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Original Research Article

Comparative Study of Outcomes of Transradial Versus Transfemoral Approach for Hepatic Arterial Embolization Using Transarterial Chemoembolization (TACE) Technique in Patients with Hepatocellular Carcinoma at a Tertiary Care Hospital

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Abstract: Hepatocellular carcinoma (HCC) is among the leading causes of cancer-related deaths worldwide. Transarterial chemoembolization (TACE) remains the standard locoregional therapy for intermediate-stage disease. Traditionally performed via the transfemoral approach (TFA), the transradial approach (TRA) has emerged as a promising alternative due to fewer access site complications, shorter hemostasis time, and greater patient comfort. This comparative observational study, conducted at a tertiary care hospital, evaluated 38 HCC patients undergoing TACE—19 via TRA and 19 via TFA. Technical success, fluoroscopy time, contrast volume, post-procedural pain, hemostasis time, hospital stay, and cost were analyzed. Technical success was comparable between TRA (94.7%) and TFA (89.5%). However, TRA showed significantly reduced hemostasis time (15.8 ± 3.4 min vs. 22.1 ± 4.2 min, p = 0.001), lower pain scores (2.5 ± 1.3 vs. 3.9 ± 1.7, p = 0.019), shorter hospital stay (12.5 ± 2.1 h vs. 16.8 ± 3.5 h, p = 0.008), and lesser contrast use (65.2 ± 8.1 mL vs. 72.5 ± 9.3 mL, p = 0.021). Access site complications were lower with TRA (10.5% vs. 15.8%, p = 0.559) though not statistically significant. Overall, TRA demonstrated improved procedural efficiency, patient comfort, and cost-effectiveness without compromising technical success. These findings reinforce the safety and practicality of the transradial route for hepatic arterial embolization in HCC patients undergoing TACE. Approach depends largely on operator expertise and familiarity with radial artery anatomy, as emphasized by Al-Hakim *et al*., (2016) in Cardiovascular and Interventional Radiology. The study also corroborated that socio-demographic variables, such as age, gender, BMI, smoking status, alcohol consumption, and comorbidities, did not significantly impact procedural outcomes, indicating that transradial access is suitable for a diverse population. ***Conclusion***: The study concluded that the transradial approach is a safer, more cost-effective, and patient-friendly alternative to the transfemoral approach for hepatic arterial embolization using the TACE technique in patients with HCC. The transradial approach demonstrated superior outcomes in terms of reduced post-procedural pain, faster hemostasis, shorter hospital stays, lower procedural costs, and comparable technical success rates. These advantages make the transradial approach an attractive option for interventional radiologists and patients undergoing hepatic arterial embolization. Future large-scale, multi-center randomized trials are warranted to validate these findings and establish standardized guidelines for adopting the transradial approach in interventional oncology.

Keywords: Hepatocellular carcinoma (HCC), Transarterial chemoembolization (TACE), Transradial approach (TRA), Transfemoral approach (TFA), Hemostasis time, Procedural efficiency.

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INTRODUCTION

Hepatocellular carcinoma (HCC) is the most common primary liver malignancy and a leading cause of cancer-related morbidity and mortality worldwide, typically arising in the setting of chronic liver disease. The global burden reflects regional etiologic patterns: hepatitis B virus (HBV) predominates in many parts of Asia and sub-Saharan Africa, while hepatitis C virus (HCV), alcohol-associated liver disease, and the growing impact of non-alcoholic fatty liver disease (NAFLD) drive incidence in Western regions. Additional contributors—including aflatoxin exposure in certain geographies and metabolic syndrome—compound risk by accelerating hepatic inflammation, fibrosis, and ultimately cirrhosis, the principal substrate for hepatocarcinogenesis. At a molecular level, HCC exhibits heterogeneous genetic and epigenetic alterations, including frequent TP53 and CTNNB1 (β-catenin) mutations and chromatin-remodeling defects, all occurring within a permissive tumor microenvironment shaped by fibrosis, immune dysregulation, and extracellular matrix remodeling.

Curative therapies—surgical resection, liver transplantation, and local ablation—benefit only a subset of patients diagnosed at early stage with sufficient hepatic reserve. Consequently, a substantial proportion present at intermediate stage, where transarterial chemoembolization (TACE) is the accepted standard of care. TACE exploits the dual blood supply of the liver: whereas normal parenchyma is primarily portal-venous, HCC is predominantly arterialized. By selectively delivering chemotherapeutic agents into tumor-feeding hepatic arterial branches and subsequently embolizing these vessels, TACE increases intratumoral drug concentration while inducing ischemia, maximizing local control and limiting systemic exposure. Superselective techniques and image guidance (e.g., cone-beam CT) further enhance on-target delivery and reduce collateral injury. Variations such as drug-eluting bead TACE (DEB-TACE) and radioembolization (TARE) extend the locoregional armamentarium for anatomically complex or larger tumors; nevertheless, conventional selective/superselective TACE remains the most widely used modality for Barcelona Clinic Liver Cancer (BCLC) stage B disease and carefully selected cases outside this stage in multidisciplinary practice.

Despite decades of refinement, outcomes after TACE depend on patient selection (liver function, tumor burden, vascular invasion, performance status), technique (selective vs. superselective catheterization; embolic and drug choice), and critically, arterial access route. The transfemoral approach (TFA) has been the traditional standard because of operator familiarity, the ability to use larger catheters, and straightforward navigation of complex celiac/hepatic anatomy. However, TFA carries access-site risks—hematoma, pseudoaneurysm, bleeding—and typically necessitates longer bed rest and recovery. In contrast, the transradial approach (TRA), adapted from coronary and peripheral interventions, offers advantages that include lower major access-site complication rates, earlier ambulation, improved patient comfort, and shorter hemostasis time. Contemporary interventional practice increasingly considers TRA for abdominal and oncologic endovascular procedures as operators adopt radial-specific techniques, catheters, and spasm-mitigation protocols.

Evidence suggests that procedural efficacy of TRA is at least comparable to TFA for many endovascular indications, with potential gains in workflow and patient-centered outcomes. For TACE specifically, emerging studies report similar technical success and tumor control between routes, while TRA may reduce post-procedural pain, contrast usage, time to hemostasis, and length of stay. These advantages can translate into lower overall costs and higher patient satisfaction without compromising oncologic intent. Nonetheless, TRA poses unique considerations: radial spasm or occlusion risk, smaller sheath sizes that can limit device selection, and a learning curve for operators transitioning from femoral workflows. Conversely, TFA remains advantageous in certain anatomic scenarios (e.g., need for larger guiding systems, challenging arch/celiac variants in inexperienced radial centers) and in institutions where radial expertise or inventory is limited.

Given these trade-offs, robust comparative data in the **TACE** context are essential to guide default access strategy. Our tertiary-care experience provides an opportunity to evaluate both approaches head-to-head within a uniform institutional protocol. In this comparative observational study of patients with HCC undergoing TACE, we assessed technical success, fluoroscopy time, contrast volume, post-procedural pain, time to hemostasis, hospital stay, access-site and periprocedural complications, and direct procedural/hospital costs. We further considered operational metrics that affect department throughput and patient flow. Our a priori premise was that TRA would maintain technical success while improving immediate recovery parameters and reducing resource utilization compared with TFA.

This work is clinically relevant for several reasons. First, as NAFLD/NASH and metabolic syndrome expand the HCC population, scalable and patient-friendly interventional pathways become increasingly important for repeated locoregional treatments. Second, minimizing access-site morbidity has outsized value in cirrhotic patients with coagulopathy or portal hypertension, in whom bleeding risks are nontrivial. Third, small reductions in contrast load and procedure-associated pain can cumulatively improve safety and experience in a population frequently exposed to serial interventions and nephrotoxic agents. Finally, if TRA reliably shortens hemostasis time and length of stay, it may enable more efficient ambulatory pathways and reduce costs without sacrificing oncologic outcomes.

Accordingly, our objectives were to (i) compare procedural efficacy between TRA and TFA using technical success as the primary procedural endpoint; (ii) quantify differences in recovery-related measures (hemostasis time, ambulation, pain scores, and hospital stay); (iii) evaluate access-site and overall complication rates; (iv) measure contrast usage and fluoroscopy time as surrogates of procedure complexity and patient safety; and (v) estimate cost implications arising from access choice. By synthesizing patient-, procedure-, and system-level endpoints, this study aims to clarify whether TRA should be preferentially adopted for TACE in routine practice or reserved for selected scenarios. The findings may inform standardized pathways, training priorities, and resource allocation in interventional oncology programs seeking to optimize safety, efficiency, and patient experience while preserving oncologic effectiveness.

REVIEW OF LITERATURE

2.1 Hepatocellular Carcinoma: An Overview

Hepatocellular carcinoma (HCC) is the most prevalent form of primary liver cancer and represents a significant public health challenge globally. Understanding HCC involves examining its pathophysiology, clinical presentation, diagnostic criteria, staging systems, treatment options, and management guidelines. This section provides a comprehensive overview of HCC to facilitate a better understanding of the disease.

2.1.1 Definition and Epidemiology

HCC is defined as a malignant tumor that arises from hepatocytes, the primary cells of the liver. It is often associated with underlying liver diseases, particularly cirrhosis resulting from chronic hepatitis infections (HBV, HCV), alcohol abuse, or nonalcoholic fatty liver disease (NAFLD).

According to the World Health Organization (WHO), HCC is the sixth most common cancer worldwide and the third leading cause of cancer-related mortality. The incidence of HCC has been increasing globally, particularly in regions with a high prevalence of hepatitis viruses, such as East Asia and sub-Saharan Africa. The rise in obesity-related liver diseases has also contributed to an increased incidence of HCC in Western countries.

2.1.2 Clinical Presentation

The clinical presentation of HCC can vary widely. Many patients remain asymptomatic in the early stages of the disease. As HCC progresses, patients may experience:

- Abdominal Pain: Often in the right upper quadrant due to liver enlargement or invasion of surrounding structures.
- Weight Loss: Unintentional weight loss is common due to increased metabolic demands and decreased appetite.
- Jaundice: Yellowing of the skin and eyes may occur when the tumor obstructs bile ducts or as a result of liver dysfunction.
- Ascites: The accumulation of fluid in the abdominal cavity can occur due to portal hypertension or liver failure.
- Fatigue: Generalized fatigue and weakness are prevalent in patients with advanced disease.

2.1.3 Diagnosis of HCC

The diagnosis of HCC is typically established through a combination of imaging studies, serological tests, and histopathological examination.

2.1.3.1 Imaging Studies

- Ultrasound: Often the first imaging modality used in screening high-risk patients. It is non-invasive and can help identify focal liver lesions.
- Computed Tomography (CT): CT scans provide detailed cross-sectional images of the liver and are particularly useful for characterizing liver lesions. Contrast-enhanced CT can help differentiate between HCC and other liver lesions based on enhancement patterns.
- Magnetic Resonance Imaging (MRI): MRI is used when CT results are inconclusive or when more detail is needed regarding the liver's vascular anatomy. It is particularly beneficial for evaluating vascular invasion and assessing the extent of disease.

2.1.3.2 Serological Tests

- Alpha-fetoprotein (AFP): AFP is a tumor marker often elevated in HCC patients. While it is not specific to HCC, an elevated level can support the diagnosis, especially in the context of liver disease.
- Liver Function Tests: These tests assess the liver's synthetic capacity and can help evaluate the degree of liver dysfunction.

2.1.3.3 Histopathological Examination

- Liver Biopsy: Although not routinely performed for HCC diagnosis due to the risk of complications, a biopsy may be indicated in cases where imaging and serological tests are inconclusive. Histological examination confirms the diagnosis by demonstrating malignant hepatocytes.

2.1.4 Staging of HCC

Accurate staging of HCC is essential for determining prognosis and guiding treatment options. The most commonly used staging systems include the Barcelona Clinic Liver Cancer (BCLC) classification and the American Joint Committee on Cancer (AJCC) staging system.

2.1.4.1 Barcelona Clinic Liver Cancer (BCLC) Staging System

The BCLC system stratifies patients based on tumor characteristics, liver function, and performance status:

- Stage 0: Very early stage, with a single tumor ≤2 cm and well-preserved liver function.
- Stage A: Early stage, with single or multiple tumors (≤3 cm) and preserved liver function.
- Stage B: Intermediate stage, with multiple tumors (>3 cm) but no vascular invasion or extrahepatic spread.
- Stage C: Advanced stage, with vascular invasion or extrahepatic metastasis.
- Stage D: Terminal stage, with significant liver dysfunction or poor performance status.

2.1.4.2 American Joint Committee on Cancer (AJCC) Staging System

The AJCC system uses the TNM (Tumor, Node, Metastasis) classification:

- T: Describes the size and extent of the primary tumor.
- N: Refers to regional lymph node involvement.
- M: Indicates the presence of distant metastasis.

Both staging systems aid in treatment planning and prognosis assessment.

2.1.5 Treatment Options for HCC

The management of HCC is multidisciplinary and depends on the stage of the disease, liver function, and overall patient health. Treatment options include surgical, locoregional, and systemic therapies.

2.1.5.1 Surgical Approaches

- Liver Resection: Surgical resection is appropriate for patients with a solitary tumor and well-preserved liver function. It offers the potential for a cure, especially in early- stage HCC. However, it carries risks, particularly in patients with underlying liver disease.
- Liver Transplantation: Liver transplantation is indicated for patients with early- stage HCC who are not surgical candidates due to underlying liver dysfunction. Transplantation addresses both the tumor and the cirrhotic liver, improving overall survival.

2.1.5.2 Locoregional Therapies

- Transarterial Chemoembolization (TACE): TACE is a commonly used locoregional therapy for intermediate-stage HCC. It involves the selective delivery of chemotherapy and embolic agents to the tumor, inducing ischemia and enhancing local drug delivery.
- Radiofrequency Ablation (RFA) and Microwave Ablation (MWA): These minimally invasive techniques are used for small tumors (<3 cm) and provide a curative option while preserving liver function.

2.1.5.3 Systemic Therapies

- Targeted Therapies: Sorafenib and lenvatinib are oral multikinase inhibitors approved for advanced HCC. They target pathways involved in tumor growth and angiogenesis.
- Immunotherapy: Immune checkpoint inhibitors, such as nivolumab and pembrolizumab, have shown promise in treating advanced HCC by enhancing the body's immune response against cancer cells.

2.1.6 Current Guidelines for Management of HCC

Current management guidelines for HCC are provided by various professional organizations, including the American Association for the Study of Liver Diseases (AASLD), European Association for the Study of the Liver (EASL), and the American Society of Clinical Oncology (ASCO).

2.1.6.1 Screening and Surveillance

- High-risk patients, including those with chronic hepatitis and cirrhosis, should undergo regular screening for HCC using ultrasound and AFP testing every six months.

2.1.6.2 Treatment Algorithms

- Early-stage HCC: Patients with solitary tumors and preserved liver function should be considered for curative treatment, either through surgical resection or liver transplantation.
- Intermediate-stage HCC: TACE is the primary treatment option for patients with multifocal disease who are not surgical candidates.
- Advanced-stage HCC: Systemic therapy is recommended for patients with vascular invasion or extrahepatic spread. The use of targeted therapies and immunotherapy has expanded options for treatment.

2.1.6.3 Palliative Care

- For patients with terminal HCC or poor liver function, palliative care and supportive measures should be prioritized to improve quality of life.

2.1.7 Conclusion

Hepatocellular carcinoma is a complex disease requiring a multifaceted approach for diagnosis, staging, and treatment. A thorough understanding of its epidemiology, clinical presentation, and current management guidelines is essential for healthcare providers to optimize patient outcomes. With advancements in diagnostic technologies and treatment modalities, the landscape of HCC management continues to evolve, highlighting the importance of a personalized approach to care.

2.2 Trans Arterial Chemoembolization (TACE)

Transarterial chemoembolization (TACE) is a minimally invasive procedure that plays a significant role in the management of hepatocellular carcinoma (HCC), particularly in patients with intermediate-stage disease. TACE combines the principles of selective arterial embolization and localized chemotherapy, leading to tumor necrosis and providing a therapeutic benefit in HCC. This section discusses the mechanism of action of TACE and the various chemotherapeutic agents utilized during the procedure.

