrhotic status.

Advancing the understanding of molecular mechanisms underlying HBV- and HCV-related HCC pathogenesis, particularly regarding host immune response and virus-host interactions, is essential for developing more effective prevention and therapeutic approaches. Additionally, a comprehensive evaluation of HCC risk must incorporate other contributing factors, including aflatoxin B1 exposure and smoking habits (E. Kim & Viatour, 2020). The WHO estimates 58 million people with chronic hepatitis C and 296 million people with chronic hepatitis B, with 1.5 million new infections and thousands of deaths each year, respectively.

3.2.2. Comparison Before and After TACE

Pre-TACE LI-RADS examination showed the majority of tumors measuring >20 mm, with most categorized as LI-RADS 4 and 5. Post-TACE, tumor size remained >20 mm in 94.6% of patients, but the tumor-to-liver ratio improved significantly, with 91.9% of patients having a ratio <50% ($p<0.001$), reflecting the effect of arterial devascularization and tumor necrosis, although overall tumor size did not change drastically (Nainggolan et al., 2025). Other prognostic factors such as pre-treatment ascites and serum albumin influence patient survival (Mishra et al., 2021), while retrospective studies show no significant difference in survival between HBV- versus HCV-related HCC patients (Ng & Wu, 2012). Further analysis of the dynamics of the tumor-to-liver ratio and initial tumor characteristics can enrich post-TACE prognosis prediction (Bannangkoon et al., 2021), including the potential influence of hepatitis virus genotype or HIV coinfection on response (Akbulut et al., 2022). Identifying patients at low risk of response can support personalized therapeutic strategies, such as combining TACE with systemic therapy or immunotherapy, as well as the use of the ART score for risk stratification and retreatment (Maimunah et al., 2020).

The performance of LI-RADS 2018 in predicting survival requires further evaluation, including comparison of CT versus MRI and the addition of imaging features, as well as optimization of TACE protocols such as number of sessions and inter-treatment intervals (Bartnik et al., 2022). Determination of parenchymal blood volume (PBV) on initial imaging shows correlation with TACE response (Vogl et al., 2024), although tumor response evaluation using LI-RADS and mRECIST requires standardization (Zhou et al., 2025). Previous studies have shown a significant reduction in viable tumor size after TACE (Bartnik et al., 2022), but initial response does not always reflect long-term outcomes, so continuous evaluation and pathological correlation are needed (El-Assaly et al., 2023; Lam et al., 2017). The use of CT perfusion imaging and PBVI C-arm CBCT can detect viable residual tumors and guide TACE replanning (Bayle et al., 2019; O'Donohoe et al., 2019; Taiji et al., 2023).

Accurate post-TACE response assessment is critically important for determining retreatment, with LI-RADS-TR being useful for identifying patients who can benefit from subsequent treatment sessions, although it is less predictive of long-term survival (Bartnik et al., 2022). The addition of ancillary features in LI-RADS v2018 increases sensitivity in detecting viable tumors, including the LR-TR Equivocal category (Patel et al., 2015). Tumor size influences TACE response, with lesions >5 cm tending to be less responsive, while tumors ≤2 cm show better survival (Amalia et al., 2020; Bannangkoon et al., 2021; Chuang et al., 2025; M. Lee & Shin, 2023). Additionally, AFP ≤20 ng/mL, serum albumin, bilirubin, and microscopic vascular invasion are independent predictors of post-TACE survival (J. Chen et al., 2017; Eltabbakh et al., 2021).

This study showed no significant difference between embolization agents and post-TACE LI-RADS-TR evaluation, possibly due to agent homogeneity or limited sample size (D. S. Kim et al., 2021; Maimunah et al., 2020). Nevertheless, tumor characteristics, size, and AFP levels influence response, with chemotherapy agents such as Doxorubicin and DEB-TACE providing higher intratumoral concentrations and lower systemic effects (Amalia et al., 2020; Cerban et al., 2018; Qi et al., 2025). DEB particle size (100-300 μm) is important for drug distribution and efficacy, with smaller beads capable of reaching distal arteries and causing more extensive tumor necrosis (Y. Cho et al., 2023; S.-Y. Lee et al., 2020; Lewis et al., 2016; Mu et al., 2016; Sattler et al., 2018; Wang et al., 2020). DEB-TACE offers comparable or better tumor response with fewer complications compared to larger particles (Chiu et al., 2020; S.-Y. Lee et al., 2020). Optimization of superselective technique remains crucial to maximize efficacy and minimize normal hepatic parenchyma injury, given that large tumors rarely undergo complete necrosis and the embolic effects of TACE are more dominant than chemotherapy agents (Y. Cho et al., 2023).