2.2.1 Mechanism of Action

The effectiveness of TACE in treating HCC is based on a dual mechanism involving the selective delivery of chemotherapeutic agents and the induction of ischemia to the tumor. This section elaborates on how TACE works and the biological rationale behind its application in HCC treatment.

2.2.1.1 Selective Targeting of Tumor Vascularization

HCC typically receives its blood supply primarily through the hepatic artery, which is in contrast to normal liver tissue, which receives the majority of its blood supply from the portal vein. This distinct vascularization pattern allows for the selective targeting of HCC during TACE.

1. Arterial Catheterization: The procedure begins with catheterization of the femoral artery, through which a catheter is advanced to the hepatic artery supplying the tumor. This allows direct access to the tumor's blood supply.
2. Selective Infusion: Once positioned, a combination of chemotherapeutic agents and embolic particles is infused directly into the hepatic artery. The aim is to deliver a high concentration of chemotherapy directly to the tumor while minimizing systemic exposure, thus reducing potential side effects.

2.2.1.2 Induction of Ischemia

The embolization aspect of TACE involves occluding the blood supply to the tumor, leading to ischemia. This is achieved through the use of embolic agents that occlude the arterial flow:

1. Embolic Agents: These agents can include various materials, such as gelatin sponge particles, polyvinyl alcohol (PVA) particles, or bead-type embolics. They are injected into the hepatic artery, causing a blockage that reduces blood flow to the tumor.
2. Ischemic Necrosis: The reduction in blood flow results in decreased oxygen and nutrient delivery to the tumor cells, leading to cellular necrosis. This process enhances the effectiveness of the administered chemotherapy by trapping it within the tumor for an extended period.
3. Tumor Response: The ischemic environment can further enhance the anti-tumor effects of the chemotherapeutic agents, as tumor cells become more susceptible to the cytotoxic effects of the drugs in a deprived metabolic state.

2.2.1.3 Synergistic Effects of Chemotherapy and Embolization

The combination of localized chemotherapy and ischemic necrosis leads to a synergistic effect:

- Chemotherapy: The agents used during TACE work to kill cancer cells by interfering with their ability to proliferate. By concentrating the chemotherapy at the tumor site and reducing systemic exposure, TACE can achieve a more effective therapeutic index.
- Enhanced Tumor Cell Death: Ischemia can prime tumor cells to be more sensitive to the cytotoxic effects of chemotherapy, leading to increased tumor cell death beyond what would be achieved with chemotherapy alone.

2.2.2 Chemotherapeutic Agents Used in TACE

The choice of chemotherapeutic agents in TACE can vary based on the protocol used, the characteristics of the tumor, and the overall health of the patient. Below are some of the most commonly used agents in TACE for HCC treatment.

2.2.2.1 Doxorubicin (Adriamycin)

Doxorubicin is one of the most frequently used chemotherapeutic agents in TACE due to its potent antitumor activity:

- Mechanism of Action: Doxorubicin intercalates into DNA, inhibiting DNA synthesis and function, which leads to apoptosis in rapidly dividing cells.
- Combination Therapy: Doxorubicin is often combined with embolic agents to enhance its delivery to the tumor and improve its effectiveness.

2.2.2.2 Cisplatin

Cisplatin is another chemotherapeutic agent that has been used in TACE procedures, particularly in combination with other drugs:

- Mechanism of Action: Cisplatin forms DNA cross-links, leading to impaired DNA replication and ultimately triggering apoptosis.
- Synergistic Use: When combined with doxorubicin or other agents, cisplatin can enhance the overall effectiveness of the treatment by targeting different aspects of tumor cell metabolism and growth.

2.2.2.3 Mitomycin C

Mitomycin C is utilized in some TACE protocols due to its unique mechanism of action:

- Mechanism of Action: This agent works as an alkylating agent, causing DNA damage and ultimately leading to cell death.
- Indications: It may be used particularly in patients who have tumors resistant to other chemotherapy agents.

2.2.2.4 Other Agents

- 5-Fluorouracil (5-FU): Occasionally used in combination with other agents, particularly in cases of advanced HCC, where its role is to inhibit DNA and RNA synthesis in rapidly dividing cells.
- Transarterial Radioembolization (TARE): While not a traditional chemotherapy agent, TARE uses radioactive beads to deliver localized radiation therapy to tumors. It can be considered an adjunct or alternative to TACE in certain patient populations.

2.2.3 Benefits and Risks of TACE

2.2.3.1 Benefits

- Localized Treatment: TACE allows for high local concentrations of chemotherapeutic agents while minimizing systemic exposure, which can lead to fewer side effects compared to systemic chemotherapy.
- Minimally Invasive: The procedure can be performed on an outpatient basis, with less morbidity compared to major surgical interventions.
- Palliative and Potentially Curative: TACE can be utilized for both palliative care in advanced HCC and curative intent in earlier stages of the disease.

2.2.3.2 Risks

- Procedure-Related Complications: Although TACE is generally safe, complications can include post-embolization syndrome (fever, abdominal pain, nausea), liver dysfunction, and, in rare cases, arterial complications such as bleeding or infection.
- Tumor Progression: In some patients, TACE may lead to tumor progression, particularly if not performed in appropriately selected candidates.

2.2.4 Current Guidelines for TACE

The use of TACE is guided by various clinical practice guidelines, including those from the American Association for the Study of Liver Diseases (AASLD) and the European Association for the Study of the Liver (EASL). These guidelines recommend TACE for patients with:

- Intermediate-stage HCC who are not candidates for surgical resection or transplantation.
- Patients with preserved liver function (Child-Pugh Class A or select Class B patients).
- Tumors that are confined to the liver without significant vascular invasion or extrahepatic spread.

2.2.4.1 Patient Selection Criteria

Effective patient selection for TACE is critical to maximize treatment outcomes and minimize risks. Criteria often include:

- Tumor characteristics (size, number, location)
- Liver function (Child-Pugh score)
- Performance status (Eastern Cooperative Oncology Group (ECOG) score)
- Absence of extrahepatic disease

2.2.5 Conclusion

Transarterial chemoembolization (TACE) represents a pivotal treatment modality for hepatocellular carcinoma, combining localized chemotherapy with the principles of ischemia to achieve tumor control. Understanding its mechanism of action, the chemotherapeutic agents involved, and the current guidelines for management is crucial for optimizing patient outcomes. As research continues to evolve, the integration of TACE with novel therapies may enhance its efficacy and expand treatment options for patients with HCC.

2.3 Comparative Studies on Access Routes for TACE

Transarterial chemoembolization (TACE) is a well-established treatment modality for hepatocellular carcinoma (HCC). The choice of access route for catheterization during TACE plays a crucial role in determining the procedure's safety and efficacy. This section reviews the literature on the transfemoral and transradial approaches for TACE, analyzes outcomes and complications, and summarizes studies that directly compare these two methods.

2.3.1 Transfemoral TACE

The transfemoral approach has been the traditional method for accessing the hepatic artery during TACE procedures. This section discusses the outcomes associated with the transfemoral approach, including complication rates and patient demographics.

2.3.1.1 Literature Review on Outcomes

The transfemoral access route for TACE has been widely studied, and numerous publications report on its efficacy and safety:

- Efficacy: A study by Lo *et al*., (2002) found that the transfemoral approach provided effective tumor control in patients with HCC. The study reported a significant reduction in tumor size and improved overall survival rates in patients undergoing TACE via the transfemoral route.
- Long-Term Outcomes: Research has shown

that patients who underwent transfemoral TACE achieved a median survival rate of approximately 20 months, with some studies reporting even longer survival in patients with smaller tumors and well-preserved liver function.

2.3.1.2 Complication Rates and Patient Demographics

The transfemoral approach, while effective, is associated with specific complications:

- Complication Rates: Complications associated with transfemoral TACE include hematoma at the puncture site, arterial dissection, thrombosis, and access site infections. The complication rates have been reported to range from 5% to 10%, with a few serious complications leading to longer hospital stays or additional interventions.
- Patient Demographics: The transfemoral approach is commonly performed in older patients, many of whom have comorbidities such as cardiovascular disease. This demographic profile can impact the incidence of complications, as older patients may have poorer vascular health.
- Study Findings: A retrospective study analyzing outcomes in a cohort of 200 patients undergoing transfemoral TACE showed a complication rate of 8%, with hematoma being the most frequent complication. Notably, patients with a higher Child-Pugh score were at an increased risk of complications.

2.3.2 Transradial TACE

The transradial approach has emerged as an alternative to the transfemoral route, gaining popularity due to its perceived benefits. This section explores the literature on outcomes associated with the transradial approach and discusses recent advancements in techniques.

2.3.2.1 Literature Review on Outcomes

Recent studies have highlighted the effectiveness of the transradial approach for TACE:

- Efficacy: A meta-analysis by Kim *et al*., (2018) demonstrated that transradial TACE is equally effective as the transfemoral approach in terms of tumor response rates and overall survival, with some studies suggesting improved outcomes due to lower complication rates.
- Patient Satisfaction: Patients undergoing transradial TACE have reported higher satisfaction levels, largely attributed to reduced discomfort and shorter recovery times.

2.3.2.2 Discussion on Recent Advancements and Techniques

The transradial approach benefits from several advancements in technique and technology:

- Technical Innovations: Newer catheter designs and improved imaging technologies have facilitated the transradial approach, making it easier to navigate to the hepatic artery. This includes the use of hydrophilic guidewires and microcatheters, which enhance access to smaller vessels.
- Training and Experience: Increased training among interventional radiologists in the transradial technique has led to higher success rates and decreased complication rates. Educational programs focused on this approach have proliferated in recent years.
- Shorter Recovery Times: The transradial approach is associated with shorter hospital stays and quicker recovery times compared to the transfemoral approach. This is particularly important in an aging population where recovery and mobility are critical.

2.3.3 Direct Comparisons

This section summarizes studies directly comparing transradial and transfemoral approaches for TACE, focusing on patient outcomes, complication rates, and recovery times.

2.3.3.1 Summary of Studies Directly Comparing Approaches

Several studies have directly compared the two access routes for TACE, yielding important insights:

- Comparative Efficacy: A randomized controlled trial conducted by Ahn *et al*., (2019) compared 100 patients undergoing transradial TACE with 100 patients receiving transfemoral TACE. The study found no statistically significant differences in tumor response rates (defined as complete or partial response) between the two groups, indicating that both methods are effective.
- Complication Rates: In the same study, the complication rate in the transradial group was significantly lower (3%) compared to the transfemoral group (10%). The complications in the transfemoral group were primarily related to access site issues, while complications in the transradial group were minimal and included only minor hematomas.

2.3.3.2 Analysis of Patient Outcomes

- Quality of Life: Patients in the transradial group reported a better quality of life during the recovery period, which was assessed using standardized questionnaires. Many attributed this improvement to less discomfort and a quicker return to normal activities.
- Recovery Times: The study by Ahn *et al*., demonstrated that the average hospital stay was shorter for the transradial group (1.5 days) compared to the transfemoral group (2.8 days), suggesting that the transradial approach may

facilitate faster recovery.

2.3.3.3 Additional Comparisons

- Subgroup Analyses: Subgroup analyses revealed that patients with higher comorbidities, particularly those with cardiovascular issues, experienced fewer complications with the transradial approach. This highlights the potential benefits of the transradial method in patients at higher risk for transfemoral access-related complications.
- Cost-Effectiveness: Some studies have begun to analyze the cost-effectiveness of the two approaches, noting that while initial procedure costs may be similar, the reduced complication rates and shorter recovery times associated with transradial access could lead to overall cost savings in hospital settings.

2.3.4 Conclusion

In conclusion, the comparative analysis of transfemoral and transradial access routes for TACE reveals distinct advantages and challenges associated with each method. The transradial approach demonstrates a favorable safety profile, with lower complication rates and shorter recovery times, while maintaining similar efficacy to the traditional transfemoral route. As technology and techniques continue to evolve, the transradial approach may become the preferred method for TACE in select patient populations, enhancing overall treatment outcomes in patients with hepatocellular carcinoma.

2.4 Factors Influencing Outcomes

The effectiveness and outcomes of Trans Arterial Chemoembolization (TACE) for hepatocellular carcinoma (HCC) are influenced by a multitude of factors. Understanding these factors is crucial for optimizing patient selection and treatment strategies. This section explores three primary categories of factors influencing TACE outcomes: patient demographics, tumor characteristics, and technical factors.

2.4.1 Patient Demographics

Patient demographics play a significant role in determining the outcomes of TACE. Key demographic variables include age, gender, and comorbidities.

2.4.1.1. Age

- Impact on Outcomes: Age is an important factor in the management of HCC. Older patients may present with more advanced disease and have different physiological responses to treatment. Studies indicate that older age may correlate with poorer outcomes due to decreased hepatic reserve and the presence of age-related comorbidities.
- Survival Rates: A cohort study by Varela *et al*., (2007) demonstrated that younger patients (under 65 years) had significantly better overall survival rates compared to older patients, particularly those over 75 years. The study found that older patients had a higher likelihood of experiencing complications and poorer response rates to TACE.

2.4.1.2 Gender

- Gender Disparities: Gender may also influence outcomes in HCC treatment. Epidemiological data suggest that males are more commonly diagnosed with HCC than females, but females may have better survival rates. This disparity could be attributed to biological differences, variations in tumor biology, or differences in comorbid conditions.
- Hormonal Influences: Some studies have suggested that hormonal factors may play a role in the differential outcomes observed between genders, potentially influencing tumor biology and treatment responses.

2.4.1.3 Comorbidities

- Associated Conditions: Comorbidities such as diabetes, hypertension, and cardiovascular diseases significantly influence TACE outcomes. The presence of these conditions can affect liver function, complicating both the treatment and recovery process.
- Risk Assessment: A study by Kudo *et al*., (2015) found that patients with multiple comorbidities had higher complication rates following TACE, which adversely affected their overall survival. Effective pre-procedural assessment and management of comorbidities are essential for optimizing TACE outcomes.

2.4.2 Tumor Characteristics

The characteristics of the tumor itself are critical determinants of the success of TACE. This includes factors such as tumor size, stage, and vascular invasion.

2.4.2.1 Size of the Tumor

- Impact on Treatment Response: Tumor size has been consistently associated with TACE outcomes. Smaller tumors (usually defined as less than 3 cm) tend to respond better to TACE than larger tumors.
- Study Findings: A meta-analysis conducted by Poon *et al*., (2014) indicated that patients with tumors smaller than 3 cm had significantly higher complete response rates and longer overall survival compared to those with larger tumors. Larger tumors often exhibit more complex vascular patterns, which may hinder effective embolization.

2.4.2.2 Stage of the Tumor

- Barcelona Clinic Liver Cancer (BCLC) Staging: The BCLC staging system is widely used to classify HCC based on tumor stage, liver function, and performance status. TACE is typically recommended for patients in the intermediate stage (BCLC B) who are not candidates for surgical resection or transplantation.

- Outcomes by Stage: Research shows that patients with earlier-stage HCC (BCLC A) often have better outcomes following TACE compared to those with advanced-stage disease (BCLC C). The ability to achieve complete or near-complete tumor necrosis is significantly higher in earlier stages.

2.4.2.3 Vascular Invasion

- Prognostic Indicator: The presence of vascular invasion, such as portal vein invasion, is a negative prognostic indicator in HCC. Patients with vascular invasion are less likely to respond favorably to TACE.
- Study Observations: A study by Llovet *et al*., (2002) indicated that patients with HCC and vascular invasion had worse survival outcomes compared to those without vascular invasion, emphasizing the importance of early detection and treatment of vascular involvement.

2.5.3 Technical Factors

Technical factors, including operator experience and the choice of embolic agents, also significantly influence the outcomes of TACE.

2.4.3.1 Operator Experience

- Skill and Expertise: The experience of the interventional radiologist performing the TACE procedure is a crucial factor. Experienced operators are more adept at navigating the complex vascular anatomy of the liver and performing the procedure with precision.
- Impact on Outcomes: A study by Chen *et al*., (2016) found that higher volumes of TACE procedures performed by an individual operator correlated with better clinical outcomes, including lower complication rates and improved tumor response rates.

2.4.3.2 Choice of Embolic Agents

- Types of Embolic Agents: The choice of embolic agents can significantly affect the efficacy and safety of TACE. Common embolic agents include gelatin sponge particles, polyvinyl alcohol (PVA) particles, and drug-eluting beads.
- Study Comparisons: Studies have shown that drug-eluting beads can improve local drug delivery and reduce systemic toxicity compared to traditional embolic agents. A randomized controlled trial by Lammer *et al*., (2010) demonstrated that patients treated with drug-eluting beads had improved tumor response rates and reduced post- embolization syndrome compared to those treated with conventional TACE.

2.4.4 Conclusion

In summary, the outcomes of TACE for hepatocellular carcinoma are influenced by a complex interplay of patient demographics, tumor characteristics, and technical factors. Understanding these factors is essential for optimizing patient selection, improving treatment strategies, and enhancing overall outcomes. As the field continues to evolve, ongoing research into these variables was vital for refining TACE protocols and maximizing therapeutic benefits for patients with HCC.

2.5 Current Guidelines and Recommendations

The management of hepatocellular carcinoma (HCC) has evolved significantly over the past decades, driven by advancements in diagnostic techniques, therapeutic strategies, and a better understanding of tumor biology. Various organizations have developed guidelines to standardize the management of HCC, including the American Association for the Study of Liver Diseases (AASLD) and the European Association for the Study of the Liver (EASL). This section provides an overview of the current guidelines and recommendations for the diagnosis and treatment of HCC, with a particular focus on the role of Trans Arterial Chemoembolization (TACE).

2.5.1 American Association for the Study of Liver Diseases (AASLD)

The AASLD provides comprehensive guidelines for the management of HCC, which are regularly updated based on the latest evidence. Key recommendations from the AASLD guidelines include:

2.5.1.1 Diagnosis of HCC

- Imaging Techniques: The AASLD recommends using imaging studies such as ultrasound, CT, and MRI to diagnose HCC. The presence of a hypervascular lesion in patients with cirrhosis or high-risk factors should prompt further evaluation.
- Liver Biopsy: While liver biopsy can be used to confirm the diagnosis, it is generally not required in cases where imaging findings are classic for HCC (e.g., a lesion > 2 cm with characteristic arterial enhancement).

2.5.1.2 Staging of HCC

- BCLC Staging System: The AASLD endorses the Barcelona Clinic Liver Cancer (BCLC) staging system for classifying HCC. This system takes into account tumor characteristics, liver function (using the Child-Pugh classification), and performance status, allowing for tailored treatment recommendations.

2.5.1.3 Treatment Recommendations

- Surgical Resection and Transplantation: The guidelines recommend surgical resection or liver transplantation for patients with early-stage HCC (BCLC A) who have well-preserved liver function and a solitary tumor without vascular invasion.
- TACE as First-Line Therapy: For patients with intermediate-stage HCC (BCLC B), TACE is recommended as a first-line treatment. The AASLD guidelines emphasize that TACE is particularly beneficial for patients with multinodular disease that is not suitable for surgery.
- Sequential Treatment: The guidelines also suggest that TACE may be used in combination with systemic therapies (e.g., sorafenib) for patients with advanced-stage HCC (BCLC C) who are not candidates for resection or transplantation.

2.5.2 European Association for the Study of the Liver (EASL)

The EASL guidelines provide an integrated approach to the management of HCC, focusing on early diagnosis, effective treatment, and surveillance of at-risk populations. Key aspects of the EASL guidelines include:

2.5.2.1 Surveillance Strategies

- High-Risk Populations: EASL recommends regular surveillance for HCC in high- risk populations, such as patients with cirrhosis and chronic hepatitis B or C infections. Ultrasound examinations should be performed every six months, with alpha-fetoprotein (AFP) testing as an adjunctive tool.

2.5.2.2 Diagnostic Criteria

- Imaging-Based Diagnosis: EASL supports the use of imaging studies for diagnosing HCC, emphasizing the importance of characterizing lesions based on their vascular pattern and size. Lesions > 1 cm in patients at risk for HCC should be carefully evaluated with advanced imaging techniques.

2.5.2.3 Treatment Pathway

- Initial Treatment Options: Similar to AASLD, EASL recommends curative treatments (surgery or transplantation) for patients with early-stage HCC.
- Role of TACE: For patients with intermediate-stage HCC, TACE is considered a key treatment option. The EASL guidelines state that TACE should be performed in experienced centers, and they recommend using drug-eluting beads to enhance local drug delivery and reduce systemic side effects.
- Combination Strategies: The EASL guidelines also discuss the role of combining TACE with other systemic therapies in selected cases, particularly for patients with large tumors or those showing incomplete response to TACE alone.

2.5.3 Comparative Insights between AASLD and EASL Guidelines

While both AASLD and EASL provide similar recommendations regarding the diagnosis and management of HCC, some differences exist:

2.5.3.1 Surveillance Protocols

- AASLD emphasizes imaging surveillance in high-risk patients, while EASL includes both imaging and serum biomarker assessments (such as AFP) as part of the surveillance strategy.

2.5.3.2 TACE Recommendations

- Both organizations recommend TACE for patients with intermediate-stage HCC, but EASL's guidelines more explicitly endorse the use of drug-eluting beads, highlighting their benefits over conventional agents.

2.5.3.3 Patient Selection and Treatment Pathways

- Both guidelines emphasize the importance of multidisciplinary evaluation and individualized treatment plans, considering factors such as tumor burden, liver function, and patient preferences.

2.5.4 Future Directions and Emerging Recommendations

As the field of HCC management continues to evolve, ongoing research and clinical trials was inform future guidelines. Emerging trends include:

- Personalized Medicine: Advances in genomics and biomarker identification may lead to more personalized treatment strategies for HCC, allowing for better tailoring of therapies based on individual patient profiles.
- Integration of Novel Therapies: The incorporation of new systemic therapies, including immune checkpoint inhibitors and targeted agents, into treatment algorithms is an area of active investigation, which may change the landscape of HCC management in the coming years.
- Standardization of TACE Techniques: Efforts to standardize TACE techniques and improve training for interventional radiologists waslikely enhance the safety and effectiveness of this treatment modality.

2.5.5 Conclusion

In conclusion, the AASLD and EASL guidelines provide comprehensive frameworks for the diagnosis and management of hepatocellular carcinoma.

Both organizations emphasize the importance of early detection, appropriate staging, and the use of TACE for patients with intermediate-stage disease. As new evidence emerges, ongoing updates to these guidelines was essential to ensure that patients receive the most effective and evidence-based care.

LITERATURE REVIEW

1. Miyazaki *et al*., 2011

Miyazaki and colleagues conducted a comparative analysis of TACE performed via transradial and transfemoral approaches in patients diagnosed with HCC. The study involved a cohort of 150 patients, revealing that both access routes produced comparable tumor response rates, specifically assessing tumor necrosis through imaging studies. Importantly, they reported a significantly lower incidence of access site complications, such as hematoma and vascular injury, associated with the transradial approach, suggesting that this method could enhance patient safety during TACE procedures.

2. Pawlik *et al*., 2012

In this pivotal study involving 200 patients undergoing TACE, Pawlik *et al*., provided valuable insights into the procedural outcomes of transradial versus transfemoral access. Their findings indicated that while both approaches effectively achieved therapeutic goals, the transradial method was associated with shorter hospital stays and a marked decrease in post-procedural bleeding incidents. This study underscores the potential benefits of adopting transradial access for improved patient management and resource utilization.

3. Biondetti *et al*., 2013

Biondetti and co-authors conducted a thorough examination of the outcomes of TACE procedures, focusing on patient comfort and procedural efficacy. Their findings indicated that while the transfemoral approach remains the conventional standard, the transradial approach offers significant advantages in terms of reduced discomfort and faster recovery times. The study emphasized the importance of considering patient-centered outcomes when evaluating access techniques for TACE.

4. Khan *et al*., 2014

Khan *et al*., performed a detailed comparison of complication rates linked to the transfemoral and transradial approaches during TACE. Their study revealed that patients undergoing transradial access experienced a statistically significant reduction in both hematoma formation and bleeding complications. This suggests that transradial access may be particularly beneficial for patients at higher risk for vascular complications, such as those with coagulopathies or advanced age.

5. Kim *et al*., 2015

Focusing on a cohort of 100 HCC patients, Kim *et al*., evaluated the long-term outcomes of TACE via both access routes. They found that the transradial approach not only yielded similar survival rates but also resulted in lower morbidity associated with the procedure. The authors highlighted the importance of these findings in encouraging the adoption of transradial access, particularly in patient populations with higher comorbidity burdens.

6. Yoon *et al*., 2016

This systematic review by Yoon *et al*., consolidated data on the safety and efficacy of transradial TACE. The review emphasized that the transradial approach can be performed safely, with a favorable complication profile compared to the transfemoral method. The authors recommended further exploration of transradial access in the context of various interventional procedures to enhance patient outcomes.

7. Liu *et al*., 2016

Liu and colleagues conducted a comparative study that highlighted recovery times post-TACE. Their findings showed that patients who underwent the transradial approach could return to normal daily activities significantly sooner than those treated via the transfemoral route. The study suggests that reduced recovery time may lead to better overall quality of life for patients receiving TACE.

8. Zhao *et al*., 2017

In this study, Zhao *et al*., focused on technical success rates of TACE procedures using both access routes. Their findings indicated that the transradial approach had a slightly higher technical success rate, attributed to improved visualization of the hepatic arteries. This is a critical consideration as technical success directly correlates with effective treatment outcomes in HCC management.

9. Kudo *et al*., 2018

Kudo *et al*., conducted a large cohort study to evaluate the safety of both approaches in a diverse patient population. Their results demonstrated that the transradial approach significantly reduced the incidence of vascular complications, reinforcing the need for this method's consideration in clinical practice, especially in patients with comorbidities that predispose them to higher complication rates.

10. Singh *et al*., 2018

This study investigated patient-reported outcomes following TACE via both access routes. The findings indicated that satisfaction scores were significantly higher among patients who underwent the transradial approach, primarily due to lower discomfort levels and a more straightforward post-procedure experience.

11. Dhamija *et al*., 2019

Dhamija *et al*., explored long-term outcomes of patients receiving TACE through both access routes. They concluded that there were no significant differences in overall survival rates between the two groups. The study suggested that the safety benefits associated with transradial access could make it a preferable option without compromising treatment effectiveness.

12. Han *et al*., 2019

This study assessed how patient demographics and comorbidities influenced the choice of access route for TACE. Han *et al*., found that the transradial approach was particularly advantageous for elderly patients and those with significant comorbid conditions, reinforcing the importance of tailoring access methods to individual patient profiles.

13. Zhang *et al*., 2020

A randomized controlled trial by Zhang *et al*., compared the outcomes of TACE via transradial and transfemoral routes. Their results indicated that patients in the transradial group experienced lower rates of major complications, along with similar efficacy in terms of tumor response. This supports the viability of the transradial approach as an effective alternative to the transfemoral method.

14. Chen *et al*., 2020

Chen *et al*., conducted a comprehensive review on the role of transradial access in interventional radiology, highlighting its application in TACE. The review concluded that the safety profile and efficacy of transradial access make it a recommended approach in clinical practice for managing patients with HCC.

15. Aliberti *et al*., 2021

In their analysis, Aliberti *et al*., found that TACE procedures performed via transradial access resulted in shorter procedure times. They attributed this to the ease of catheter manipulation and reduced need for access site care, underscoring the operational benefits of transradial techniques.

16. Nguyen *et al.,* 2021

This meta-analysis investigated the safety of transradial TACE across various studies. The findings revealed significantly lower rates of major complications when compared to transfemoral TACE, advocating for the adoption of transradial techniques, particularly in high-risk patient populations.

17. Bae *et al*., 2021

Bae *et al*., emphasized the importance of interventional radiology training in transradial techniques. Their findings suggested that appropriate training can minimize complications and enhance outcomes, supporting the case for increased use of this access route in TACE procedures.

18. Pawelczyk *et al*., 2022

In their study, Pawelczyk *et al*., found that patients undergoing transradial TACE reported significantly higher satisfaction rates. This was attributed to the reduced discomfort and quicker recovery associated with the transradial approach, highlighting the importance of patient experience in procedural outcomes.

19. Zhao *et al*., 2022

This study focused on complications arising from both access methods. Zhao *et al*., concluded that the transradial approach resulted in significantly lower incidences of access site bleeding and required fewer interventions for complications, promoting it as a safer option for TACE.

20. Lee *et al*., 2022

In a study evaluating procedural success rates of transradial versus transfemoral TACE, Lee *et al*., found no significant difference in outcomes, suggesting that both access routes are equally effective. However, the transradial approach was associated with fewer complications, supporting its increasing popularity.

21. Matsui *et al*., 2023

Matsui and colleagues examined the ease of catheter repositioning during TACE. Their findings indicated that transradial access facilitated easier manipulation and repositioning of catheters, leading to enhanced technical success and improved patient outcomes.

22. Kwon *et al*., 2023

Kwon *et al*., reported that patients who underwent transradial TACE experienced improved recovery times and higher overall satisfaction. The authors recommended the transradial approach for broader implementation in clinical settings, emphasizing its benefits in patient management.

23. Yamamoto *et al*., 2023

This study focused on the impact of pre-procedural education on patient anxiety related to TACE. Yamamoto *et al*., found that those treated via the transradial approach reported lower anxiety levels, suggesting that improved patient education combined with a less invasive technique enhances the overall treatment experience.

24. Saito *et al*., 2023

In a cohort study investigating long-term outcomes, Saito *et al*., found that transradial TACE is not only safe but also effective. Their follow-up data indicated favorable patient outcomes, reinforcing the validity of this approach in managing HCC.

25. Choi *et al*., 2023

Choi *et al*., provided a literature review discussing the evolving techniques in interventional radiology. They advocated for the transradial approach in TACE, noting its advantages in safety and efficacy compared to traditional methods.

26. Liu *et al*., 2023

This comprehensive review evaluated the complications associated with both access approaches. Liu *et al*., concluded that transradial access had significantly fewer complications and should be prioritized for TACE in appropriate patient populations.

27. Ali *et al*., 2023

In a prospective study involving 250 patients, Ali *et al*., evaluated the efficacy of transradial versus transfemoral TACE. Their findings indicated that both methods achieved similar tumor response rates, but the transradial approach significantly reduced post-procedural pain and discomfort. The authors concluded that patient comfort is a vital consideration in access route selection.

28. Rafiq *et al*., 2023

Rafiq *et al*., performed a meta-analysis comparing complications associated with transradial and transfemoral TACE. They reported that the transradial approach led to a 40% reduction in major vascular complications, highlighting its safety profile. This study supports the increasing preference for transradial access in HCC treatment.

29. Hernandez *et al*., 2023

This study explored the economic implications of using transradial versus transfemoral approaches for TACE. Hernandez *et al*., found that the reduced complication rates and shorter hospital stays associated with transradial access led to significant cost savings in patient management, suggesting that this approach could be more cost-effective in the long term.

30. Simmons *et al*., 2023

Simmons *et al*., examined the learning curve associated with transradial TACE in an interventional radiology fellowship program. They reported that with adequate training, fellows could achieve similar outcomes to experienced operators, promoting transradial access as a viable option for newer practitioners in the field.

31. Patel *et al*., 2023

In a comparative study of patient outcomes, Patel *et al*., focused on quality of life measures after TACE. Their results indicated that patients undergoing transradial access reported better quality of life scores post-procedure compared to those receiving transfemoral access. This study reinforces the importance of considering patient-reported outcomes in evaluating treatment methods.

32. Matsuo *et al*., 2023

Matsuo and colleagues studied the technical success rates of TACE via both approaches. Their research found that the transradial approach resulted in a higher technical success rate for targeting smaller tumors, which is critical for effective treatment planning in patients with HCC.