Overall, TACE response is influenced by patient and tumor characteristics, hepatic functional reserve, tumor size, initial response, and other clinical and biological factors, so comprehensive evaluation is required for planning optimal treatment strategies and personalizing therapy in HCC patients (Amalia et al., 2020; Cerban et al., 2018; Y. Chang et al., 2020; Goh et al., 2023; Hasdemir et al., 2017; Kocyigit et al., 2014; E. W. Lee & Khan, 2017; Rinke et al., 2018).

3.2.3. Research Limitations

This study has several limitations that need to be considered. First, the retrospective observational design and single-center implementation (Dr. Soetomo Regional General Hospital) limits generalizability of results and is susceptible to selection bias and uncontrolled confounding factors (Bartnik et al., 2022; Ji et al., 2022; S.-Y. Lee et al., 2020). Second, heterogeneity of tumor size, BCLC stage, variation in chemotherapy agents, dosages, and patient eligibility criteria may influence the interpretation of treatment response despite subgroup analysis having been performed (S.-Y. Lee et al., 2020; Leng et al., 2023; Liang et al., 2021). Third, the relatively small sample size and use of consecutive sampling limits statistical power and introduces potential selection bias (Y. Chen et al., 2023; Ding et al., 2023; H. Li et al., 2023; Wang et al., 2020). Fourth, the limited follow-up period (6 months) and short post-TACE observation duration may not be sufficient to evaluate long-term recurrence and impact on patient survival (Dioguardi Burgio et al., 2019; Shi et al., 2023; Wang et al., 2020).

Fifth, the absence of a control group receiving conventional TACE or alternative therapies limits direct comparison of efficacy and safety (Albrecht et al., 2021) while pharmacokinetic data such as maximum plasma concentration and doxorubicin AUC are unavailable, hampering calculation of progression-free survival (C.-Y. Lin et al., 2021). Sixth, the lack of histopathological data in the majority of patients and variability in TACE procedures and surgical techniques may introduce additional bias in evaluating treatment response (C. Guo et al., 2024; Z.-W. Li et al., 2022). Seventh, the complexity of imaging methods such as CTHA introduces high radiation exposure despite providing valuable tumor hemodynamic understanding (Asayama et al., 2016).

Several other studies also emphasize similar limitations regarding small sample size, retrospective nature, heterogeneity of TACE procedures, and the absence of consistent pathological diagnosis that limit the generalization and interpretation of findings (Gruber-Rouh et al., 2018). Therefore, future research should use a prospective multicenter design, expand sample size, include control groups, and explore the use of alternative devices such as balloon occlusion microcatheters to evaluate penetration and intrahepatic blood flow effects (K.-H. Chang et al., 2019; Van Der Gucht et al., 2017). Additionally, further studies are needed to assess the impact of patient socioeconomic status on treatment choices and prognosis (S. Lin et al., 2025).

4. Conclusion

The study concludes that the majority of subjects were male (67.6%) with a mean age of 55.3 years. Hepatitis B and C were diagnosed in 48.6% and 18.9% of subjects, respectively, confirming viral infection as the predominant etiology of hepatocellular carcinoma (HCC). Pre-TACE LI-RADS assessment revealed predominantly LI-RADS 5 (51.4%) and LI-RADS 4 (48.6%) categorizations, underscoring the critical role of risk stratification in guiding treatment decisions and predicting therapeutic response. Post-TACE, 78.4% of tumors remained viable, indicating the need for combination strategies to improve therapeutic effectiveness, suggesting that TACE alone may be insufficient for a substantial proportion of patients and that further investigation into adjunctive approaches, such as TACE combined with systemic agents or local ablation, is warranted. Although this retrospective study provides preliminary insights, generalizability is limited due to population and methodological heterogeneity, so prospective research with larger samples and control groups is required. Selective TACE has been shown to have low complications and good therapeutic outcomes, but success remains dependent on tumor characteristics, patient hepatic function, and procedural technique.

Based on these findings, subsequent research is recommended to use a prospective multi-center design to reduce bias and improve generalizability, as well as to conduct detailed analysis of correlations between patient and tumor characteristics with TACE response. Future studies may also consider incorporating ART scores and AFP levels to improve survival prediction. Utilization of advanced imaging (diffusion MRI, CT, radiomics), gold standard pathological criteria, and integration of multimodal data (medical records, genomics, imaging) can improve prediction accuracy and therapy personalization. The use of artificial intelligence and machine learning, including automatic segmentation and multi-class classification, is expected to predict treatment response more accurately, reduce variability, and identify markers of tumor aggressiveness. Integration of advanced AI techniques such as reinforcement learning and transfer learning is also recommended for adapting models to evolving clinical scenarios and for providing more transparent decision-making insights.

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