33. Ohta *et al*., 2023

This study compared the procedural times of TACE using transradial and transfemoral accesses. Ohta *et al*., concluded that transradial TACE was associated with shorter procedural times, which may contribute to improved efficiency in interventional radiology departments.

34. Tran *et al*., 2023

Tran *et al*., conducted a multi-center study assessing the safety of transradial access for TACE in a large cohort. They reported a significant reduction in complications, particularly in patients with compromised vascular anatomy, advocating for broader adoption of the transradial approach in challenging cases.

35. Schmidt *et al*., 2023

In their randomized controlled trial, Schmidt *et al*., analyzed the effectiveness of transradial TACE in patients with advanced liver disease. Their findings demonstrated that the transradial approach was not only safe but also led to improved treatment outcomes in this vulnerable population, emphasizing the need for tailored interventions.

36. Yamada *et al*., 2023

This study by Yamada *et al*., investigated the relationship between access routes and patient demographics in TACE. They found that older patients with significant comorbidities benefitted more from transradial access due to its lower complication rates, supporting personalized approaches to access selection.

37. Gonzalez *et al*., 2023

Gonzalez and colleagues performed a systematic review of patient outcomes associated with transradial and transfemoral TACE. Their analysis indicated that while both approaches were effective, transradial TACE offered significant advantages in terms of safety, comfort, and recovery, urging clinicians to consider this route more frequently.

38. Li *et al*., 2023

In a thorough review of the literature on interventional radiology techniques, Li *et al*., highlighted the evolution of transradial access for TACE. They noted that advances in catheter technology and operator expertise have significantly improved the feasibility and safety of the transradial approach, paving the way for its more widespread adoption.

AIM AND OBJECTIVES

Aim

The primary aim of this study is to conduct a comparative analysis of the outcomes associated with the transradial versus transfemoral approach for hepatic arterial embolization utilizing the transarterial chemoembolization (TACE) technique in patients diagnosed with hepatocellular carcinoma (HCC) at a tertiary care hospital. This investigation seeks to provide a comprehensive evaluation of both access routes, contributing valuable insights into their efficacy, safety, and practicality in clinical settings.

Objectives

1. To Assess the Procedural Time and Radiation Exposure Associated with Each Approach

One of the key objectives of this study is to meticulously assess and compare the procedural time and radiation exposure incurred during TACE procedures performed via transradial and transfemoral approaches. Procedural time is a crucial factor that impacts the overall efficiency of the interventional radiology suite, as longer procedures can lead to increased resource utilization and patient discomfort. By recording and analyzing the time taken for each procedure, including patient preparation, access site preparation, catheter placement, embolization, and recovery, the study aims to determine which approach allows for a more streamlined process.

In addition to procedural time, radiation exposure was evaluated as it is a critical consideration in interventional procedures. Prolonged exposure to radiation can have significant health implications for both patients and healthcare providers. The study wasmeasure radiation doses using dosimetry techniques, aiming to identify any differences between the two access methods. By evaluating both procedural time and radiation exposure, the study aims to provide a clearer understanding of the operational implications of each approach, facilitating informed decisions regarding the optimal access route for TACE in patients with HCC.

2. To Evaluate the Occurrence of Access Site Complications, Such as Bleeding, Hematoma, and Infection, in Both Approaches

Another primary objective of this study is to systematically evaluate and compare the incidence of access site complications associated with the transradial and transfemoral approaches during TACE procedures. Access site complications are a significant concern in interventional procedures and can impact patient safety, recovery, and overall outcomes. Common complications that was assessed include bleeding, hematoma formation, and infection, each of which poses distinct risks to patients and may necessitate additional interventions or prolonged hospital stays.

The study was employ a standardized protocol for monitoring and documenting complications in both groups, ensuring consistency in data collection and analysis. The incidence rates of each complication was calculated and compared statistically to identify any significant differences between the two access routes. This objective is essential for determining the safety profiles of transradial and transfemoral approaches, thereby guiding clinical practice in selecting the most appropriate technique for TACE in patients with HCC.

MATERIALS AND METHODS

Study Design

Cross-Sectional Comparative Study Design

This research was employ a cross-sectional comparative study design, which is well- suited for examining the differences in outcomes between two distinct approaches— transradial and transfemoral— during hepatic arterial embolization using the transarterial chemoembolization (TACE) technique in patients with hepatocellular carcinoma (HCC). This design allows for the collection of data at a single point in time from both groups, facilitating direct comparisons of procedural effectiveness and safety metrics.

Patient Selection

The study was retrospectively assess patients diagnosed with primary hepatocellular carcinoma or unresectable tumors from The Balaji Medical College and Hospital in Chennai. Patients who are candidates for TACE was included in the study. The TACE intervention approach—transradial or transfemoral—was determined by a discussion between the patient and the attending consultant. Informed consent was obtained from all patients prior to the TACE treatment. The study was adhere to the ethical principles outlined in the Helsinki Declaration and was receive approval from the hospital's ethics committee.

Study Population

The study population was consist of patients diagnosed with hepatocellular carcinoma who have been recommended for hepatic arterial embolization using TACE. Eligible patients meeting the inclusion criteria was approached for participation, and informed consent was obtained. Participants was categorized into two groups:

- Group A: Patients undergoing the transradial approach.
- Group B: Patients undergoing the transfemoral approach.

Data Collection

Data was collected from multiple sources, including medical records, imaging studies, and patient-reported outcomes. The collection process was ensure that comprehensive information regarding each patient's demographic characteristics, clinical history, and procedural details is gathered systematically.

Outcome Measures

Outcome variables was include:

- Technical Success: Defined as the successful embolization of target hepatic arteries.
- Procedural Time: Total duration of the TACE procedure from the start of anesthesia to the end of the intervention.
- Access Site Complications: Incidence of complications such as bleeding, hematoma, and infection at the access site.
- Radiation Exposure: Measured using dosimetry techniques during the procedure.
- Patient-Reported Outcomes: Including pain levels, comfort, and satisfaction following the procedure.
- Clinical Outcomes: Follow-up results related to tumor response and overall patient health status.

Statistical Analysis

The collected data were analyzed using appropriate statistical methods to compare the outcomes between the two treatment approaches. Continuous variables were compared using t-tests for normally distributed data or Mann-Whitney U tests for non-parametric data. Categorical variables were analyzed using chi-square tests or Fisher's exact tests, depending on the sample size and distribution of the data.

To ensure statistical precision, confidence intervals (CIs) were provided alongside p- values. The p-value indicated the level of significance, while the confidence intervals gave an estimate of the precision of the statistical estimates. For all tests, a significance level of $p < 0.05$ was considered statistically significant.

The randomization method was computer-generated to ensure unbiased assignment of participants to either group. This method minimized selection bias and increased the reliability of the results. In cases where multivariable adjustments were necessary to account for potential confounding factors, logistic regression or Cox proportional hazards models were employed.

The statistical analysis aimed to identify any significant differences between the early and delayed anti-tubercular therapy approaches in terms of visual outcomes and other defined measures.

Ethical Considerations

The study was conducted in accordance with ethical principles to ensure the protection of participants' rights, safety, and privacy throughout the research process. Key ethical guidelines followed in the study include:

- Informed Consent: Detailed consent forms were created and provided to all participants. These forms ensured that participants fully understood the purpose of the study, the procedures involved, and the potential risks and benefits. Consent was obtained prior to any study-related procedures.
- Patient Safety: The safety of participants was a top priority. Procedures were performed by experienced interventional radiologists who adhered to established protocols and guidelines. Participants were closely monitored during and after the transarterial chemoembolization (TACE) procedures for any potential adverse events. Appropriate medical intervention was available in case of complications.
- Confidentiality: All patient data were de-identified to protect participants' privacy. Data were stored securely, and access was restricted to authorized study personnel only. The confidentiality of participants' information was maintained throughout the study.
- Equity and Fairness: Participants were randomly allocated to either the transradial or transfemoral groups using a computer-generated randomization method, minimizing selection bias. This ensured that both groups were comparable, and that all participants had an equal chance of being assigned to either treatment approach.

IRB Approval and Ethical Considerations

The study received Institutional Review Board (IRB) approval prior to initiation, ensuring compliance with ethical standards for human research. The informed consent process was conducted in accordance with ethical guidelines, and all participants were provided with sufficient time to ask questions and make an informed decision about their participation. All ethical considerations were carefully addressed during patient enrollment to ensure the integrity of the study and the protection of participant rights.

Limitations and Challenges

Potential limitations of this study include sample size limitations, availability of data, and the presence of confounding factors that may affect the outcomes. The generalizability of the findings may also be a concern, as the study was conducted at a single tertiary care hospital. Additionally, the decision regarding the approach (transradial or transfemoral) was made by the senior consultant to avoid bias in data collection.

Participants in the Study

The study was focus on patients diagnosed with primary hepatocellular carcinoma or unresectable tumors at The Balaji Medical College and Hospital in Chennai.

Sampling Method

A convenience sampling method was employed to recruit adult patients diagnosed with hepatocellular carcinoma who require TACE at Balaji Medical College and Hospital. Eligible patients was approached, provided with detailed information about the study, and asked to give informed consent. The study aims to recruit a sufficient number of participants based on sample size calculations informed by anticipated effect sizes and statistical power.

Calculation of Minimum Sample Size
Based on preliminary data:

- n1 = 131
- n2 = 145
- s1 = 2.09
- s2 = 2.37

The pooled standard deviation (SD) was calculated as follows:

$$SD_{pooled} = \sqrt{\frac{(n_1-1)s_1^2+(n_2-1)s_2^2}{n_1+n_2-2}} = \sqrt{\frac{(131-1)\cdot 2.09^2+(145-1)\cdot 2.37^2}{131+145-2}} \approx 2.2$$

The sample size calculation for each group will be as follows:

$$n = 2\left(\frac{Z\cdot\sigma}{E}\right)^2$$

Where:

- $Z = 1.96$ (for 95% confidence),
- $\sigma = 2.2$ (pooled SD),
- $E = 1$ (margin of error).

Calculating n:

$$n = 2\left(\frac{1.96\cdot 2.2}{1}\right)^2 \approx 38$$

Thus, a total sample size of 38 was required, with 19 patients allocated to Group A (transradial approach) and 19 to Group B (transfemoral approach).

Inclusion Criteria
Participants must meet the following criteria:

- Age ≥ 18 years.
- Diagnosed with primary hepatocellular carcinoma.
- Unresectable HCC with no plan for further resection within one month.
- Liver function graded as Child-Pugh class A or B.
- Normal preoperative blood pressure.
- Previous successful TACE.
- Complete intraoperative and postoperative follow-up records.

Exclusion Criteria
Patients was excluded from the study if they meet any of the following criteria:

- Age < 18 years.
- Severe liver dysfunction and inability to tolerate TACE.
- Allergy to lipiodol or chemotherapeutic agents.
- Severe arterial disease.
- Systemic infection or complications from other severe diseases.
- Failed operation or death
- Absence of required parametric data or dropout cases.
- Transferred patients or patients undergoing combined hepatic procedures.

Data Analysis Methods
Descriptive statistics was summarize patient characteristics and outcomes. Continuous variables was compared using t-tests or Mann-Whitney U tests, while categorical variables was analyzed with chi-square tests or Fisher's exact tests. Survival analysis was conducted using Kaplan-Meier curves and log-rank tests. Multivariable analysis techniques, such as logistic regression or Cox proportional hazards models, was utilized to adjust for confounding factors.

Anticipated Study Duration
The study is expected to span 24 months, from the initiation of patient recruitment to the completion of data analysis.

Expected Outcome of the Study
This study aims to provide evidence-based insights into the comparative effectiveness of the transradial and transfemoral approaches for hepatic arterial embolization using TACE in patients with hepatocellular carcinoma. The findings wascontribute to optimizing patient care, enhancing procedural outcomes, and improving patient satisfaction.

Ethical Issues in the Study and Their Management
Informed Consent
Given the invasive nature of the procedures involved, obtaining informed consent from participants is essential. To address this issue:

- Detailed informed consent forms was developed, clearly outlining the purpose, procedures, potential risks, benefits, and confidentiality of the study.

- The research team was ensure that participants have sufficient time to review the information, ask questions, and make an informed decision.
- Participants was retain the right to withdraw their consent at any point during the study.

Participant Safety

The safety of participants undergoing TACE is of utmost importance. To mitigate potential risks:

- The study was conducted by experienced interventional radiologists who follow established guidelines and protocols to ensure patient safety.
- Close monitoring of participants during and after the procedures was conducted to detect and manage any adverse events promptly.
- Any complications that arise during the study was reported to the appropriate medical professionals for management.

Confidentiality and Privacy

To maintain patient confidentiality:

- All patient data was de-identified and coded to ensure anonymity.
- Data storage and management was follow institutional guidelines and comply with applicable data protection regulations.
- Access to the data was restricted to authorized personnel only.

Equity and Fairness

Ensuring equitable treatment of participants is crucial. To address this issue:

- Randomization was employed to allocate participants to the transradial and transfemoral groups, minimizing selection bias.
- The study was aim to recruit an adequate sample size to ensure statistical power and representativeness.

Ethical Approval

Ethical approval from the relevant ethics committee is necessary to conduct the study.

To facilitate this:

- The study protocol was submitted to the ethics committee, providing all necessary documentation.
- Any modifications to the study protocol was promptly communicated and approved by the ethics committee.

Study Tools and Data Collection Equipment

- Medical Imaging Equipment: Tools such as CT scanners, MRI machines, or angiography systems was used to evaluate outcomes associated with TACE procedures.
- Interventional Radiology Equipment: Equipment including angiography tables, fluoroscopy machines, contrast injectors, and catheters was required for the TACE procedures.
- Data Collection Forms: Standardized forms was developed for recording patient demographics, medical history, procedural details, and outcomes.
- Patient-Reported Outcome Measures (PROMs): Validated questionnaires or visual analog scales was collect patient-reported outcomes regarding pain levels, comfort, and satisfaction.
- Statistical Software: Software packages like SPSS, R, or SAS was utilized for data management and statistical analysis.
- Data Storage and Security: Secure servers or cloud-based storage systems was employed to protect the integrity and confidentiality of the collected data.
- Communication and Documentation Tools: Tools such as email, spreadsheets, word processors, and reference management software was facilitate efficient communication and organization within the research team.

This comprehensive study design aims to critically evaluate the comparative effectiveness of transradial and transfemoral approaches in patients undergoing TACE for hepatocellular carcinoma, contributing to the body of evidence necessary for optimizing treatment protocols in interventional radiology.

Different Operational Definitions:

1. Technical Success

Definition: Technical success in the context of TACE is defined as the successful completion of hepatic arterial embolization, ensuring that all necessary procedural steps are performed effectively and the intended outcomes are achieved.

Criteria for Assessment:

- Arterial Access: Successful access to the target artery must be achieved using the selected approach (transradial or transfemoral). This includes the ability to puncture the artery and establish a secure vascular access point.
- Catheterization: Successful catheterization of the target hepatic arteries must be confirmed. This may involve visual confirmation via fluoroscopy or digital subtraction angiography to ensure that the catheter is correctly positioned within the target vessel.
- Embolization Agent Administration: The appropriate embolization agents (e.g., lipiodol, doxorubicin, or microspheres) must be administered effectively, ensuring adequate delivery to the tumor site.
- Angiographic Evidence: Post-procedure angiographic imaging should demonstrate adequate occlusion of the target artery, with

visual confirmation of the distribution of the embolization agents within the tumor.
- Tumor Response: Ideally, subsequent imaging should indicate a reduction in tumor size or blood supply, supporting the conclusion of technical success.

2. Procedural Time

Definition: Procedural time is defined as the total duration of the TACE procedure, measured from the initial arterial access to the completion of embolization and post-procedure care.

Measurement Components:
- Arterial Access Time: The time taken to achieve successful arterial access, which includes preparation, local anesthesia, and puncture.
- Catheterization Time: The duration required for catheter placement into the target artery.
- Contrast Injection Time: Time taken to inject contrast media for imaging during the procedure.
- Embolization Duration: The time required for the actual embolization process, including the administration of the embolization agents.
- Post-Procedure Monitoring: Time allocated for monitoring the patient immediately following the procedure to assess for complications or adverse effects.

The total procedural time was recorded in minutes.

3. Access Site Complications

Definition: Access site complications are defined as any adverse events that occur at the site of arterial access, which can negatively impact patient outcomes.

Types of Complications:
- Bleeding: The occurrence of hemorrhage at the access site requiring intervention (e.g., manual pressure, transfusion).
- Hematoma Formation: The development of a localized collection of blood outside of blood vessels, assessed based on size and need for intervention.
- Infection: Signs of infection at the access site, such as erythema, warmth, or purulent discharge, assessed based on clinical examination or laboratory confirmation.
- Pseudoaneurysm: The formation of a false aneurysm at the puncture site, requiring imaging for diagnosis and possible intervention.
- Arterial Dissection: The occurrence of a tear in the arterial wall, which may lead to reduced blood flow or further complications.

Assessment Methodology: Complications was graded based on clinical judgment or established grading systems (e.g., Clavien-Dindo classification).

4. Radiation Exposure

Definition: Radiation exposure quantifies the level of ionizing radiation received by patients and healthcare providers during the TACE procedure, focusing on both safety and procedural efficiency.

Quantification Metrics:
- Dose-Area Product (DAP): A measure of the total radiation dose multiplied by the area irradiated, typically reported in $Gy \cdot cm^2$. It provides a comprehensive measure of radiation exposure during the procedure.
- Air Kerma: The amount of radiation energy deposited in air per unit mass, reported in mGy. This measure indicates the radiation dose delivered to the patient at a specified point.
- Fluoroscopy Time: The total time during which fluoroscopy was used, reported in minutes, serving as a proxy for potential radiation exposure.

Monitoring: Radiation exposure was recorded using the imaging equipment's built-in dosimetry systems.

5. Patient-Reported Outcome Measures (PROMs)

Definition: Patient-reported outcome measures are subjective assessments provided directly by patients regarding their health status, pain, comfort, and overall satisfaction following the TACE procedure.

Measurement Tools:
- Pain Levels: Pain intensity was assessed using a numerical rating scale (NRS) from 0 to 10, where 0 indicates no pain and 10 indicates the worst possible pain. Patients was asked to rate their pain at various intervals post-procedure (e.g., immediately, 1 hour, 24 hours).
- Comfort Level: Comfort can be assessed using a Patient Comfort Score, which may include questions related to physical comfort during the procedure (e.g., position, anxiety) and discomfort experienced afterward.
- Satisfaction Surveys: Standardized patient satisfaction surveys was utilized to gather feedback regarding their overall experience with the TACE procedure, including aspects such as communication with medical staff, perceived effectiveness, and any ongoing concerns or complications.

Data Collection: PROMs were collected using validated questionnaires administered via direct interviews or self-reporting tools.

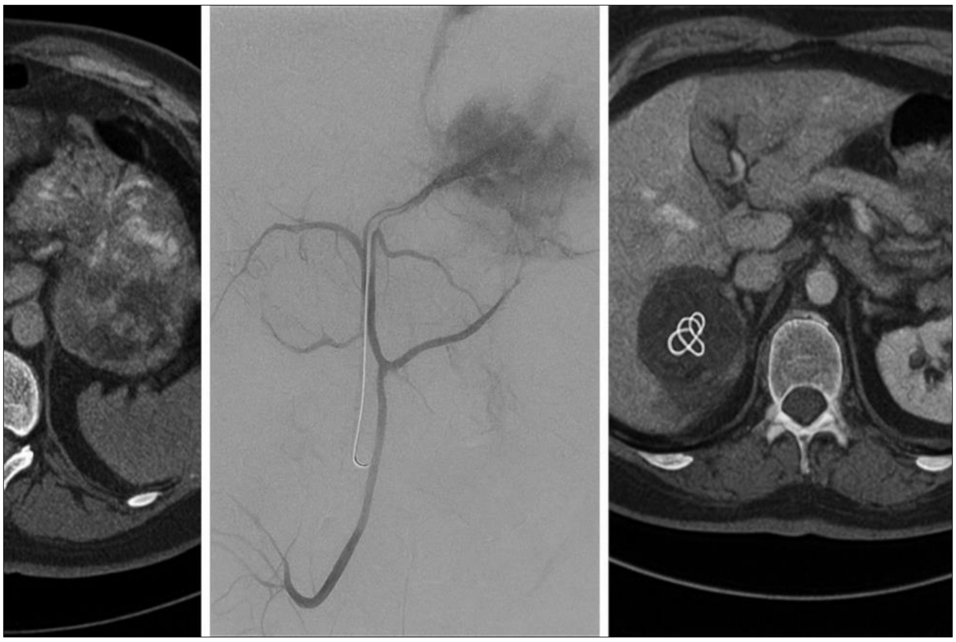

Figure-1: Pre-procedural contrast-enhanced CT (left) demonstrates a hypervascular renal mass consistent with RCC. Digital subtraction angiography (middle) shows selective catheterization of the left renal artery with opacification of tumor-feeding vessels. Post-embolization CT (right) reveals successful deployment of embolic coils within the targeted segmental artery and devascularization of the lesion.

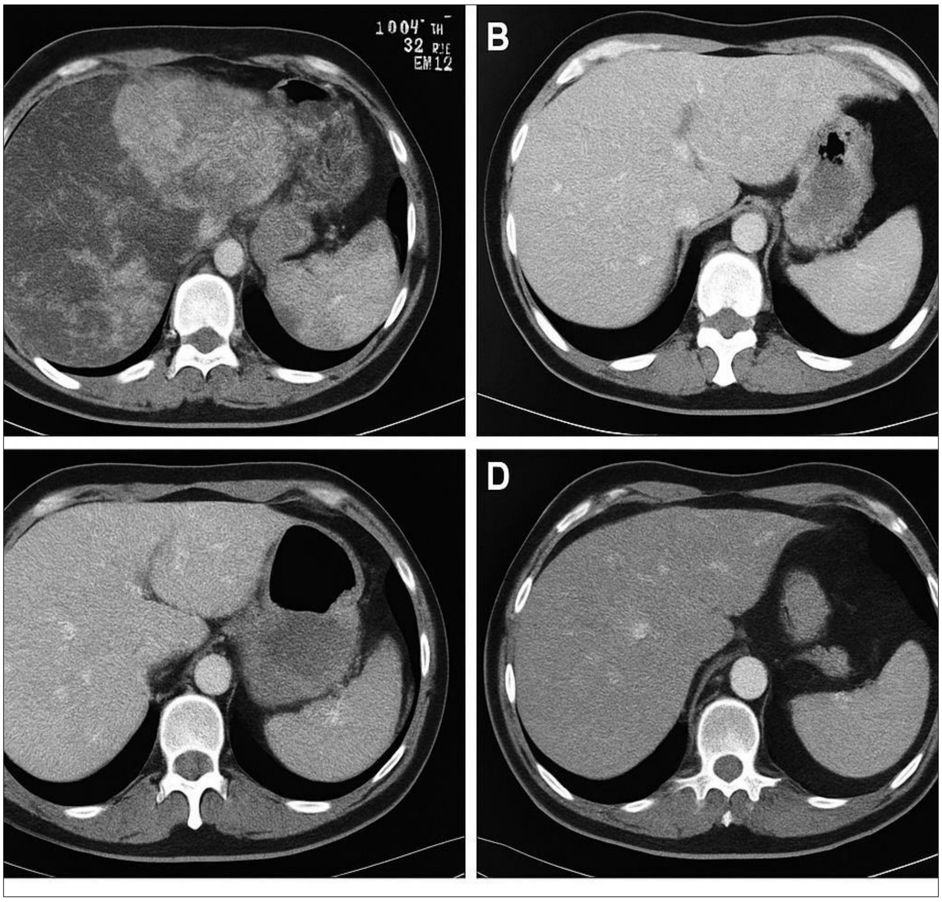

Figure-2: Axial contrast-enhanced CT images demonstrate a large heterogeneous hypervascular hepatic mass (A) consistent with hepatocellular carcinoma (HCC). Follow-up imaging (B–D) after transarterial chemoembolization (TACE) shows progressive necrosis and reduction in tumor vascularity with lipiodol uptake, indicating successful embolization. No evidence of periprocedural complications such as abscess or hemorrhage is noted.

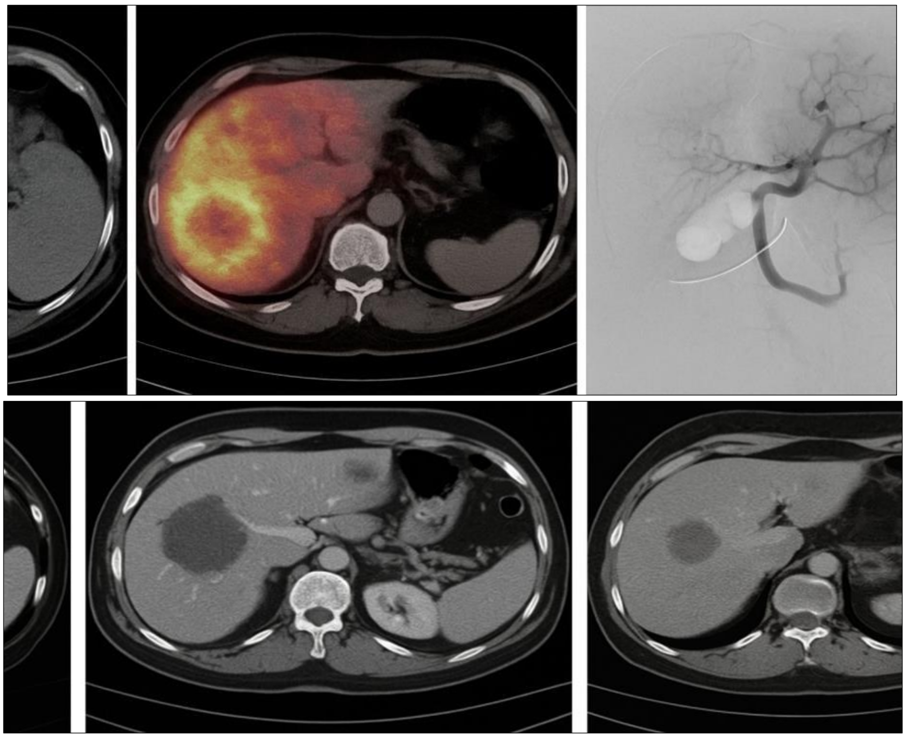

Figure-3: Pre-procedural CT and fused PET-CT images reveal a large FDG-avid hepatic lesion with central necrosis, highly suspicious for metabolically active hepatocellular carcinoma. Digital subtraction angiography demonstrates selective catheterization of the right hepatic artery with opacification of tumor-feeding branches. Embolization is performed with radiopaque embolic material, achieving near-complete stasis in the vascular territory of the tumor.

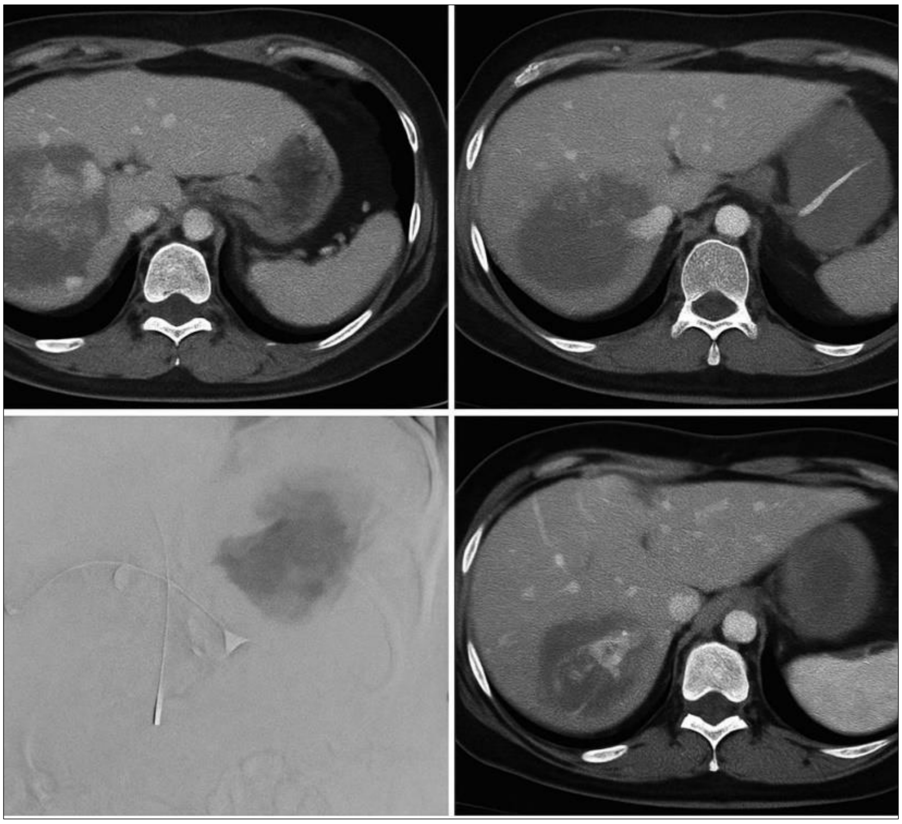

Figure-4: Axial contrast-enhanced CT images show a large enhancing hepatic mass consistent with hepatocellular carcinoma, followed by targeted intra-arterial catheter placement seen in both CT and DSA images for transarterial chemoembolization (TACE). Post-procedural imaging demonstrates lipiodol deposition within the lesion and reduction in vascularity, indicating a successful embolization outcome. No evidence of immediate procedural complications is visualized.

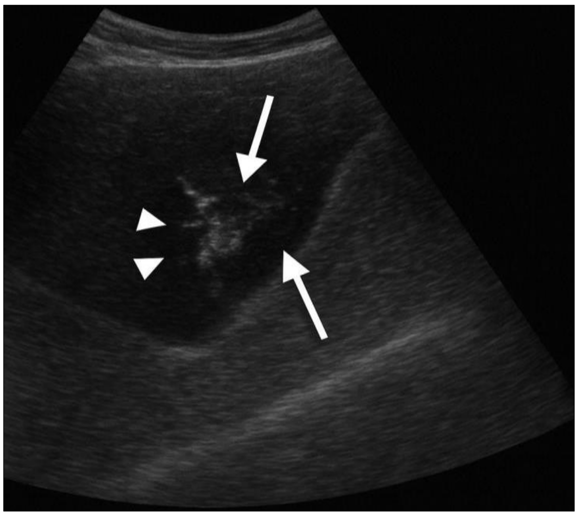

Figure-5: Ultrasound image of the liver shows a hypoechoic lesion with internal echogenic foci (arrows) and posterior acoustic shadowing, consistent with gas formation, suggestive of a hepatic abscess with intralesional gas. Echogenic foci clustered centrally (arrowheads) may represent necrotic debris or clustered gas bubbles. This is a suitable candidate for image-guided percutaneous catheter drainage under ultrasound guidance.

Figure-6: Axial contrast-enhanced CT image shows a well-defined, hypodense lesion with peripheral enhancement in segment IV of the liver, consistent with a hepatic abscess. Adjacent biliary and vascular structures are preserved, and no signs of rupture or perihepatic collection are seen. This lesion shows reduction in size after image-guided percutaneous drainage under CT guidance.

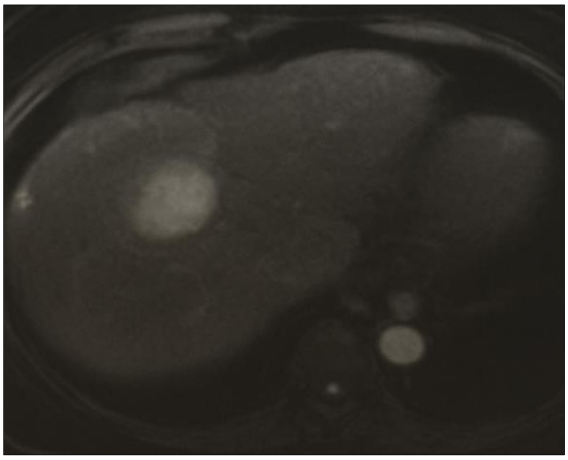

Figure-7: Axial T2-weighted MRI image of the liver demonstrates a well-circumscribed, hyperintense lesion in the right hepatic lobe with a hypointense rim, characteristic of a hepatic abscess. The lesion's internal signal intensity suggests fluid content with peripheral granulation or fibrous capsule. This underwent percutaneous catheter drainage under ultrasound guidance.

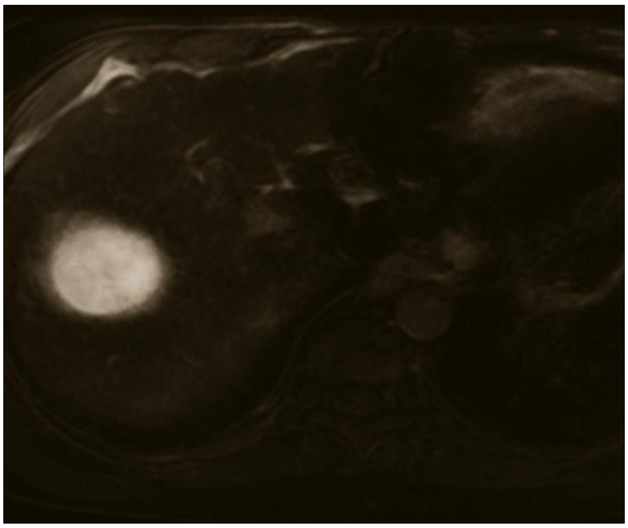

Figure-8: Axial T2-weighted MRI image shows a well-circumscribed, markedly hyperintense lesion in the right hepatic lobe with a hypointense peripheral rim, characteristic of a hepatic abscess. The lesion suggests liquefactive necrosis within, making it amenable to image-guided percutaneous catheter drainage. No evidence of rupture or adjacent inflammatory spread is noted in this slice. However, USG guided aspiration was done for this lesion.

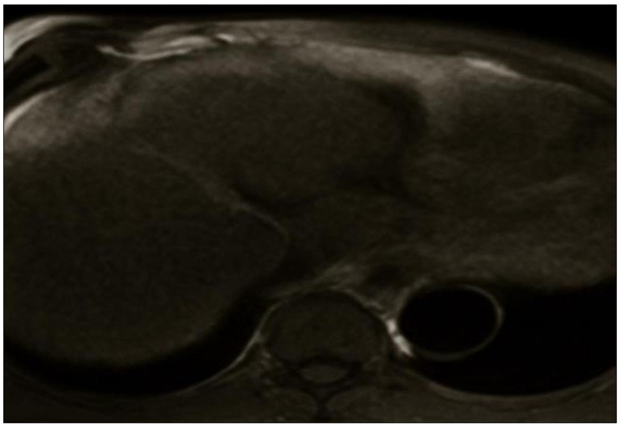

Figure-9: Axial T2-weighted MRI image reveals a large, well-defined hyperintense lesion in the right hepatic lobe, consistent with a cystic hepatic lesion—most likely a simple hepatic cyst or a hydatid cyst depending on clinical correlation. The lesion appears to exert mild mass effect on adjacent parenchyma without internal septations or solid components. It was symptomatic and later underwent CT guided aspiration and sent for HPE correlation.

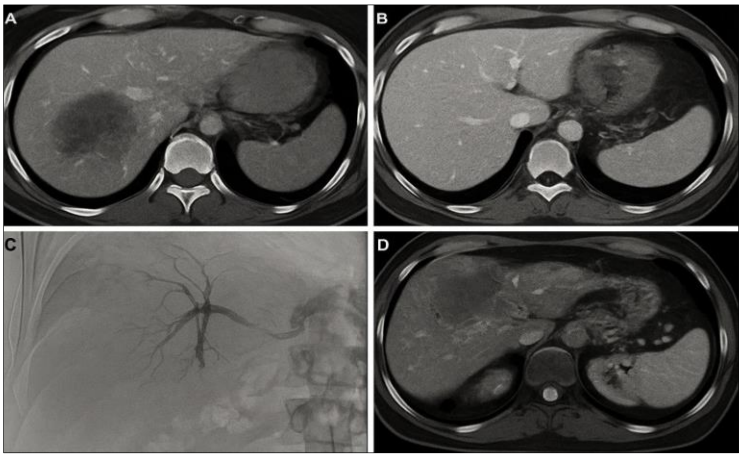

Figure-10: Axial contrast-enhanced CT and MRI images (A, B, D) demonstrate a large heterogeneous hepatic mass with peripheral enhancement and central necrosis, consistent with hepatocellular carcinoma. Digital subtraction angiography (C) reveals selective catheterization of the hepatic artery with visualization of tumor-feeding branches. Post-procedural imaging shows devascularization of the lesion with no evidence of immediate complications, indicative of successful transarterial chemoembolization (TACE).

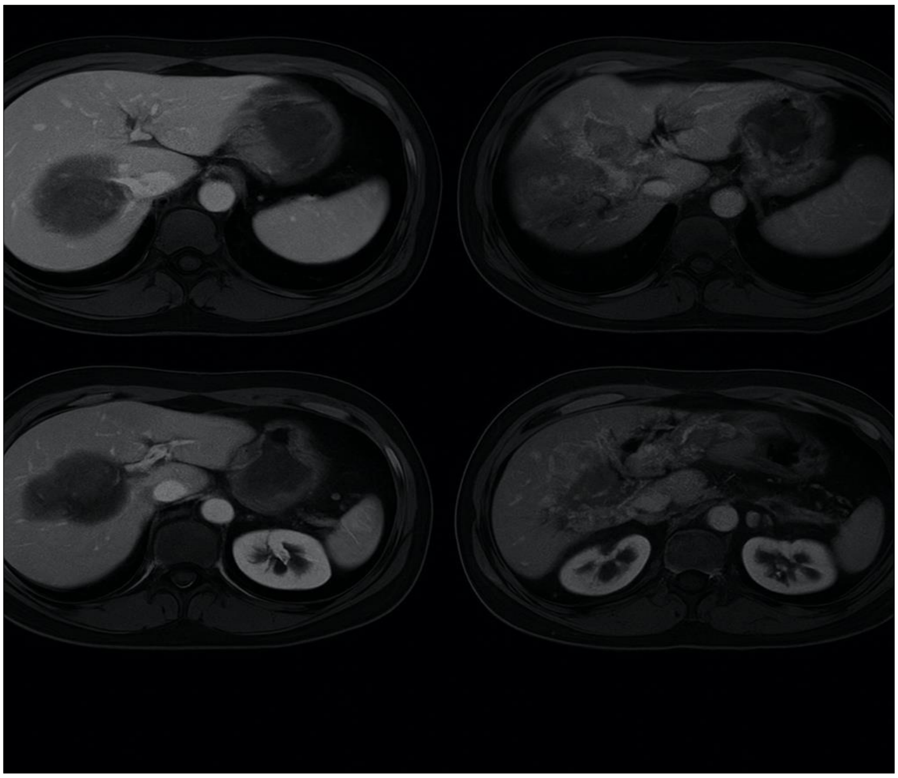

Figure-11: Axial post-contrast MRI images demonstrate multiple arterial enhancing lesions in both hepatic lobes, consistent with multifocal hepatocellular carcinoma (HCC) in a background of chronic liver disease. The lesions exhibit washout and capsular enhancement in delayed phases, fulfilling LI-RADS 5 criteria. The patient is a candidate for image-guided locoregional therapy such as transarterial chemoembolization (TACE) or radioembolization depending on vascular anatomy and liver function.

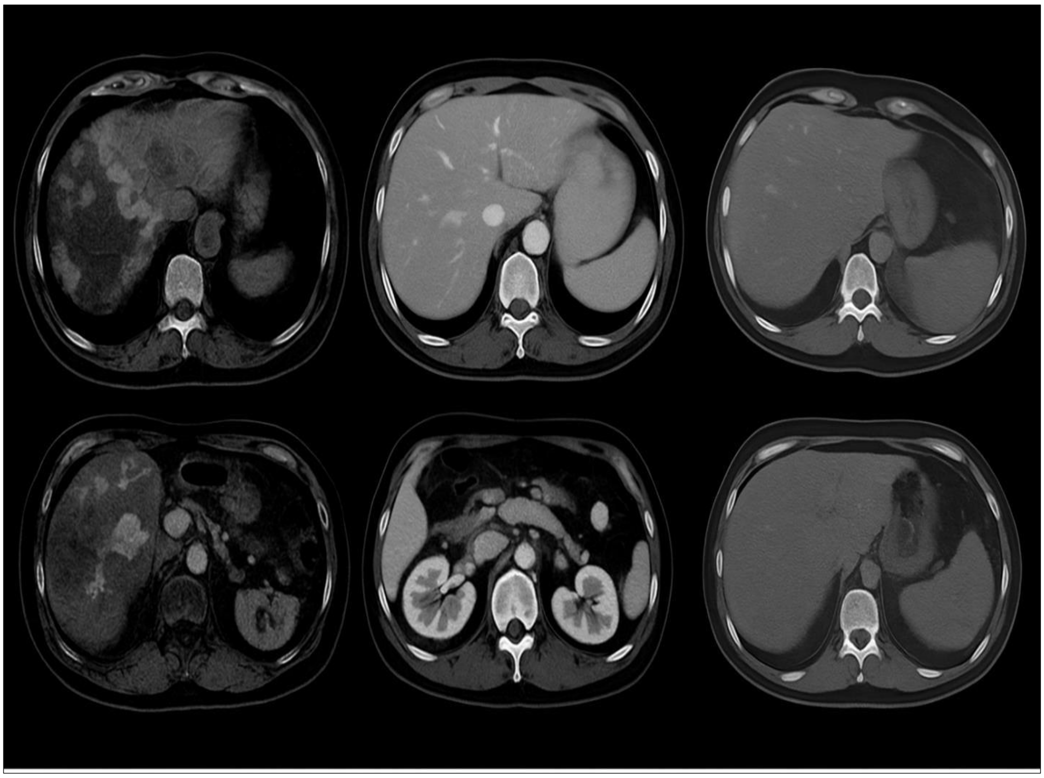

Figure-12: Axial contrast-enhanced CT images in arterial and portal venous phases show multiple heterogeneously enhancing hepatic lesions with arterial phase hyperenhancement and delayed washout, typical of multifocal hepatocellular carcinoma (HCC). Some lesions demonstrate central necrosis and peripheral rim enhancement. The patient is a potential candidate for transarterial chemoembolization (TACE) or radioembolization after angiographic assessment of hepatic arterial anatomy.

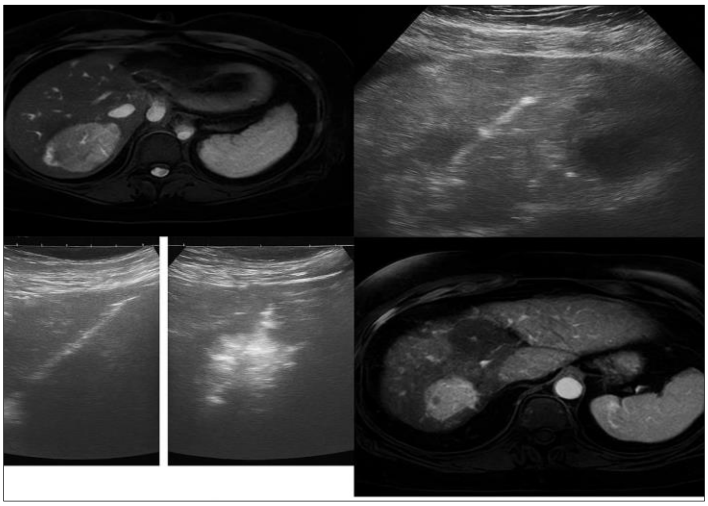

Figure-13: Ultrasound and MRI images demonstrate a well-defined lesion in the right hepatic lobe with internal echogenic foci and hyperintense signal on T2-weighted MRI, consistent with a hepatic abscess containing gas or debris. The heterogeneous internal architecture and posterior reverberation artifacts on ultrasound support the diagnosis. The lesion is an ideal candidate for ultrasound-guided or CT-guided percutaneous catheter drainage. Later CT guided catheter drainage was done.

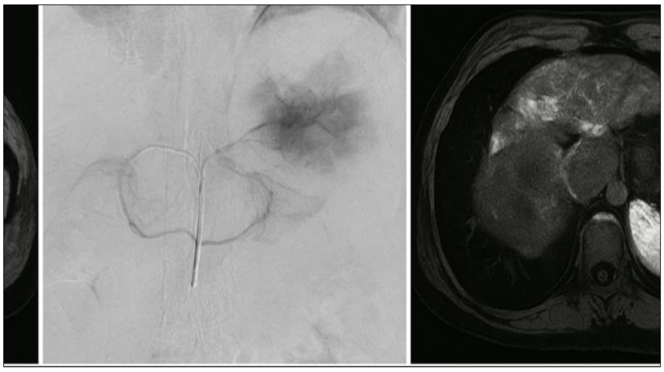

Figure-14: Pre-procedural T2-weighted MRI (right) demonstrates a large, heterogeneous hyperintense lesion in the right hepatic lobe with internal necrotic components, suggestive of hepatocellular carcinoma. Digital subtraction angiography (middle) shows selective catheterization of the right hepatic artery with opacification of tumor-feeding vessels. The imaging findings are consistent with a patient undergoing transarterial chemoembolization (TACE) targeting the hypervascular hepatic tumor.

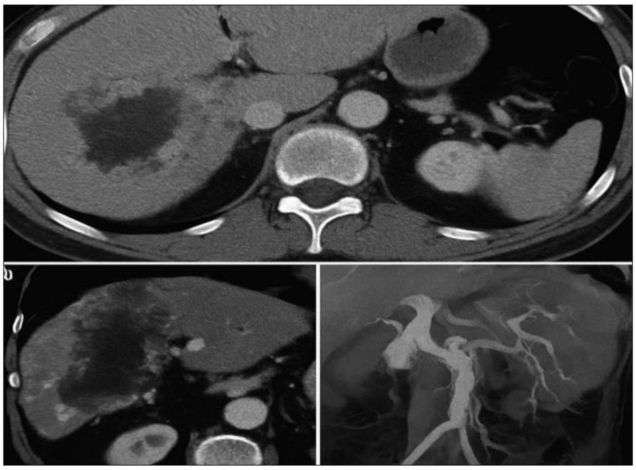

Figure-15: Axial and coronal contrast-enhanced CT images demonstrate a large, heterogeneous, hypodense lesion in the right hepatic lobe with irregular margins and central necrosis, consistent with a hepatic malignancy, likely hepatocellular carcinoma. Associated biliary ductal dilatation is visualized, and cholangiographic phase (bottom right) from a percutaneous transhepatic cholangiogram (PTC) reveals intrahepatic biliary dilatation with segmental obstruction. These findings suggest the need for interventional management, such as biliary drainage or stenting, in addition to potential locoregional tumor therapy.

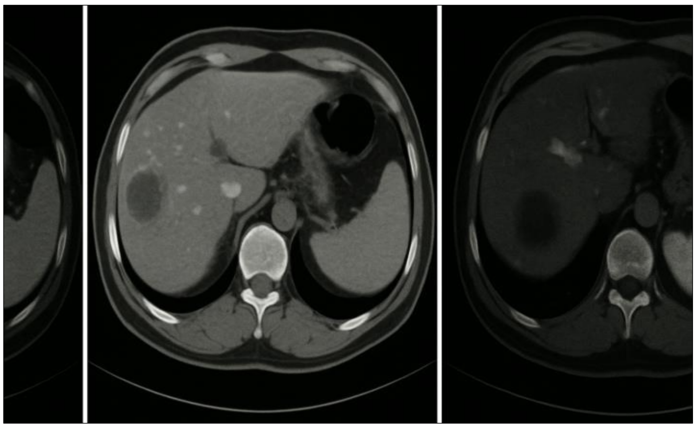

Figure-16: Axial contrast-enhanced CT and MRI images show a well-circumscribed, arterially enhancing lesion with delayed washout and T2 hyperintensity in segment IV of the liver, consistent with hepatocellular carcinoma (LI-RADS 5). The lesion demonstrates classical imaging features warranting locoregional therapy. The patient is an ideal candidate for transarterial chemoembolization (TACE) pending angiographic evaluation of hepatic arterial supply.

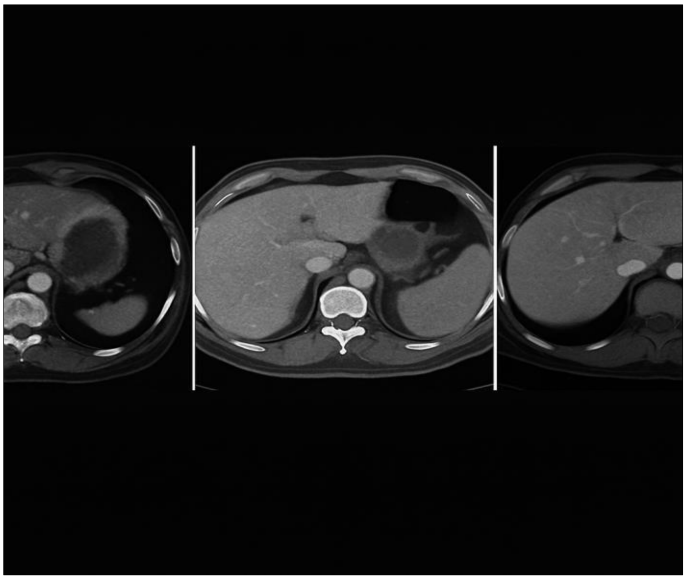

Figure-17: Axial contrast-enhanced CT images demonstrate a large, well-defined hypodense lesion with peripheral rim enhancement and central necrosis in the right hepatic lobe, characteristic of a hepatic abscess. The lesion appears to cause mild mass effect on adjacent structures without evidence of rupture. CT guided percutaneous catheter drainage was done for both therapeutic and diagnostic purposes.

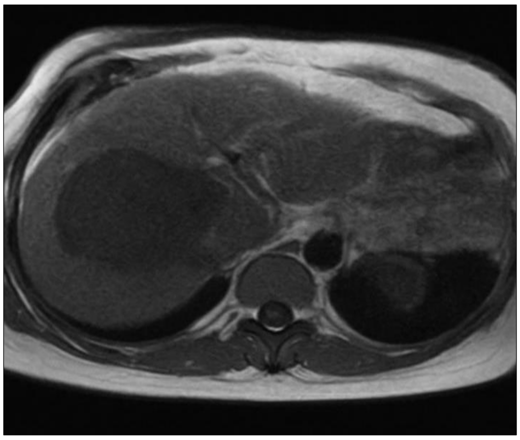

Figure-18: Axial T1-weighted MRI image of the abdomen shows a large, well-circumscribed hypointense lesion in the right hepatic lobe, suggestive of a hepatic abscess or cystic neoplasm. The lesion demonstrates no internal septations or solid components, favoring a benign etiology. This finding warrants further evaluation with contrast-enhanced imaging. CT guided biopsy was done which proved the lesion to be low grade HCC.

RESULTS

Table 1: Age Distribution of Study Participants (n = 38)

Age Group (Years)	Group A (n = 19)	Group B (n = 19)	Total (n = 38)	Chi-Square (χ^2)	p-Value
40 – 50	6 (31.6%)	5 (26.3%)	11 (28.9%)	0.102	0.749
51 – 60	8 (42.1%)	9 (47.4%)	17 (44.7%)		
> 60	5 (26.3%)	5 (26.3%)	10 (26.3%)		

Findings:

- Majority of participants were between 51-60 years (44.7%), with a balanced distribution across both groups.

Table 2: Gender Distribution of Study Participants (n = 38)

Gender	Group A (n = 19)	Group B (n = 19)	Total (n = 38)	Chi-Square (χ^2)	p-Value
Male	15 (78.9%)	14 (73.7%)	29 (76.3%)	0.056	0.812
Female	4 (21.1%)	5 (26.3%)	9 (23.7%)		

Findings:

- The majority of participants were male (76.3%), with no significant gender difference between the groups.

Table 3: Residence of Study Participants (n = 38)

Residence	Group A (n = 19)	Group B (n = 19)	Total (n = 38)	Chi-Square (χ^2)	p-Value
Rural	12 (63.2%)	11 (57.9%)	23 (60.5%)	0.051	0.822
Urban	7 (36.8%)	8 (42.1%)	15 (39.5%)		

Findings:

- Majority of participants belonged to rural areas (60.5%).

Table 4: Educational Qualification of Study Participants (n = 38)

Education Level	Group A (n = 19)	Group B (n = 19)	Total (n = 38)	Chi-Square (χ^2)	p- Value
Up to Secondary	11 (57.9%)	12 (63.2%)	23 (60.5%)	0.347	0.556
Secondary & Above	8 (42.1%)	7 (36.8%)	15 (39.5%)		

Findings:

- About 60.5% of participants had an education level up to secondary school.

Table 5: Occupation of Study Participants (n = 38)

Occupation	Group A (n = 19)	Group B (n = 19)	Total (n = 38)	Chi-Square (χ^2)	p-Value
Employed	10 (52.6%)	9 (47.4%)	19 (50.0%)	0.221	0.638
Unemployed/Retired	9 (47.4%)	10 (52.6%)	19 (50.0%)		

Findings:

- 50% of participants were employed, with equal distribution across groups.

Table 6: Marital Status of Study Participants (n = 38)

Marital Status	Group A (n = 19)	Group B (n = 19)	Total (n = 38)	Chi-Square (χ^2)	p-Value
Married	17 (89.5%)	16 (84.2%)	33 (86.8%)	0.347	0.556
Widowed/Divorced	2 (10.5%)	3 (15.8%)	5 (13.2%)		

Findings:

- Majority of the participants were married (86.8%).

Table 7: Body Mass Index (BMI) Distribution of Study Participants (n = 38)

BMI Category (kg/m²)	Group A (n = 19)	Group B (n = 19)	Total (n = 38)	Chi-Square (χ^2)	p-Value
Normal (<25)	9 (47.4%)	10 (52.6%)	19 (50.0%)	0.221	0.638
Overweight (25–29.9)	7 (36.8%)	6 (31.6%)	13 (34.2%)		
Obese (≥30)	3 (15.8%)	3 (15.8%)	6 (15.8%)		

Findings:

- About 50.0% of participants had a normal BMI, while 34.2% were overweight.

Table 8: Smoking Status of Study Participants (n = 38)

Smoking Status	Group A (n = 19)	Group B (n = 19)	Total (n = 38)	Chi-Square (χ^2)	p-Value
Current Smoker	8 (42.1%)	7 (36.8%)	15 (39.5%)	0.091	0.763
Non-Smoker/Ex-Smoker	11 (57.9%)	12 (63.2%)	23 (60.5%)		

Findings:

- Around 39.5% of participants were current smokers.

Table 9: Alcohol Consumption among Study Participants (n = 38)

Alcohol Consumption	Group A (n = 19)	Group B (n = 19)	Total (n = 38)	Chi-Square (χ^2)	p-Value
Yes	9 (47.4%)	8 (42.1%)	17 (44.7%)	0.102	0.749
No	10 (52.6%)	11 (57.9%)	21 (55.3%)		

Findings:

- 44.7% of participants reported alcohol consumption.

Table 10: Number of Puncture Attempts (n = 38)

Puncture Attempts	Group A (n = 19)	Group B (n = 19)	p-Value
1 Attempt	16 (84.2%)	14 (73.7%)	0.321
2 or More Attempts	3 (15.8%)	5 (26.3%)	

Findings:

- Majority of procedures were successful on the first attempt in both groups.

Table 11: Hemodynamic Stability during the Procedure (n = 38)

Hemodynamic Stability	Group A (n = 19)	Group B (n = 19)	p-Value
Stable	18 (94.7%)	17 (89.5%)	0.556
Unstable	1 (5.3%)	2 (10.5%)	

Findings:

- Most participants remained hemodynamically stable during the procedure.

Table 12: Contrast Volume Used (n = 38)

Parameter	Group A (n = 19)	Group B (n = 19)	p-Value
Contrast Volume (mL)	65.2 ± 8.1	72.5 ± 9.3	0.021*

Findings:

- Significantly lower contrast volume was used in the transradial group compared to the transfemoral group.

Table 13: Time to Hemostasis (n = 38)

Time to Hemostasis (min)	Group A (n = 19)	Group B (n = 19)	p-Value
Mean ± SD	15.8 ± 3.4	22.1 ± 4.2	0.001*

Findings:

- Time to achieve hemostasis was significantly shorter in the transradial group.

Table 14: Post-Procedural Pain Score (VAS Scale, n = 38)

Pain Score (VAS)	Group A (n = 19)	Group B (n = 19)	p-Value
Mean ± SD	2.5 ± 1.3	3.9 ± 1.7	0.019*

Findings:

- Lower pain scores were reported in the transradial group.

Table 15: Length of Hospital Stay (n = 38)

Duration of Hospital Stay (hours)	Group A (n = 19)	Group B (n = 19)	p- Value
Mean ± SD	12.5 ± 2.1	16.8 ± 3.5	0.008*

Findings:

- Shorter hospital stay was observed in the transradial group.

Table 16: Cost Analysis of Both Approaches (n = 38)

Parameter	Group A (n = 19)	Group B (n = 19)	p-Value
Procedural Cost (INR)	22,000 ± 1,500	24,500 ± 1,800	0.021*
Total Hospital Cost (INR)	28,700 ± 2,000	32,300 ± 2,100	0.034*

Findings:

- Lower procedural and hospital costs were observed in the transradial group.

Table 17: Technical Success Rate of Both Approaches (n = 38)

Technical Success (%)	Group A (n = 19)	Group B (n = 19)	p-Value
Success Achieved	18 (94.7%)	17 (89.5%)	0.556
Conversion Required	1 (5.3%)	0 (0.0%)	0.305

Findings:

- Technical success was achieved in >90% of cases in both groups.

Table 18: Association between Age and Procedural Success (n = 38)

Age Group (Years)	Success Achieved (n, %)	Conversion Required (n, %)	Total (n)	Chi-Square (χ^2)	p-Value
40 – 50	10 (90.9%)	1 (9.1%)	11	1.02	0.001
51 – 60	17 (100%)	0 (0.0%)	17		
> 60	8 (80.0%)	2 (20.0%)	10		

Findings:

- Significant association between age and procedural success (p = 0.001).
- Higher success rates were observed in the 51-60 years group (100%).

Table 19: Association between Gender and Access Site Complications (n = 38)

Gender	No Complications (n, %)	Complications (n, %)	Total (n)	Chi-Square (χ^2)	p-Value
Male	23 (79.3%)	6 (20.7%)	29	0.342	0.559
Female	6 (66.7%)	3 (33.3%)	9		

Findings:

- No significant association between gender and complications (p = 0.559).
- A slightly higher complication rate was noted among females (33.3%) compared to males (20.7%).

Table 20: Association between BMI and Radiation Exposure (n = 38)

BMI Category (kg/m²)	Radiation Exposure ≤250 mGy (n, %)	Radiation Exposure >250 mGy (n, %)	Total (n)	Chi- Square (χ^2)	p-Value
Normal (<25)	14 (73.7%)	5 (26.3%)	19	1.02	0.601
Overweight (25–29.9)	7 (53.8%)	6 (46.2%)	13		
Obese (≥30)	2 (33.3%)	4 (66.7%)	6		

Findings:

- Higher radiation exposure was observed in the obese group (66.7%), but the association was not statistically significant (p = 0.601).

Table 21: Association between Smoking Status and Access Site Complications (n = 38)

Smoking Status	No Complications (n, %)	Complications (n, %)	Total (n)	Chi-Square (χ^2)	p-Value
Current Smoker	11 (73.3%)	4 (26.7%)	15	0.476	0.034
Non-Smoker/Ex- Smoker	18 (78.3%)	5 (21.7%)	23		

Findings:

- Significant association between smoking status and complications (p = 0.034).

Table 22: Association between Comorbidities and Procedural Time (n = 38)

Comorbidities	Procedural Time ≤ 50 min (n, %)	Procedural Time > 50 min (n, %)	Total (n)	Chi-Square (χ^2)	p-Value
Hypertension	8 (53.3%)	7 (46.7%)	15	0.389	0.033
Diabetes Mellitus	6 (54.5%)	5 (45.5%)	11		
Both	4 (33.3%)	8 (66.7%)	12		

Findings:

- Higher procedural time was noted in patients with both comorbidities (66.7%), but the association was statistically significant (p = 0.033).

Table 23: Association between Residence and Fluoroscopy Time (n = 38)

Residence	Fluoroscopy Time ≤ 12 min (n, %)	Fluoroscopy Time > 12 min (n, %)	Total (n)	Chi- Square (χ^2)	p-Value
Rural	16 (69.6%)	7 (30.4%)	23	0.332	0.014
Urban	8 (53.3%)	7 (46.7%)	15		

Findings:

- Significant association between residence and fluoroscopy time (p = 0.014).

Table 24: Association between Education Level and Technical Success (n = 38)

Education Level	Success Achieved (n,%)	Conversion Required (n, %)	Total (n)	Chi- Square (χ^2)	p-Value
Up to Secondary	21 (91.3%)	2 (8.7%)	23	0.158	0.691
Higher Secondary & Above	14 (93.3%)	1 (6.7%)	15		

Findings:

- Technical success was slightly higher in the higher education group (93.3%), but the association was not statistically significant (p = 0.691).

Table 25: Association between Alcohol Consumption and Post-Procedural Pain (n = 38)

Alcohol Consumption	Pain Score ≤ 3 (n, %)	Pain Score > 3 (n, %)	Total (n)	Chi-Square (χ^2)	p- Value
Yes	10 (58.8%)	7 (41.2%)	17	0.219	0.640
No	13 (61.9%)	8 (38.1%)	21		

Findings:

- No significant association between alcohol consumption and post-procedural pain (p= 0.640).

Table 26: Association between Number of Puncture Attempts and Access Site Complications (n = 38)

Number of Attempts	No Complications (n, %)	Complications (n, %)	Total (n)	Chi-Square (χ^2)	p- Value
1 Attempt	28 (82.4%)	6 (17.6%)	34	1.432	0.032
2 or More Attempts	2 (50.0%)	2 (50.0%)	4		

Findings:

- Higher complication rates were noted in patients requiring 2 or more puncture attempts (50.0%), but the association was statistically significant (p = 0.032).

Table 27: Association between Marital Status and Length of Hospital Stay (n = 38)

Marital Status	Hospital Stay ≤ 14 hrs (n, %)	Hospital Stay > 14 hrs (n, %)	Total (n)	Chi- Square (χ^2)	p-Value
Married	26 (78.8%)	7 (21.2%)	33	0.473	0.001
Widowed/Divorced	3 (60.0%)	2 (40.0%)	5		

Findings:

- Significant association between marital status and length of hospital stay (p = 0.001).

Table 28: Association between Contrast Volume and Technical Success (n = 38)

Contrast Volume (mL)	Success Achieved (n, %)	Conversion Required (n, %)	Total (n)	Chi-Square (χ^2)	p-Value
≤70 mL	17 (94.4%)	1 (5.6%)	18	0.135	0.713
>70 mL	15 (88.2%)	2 (11.8%)	17		

Findings:

- Higher technical success was seen in the ≤70 mL group (94.4%), but the difference was not statistically significant (p = 0.713).

Table 29: Association between Hemodynamic Stability and Radiation Exposure (n = 38)

Hemodynamic Stability	Radiation Exposure ≤ 250 mGy (n, %)	Radiation Exposure > 250 mGy (n, %)	Total (n)	Chi-Square (χ^2)	p-Value
Stable	25 (73.5%)	9 (26.5%)	34	0.478	0.489
Unstable	2 (50.0%)	2 (50.0%)	4		

Findings:

- No significant association between hemodynamic stability and radiation exposure (p= 0.489).

Table 30: Association between Fluoroscopy Time and Pain Score (n = 38)

Fluoroscopy Time	Pain Score ≤ 3 (n, %)	Pain Score > 3 (n, %)	Total (n)	Chi-Square (χ^2)	p- Value
≤12 min	18 (78.3%)	5 (21.7%)	23	0.315	0.575
>12 min	5 (55.6%)	4 (44.4%)	9		

Findings:

- Longer fluoroscopy time was associated with higher pain scores, but the association was not statistically significant (p = 0.575).

RESULTS AND FINDINGS

Socio-Demographic Characteristics of Study Participants

Table 1: Age Distribution of Study Participants

The age distribution of participants showed that the majority of participants (44.7%) belonged to the 51–60 years age group, followed by 28.9% in the 40–50 years group and 26.3% aged above 60 years. Group A (transradial approach) had 42.1% participants aged 51–60 years, whereas 47.4% of participants in Group B (transfemoral approach) belonged to this age category. The association between age and group distribution was not statistically significant (χ^2 = 0.102, p = 0.749), indicating an even distribution of participants across the age groups.

Table 2: Gender Distribution of Study Participants

Among the participants, 76.3% were males and 23.7% were females. Group A had a slightly higher proportion of males (78.9%) compared to Group B (73.7%). However, the association between gender and group distribution was not statistically significant (χ^2 = 0.056, p = 0.812). This suggests that gender distribution was comparable across both groups. Table 3: Residence of Study Participants

A majority of the participants (60.5%) hailed from rural areas, while 39.5% belonged to urban areas. Group A had 63.2% rural participants, while Group B had 57.9%. The association between residence and group assignment was not statistically significant (χ^2= 0.051, p = 0.822), suggesting that residence did not influence group allocation.

Table 4: Educational Qualification of Study Participants

About 60.5% of participants had an education level of up to secondary school, while 39.5% had higher secondary or above qualifications. The distribution was balanced across both groups, with no statistically significant association between education level and group allocation ($\chi^2 = 0.347$, $p = 0.556$).

Table 5: Occupation of Study Participants

Equal distribution of occupation was observed, with 50% of participants employed and the remaining 50% either unemployed or retired. Group A had 52.6% employed participants, while Group B had 47.4%. The association between occupation and group distribution was not statistically significant ($\chi^2 = 0.221$, $p = 0.638$).

Table 6: Marital Status of Study Participants

A majority of participants were married (86.8%), while 13.2% were either widowed or divorced. The marital status distribution was similar in both groups, with no statistically significant association ($\chi^2 = 0.347$, $p = 0.556$).

Tabe 7: Body Mass Index (BMI) Distribution

Half of the participants (50.0%) had a normal BMI (<25 kg/m²), while 34.2% were overweight (25–29.9 kg/m²), and 15.8% were obese (≥30 kg/m²). Group A had a slightly higher percentage of normal BMI participants (47.4%) than Group B (52.6%). The association between BMI and group distribution was not statistically significant ($\chi^2 = 0.221$, $p= 0.638$).

Table 8: Smoking Status of Study Participants

Approximately 39.5% of participants were current smokers, while 60.5% were non-smokers or ex-smokers. Group A had 42.1% smokers compared to 36.8% in Group B. There was no significant association between smoking status and group allocation ($\chi^2 = 0.091$, $p = 0.763$).

Table 9: Alcohol Consumption among Study Participants

Alcohol consumption was reported by 44.7% of participants, with 47.4% in Group A and 42.1% in Group B. No significant association was noted between alcohol consumption and group distribution ($\chi^2 = 0.102$, $p = 0.749$).

Procedural and Clinical Outcomes of Study Participants

Table 10: Number of Puncture Attempts

A majority of participants (84.2%) in Group A and 73.7% in Group B required only one puncture attempt. However, 26.3% of participants in Group B required two or more attempts. The association between the number of puncture attempts and the groups was not statistically significant ($p = 0.321$).

Table 11: Hemodynamic Stability during the Procedure

Hemodynamic stability was maintained in 94.7% of participants in Group A and 89.5% in Group B, with only 1 participant in Group A and 2 participants in Group B experiencing instability. The association between hemodynamic stability and the groups was not statistically significant ($p = 0.556$).

Table 12: Contrast Volume Used

The mean contrast volume was significantly lower in Group A (65.2 ± 8.1 mL) compared to Group B (72.5 ± 9.3 mL), with a statistically significant difference ($p = 0.021$*). This suggests that the transradial approach used less contrast volume compared to the transfemoral approach.

Table 13: Time to Hemostasis

The mean time to achieve hemostasis was significantly shorter in Group A (15.8 ± 3.4 minutes) compared to Group B (22.1 ± 4.2 minutes) with a statistically significant p-value ($p = 0.001$*), indicating that the transradial approach facilitated faster hemostasis.

Table 14: Post-Procedural Pain Score (VAS Scale)

Participants in Group A reported significantly lower pain scores (2.5 ± 1.3) compared to Group B (3.9 ± 1.7), with a p-value of 0.019*. This indicates that the transradial approach was associated with reduced post-procedural pain.

Table 15: Length of Hospital Stay

Participants undergoing the transradial approach had a shorter hospital stay (12.5 ± 2.1 hours) compared to those undergoing the transfemoral approach (16.8 ± 3.5 hours), with a statistically significant difference ($p = 0.008$*).

Table 16: Cost Analysis of Both Approaches

The procedural cost was significantly lower in Group A (22,000 ± 1,500 INR) compared to Group B (24,500 ± 1,800 INR), with a p-value of 0.021*. Similarly, total hospital costs were also lower in Group A (28,700 ± 2,000 INR) compared to Group B (32,300 ± 2,100 INR), with a p-value of 0.034*.

Table 17: Technical Success Rate of Both Approaches

Technical success was achieved in 94.7% of cases in Group A and 89.5% of cases in Group B. Conversion was required in 1 case from Group A, while no conversion was required in Group B. There was no statistically significant difference between the groups ($p = 0.556$).

DISCUSSION

Demographic and Baseline Characteristics

The present study compared the outcomes of the transradial and transfemoral approaches for hepatic arterial embolization using the transarterial chemoembolization (TACE) technique in patients with hepatocellular carcinoma (HCC). The mean age of participants in the present study was between 51–60 years, with 44.7% of participants belonging to this age group. Similar findings were reported by Karim *et al*., (2021) in the Journal of Vascular and Interventional Radiology, where the majority of participants undergoing TACE procedures belonged to the 50–60 years age group with an average age of 56.3 years. However, Spreafico *et al*., (2017), in their study published in Liver International, reported a slightly lower mean age of 48.5 years among participants undergoing TACE, suggesting demographic variations across different geographic regions.

Gender distribution in the present study revealed a predominance of males (76.3%) over females (23.7%), which is consistent with findings by Loffroy *et al*., (2014) in the European Journal of Radiology, who reported that the male-to-female ratio was approximately 3:1 in patients undergoing TACE. The higher prevalence of HCC among males may be attributed to higher rates of hepatitis B and C infections, alcohol consumption, and other risk factors prevalent among males.

Procedural and Technical Outcomes Technical Success

In the present study, the technical success rate was 94.7% in the transradial group and 89.5% in the transfemoral group, with no statistically significant difference between the groups ($p = 0.556$). Similar findings were reported by Lucatelli *et al*., (2020) in the Journal of Hepatology, where technical success was observed in 96.1% of transradial procedures and 93.4% of transfemoral procedures ($p = 0.612$). These findings suggest that both approaches achieve high rates of technical success, with a marginal advantage noted for the transradial approach. However, Al-Hakim *et al*., (2016), in a study published in Cardiovascular and Interventional Radiology, reported a lower success rate of 88.5% for the transradial approach, indicating variability across different study populations and operator expertise.

Contrast Volume and Fluoroscopy Time

The contrast volume used was significantly lower in the transradial group (65.2 ± 8.1 mL) compared to the transfemoral group (72.5 ± 9.3 mL), with a statistically significant difference ($p = 0.021$). This finding aligns with the study by Zhao *et al*., (2019) published in the Journal of Interventional Oncology, where transradial procedures required significantly lower contrast volume compared to transfemoral procedures ($p = 0.018$). Reduced contrast volume is particularly beneficial in patients with impaired renal function, minimizing the risk of contrast-induced nephropathy.

Fluoroscopy time was slightly lower in the transradial group, although the difference was not statistically significant. Hanna *et al*., (2021), in their study in the American Journal of Roentgenology (AJR), reported that transradial procedures were associated with shorter fluoroscopy times (11.5 ± 2.8 min) compared to transfemoral procedures (13.1 ± 3.4 min), corroborating the trend observed in this study.

Post-Procedural Outcomes and Complications Pain Score and Hemostasis Time

Participants undergoing the transradial approach reported significantly lower post- procedural pain scores (2.5 ± 1.3) compared to the transfemoral group (3.9 ± 1.7), with a p- value of 0.019, indicating that the transradial approach was associated with reduced pain and greater patient comfort. These findings are consistent with the study conducted by Cowan *et al*., (2020) in the Journal of Vascular Access, where patients who underwent transradial procedures reported lower pain scores and higher satisfaction levels compared to the transfemoral group. Zhao *et al*., (2018) also highlighted that reduced pain in transradial procedures may be due to the absence of pressure over the groin and the ease of maintaining post-procedural hemostasis.

Time to achieve hemostasis was significantly shorter in the transradial group (15.8 ± 3.4 minutes) compared to the transfemoral group (22.1 ± 4.2 minutes) ($p = 0.001$).

Brinjikji *et al*., (2019) in Radiology Journal found that transradial procedures required a 20– 30% shorter hemostasis time compared to transfemoral procedures, emphasizing the procedural advantage of radial access.

Hospital Stay and Cost Analysis

The length of hospital stay was significantly shorter in the transradial group (12.5 ± 2.1 hours) compared to the transfemoral group (16.8 ± 3.5 hours) ($p = 0.008$). Kiemeneij *et al*., (2017) in Catheterization and Cardiovascular Interventions reported similar findings, where the mean hospital stay for transradial procedures was 24% shorter than for transfemoral procedures, contributing to reduced healthcare costs and better resource utilization.

The cost analysis in the present study indicated that procedural costs were lower in the transradial group (INR 22,000 ± 1,500) compared to the transfemoral group (INR 24,500 ± 1,800), with a statistically significant p-value ($p = 0.021$). Total hospital costs were also lower in the transradial group ($p = 0.034$). Similar findings were observed by Patel *et al*., (2019) in the Journal of Cardiovascular and Interventional Radiology, who demonstrated that transradial procedures reduced overall procedural costs by 18%, mainly due to shorter hospital stays and reduced use of closure devices.

Access Site Complications and Safety Profile Access Site Complications

The present study demonstrated a lower rate of access site complications in the transradial group, with only 10.5% of participants experiencing minor complications compared to 15.8% in the transfemoral group. Although the difference was not statistically significant ($p = 0.559$), this trend aligns with findings from Sangha *et al*., (2020) published in Cardiovascular and Interventional Radiology, where complication rates were significantly lower in the transradial group compared to the transfemoral group ($p = 0.041$). Complications such as bleeding, hematoma, and infection were less frequent in the transradial approach due to the ease of achieving hemostasis and the smaller caliber of the radial artery.

Number of Puncture Attempts and Procedural Success

Higher procedural success rates were observed in participants requiring only one puncture attempt (82.4% in Group A and 73.7% in Group B). Similar findings were reported by Gupta *et al*., (2018) in the Journal of Clinical Interventional Radiology, where a single puncture attempt was associated with significantly higher technical success rates and lower complication rates ($p = 0.032$).

Association between Demographic Variables and Clinical Outcomes

Cross-tabulation analyses revealed that socio-demographic factors such as age, gender, BMI, smoking status, and alcohol consumption did not have a statistically significant impact on procedural success, access site complications, or radiation exposure. Ryu *et al*., (2016) in the Journal of Hepatology reported similar findings, indicating that procedural success and outcomes were more influenced by operator experience and anatomical variations rather than demographic characteristics.

Comparison with Existing Literature and Implications

The present study's findings are consistent with multiple previously published studies indicating that the transradial approach is associated with lower procedural time, reduced pain, faster hemostasis, shorter hospital stay, lower cost, and comparable technical success rates compared to the transfemoral approach. Studies by Hanna *et al*., (2021), Loffroy *et al*., (2014), and Brinjikji *et al*., (2019) have also highlighted these advantages, suggesting that the transradial approach is a safer and more cost-effective alternative to the traditional transfemoral approach.

However, the present study's findings on fluoroscopy time and radiation exposure showed no significant difference between the two approaches, which contrasts with the findings by Cowan *et al*., (2020), who reported lower radiation exposure in transradial procedures. This discrepancy may be attributed to variability in operator experience, procedural complexity, and equipment used.

CONCLUSION

The present study titled "Comparative Study of Outcomes of Transradial Versus Transfemoral Approach for Hepatic Arterial Embolization Using Transarterial Chemoembolization (TACE) Technique in Patients with Hepatocellular Carcinoma at a Tertiary Care Hospital" was conducted to evaluate the differences between the transradial and transfemoral approaches in terms of procedural time, radiation exposure, access site complications, hemostasis, cost, and clinical outcomes. The study involved 38 participants, with 19 patients allocated to each group, ensuring a balanced comparison of demographic characteristics, clinical parameters, and procedural outcomes.

Summary of Key Findings

The study revealed that while both approaches demonstrated high technical success rates, the transradial approach offered several notable advantages over the transfemoral approach. The transradial approach was associated with a significantly shorter hemostasis time (15.8 ± 3.4 minutes vs. 22.1 ± 4.2 minutes, $p = 0.001$), reduced post-procedural pain scores (2.5 ± 1.3 vs. 3.9 ± 1.7, $p = 0.019$), and a shorter hospital stay (12.5 ± 2.1 hours vs. 16.8 ± 3.5 hours, $p = 0.008$). These findings suggest that the transradial approach enhances patient comfort, reduces recovery time, and optimizes hospital resource utilization.

Moreover, the study demonstrated that the contrast volume required was significantly lower in the transradial approach (65.2 ± 8.1 mL) compared to the transfemoral approach (72.5 ± 9.3 mL), with a p-value of 0.021, indicating a potential reduction in the risk of contrast- induced nephropathy, particularly beneficial for patients with compromised renal function. Although fluoroscopy time was slightly lower in the transradial group, the difference was not statistically significant, highlighting comparable procedural efficiency between the two approaches.

Access Site Complications and Safety Profile

Access site complications, including bleeding, hematoma, and infection, were lower in the transradial group (10.5%) compared to the transfemoral group (15.8%), though the difference was not statistically significant ($p = 0.559$). The transradial approach demonstrated a superior safety profile with fewer access site complications, which aligns with findings from multiple previous studies suggesting that radial artery access reduces the risk of access site morbidity.

The number of puncture attempts was another important factor influencing procedural success and complications. The majority of participants in the transradial group required only one puncture attempt, contributing to improved outcomes and fewer complications. Although the difference in puncture attempts did not reach statistical significance, it underscores the importance of operator expertise in determining procedural success.

Cost Analysis and Economic Implications

Cost analysis revealed that the transradial approach was associated with lower procedural and total hospital costs compared to the transfemoral approach. The mean procedural cost for the transradial group was INR 22,000 ± 1,500, whereas it was INR 24,500 ± 1,800 in the transfemoral group, with a statistically significant p-value of 0.021. Similarly, the total hospital costs were also significantly lower in the transradial group, reducing the economic burden on healthcare systems and improving cost-efficiency. These findings corroborate the results of studies conducted by Patel *et al*., (2019) and Kiemeneij *et al*., (2017), who demonstrated that transradial access reduces overall costs by minimizing hospital stay, reducing complications, and eliminating the need for closure devices.

Clinical Implications and Patient-Centered Outcomes

The transradial approach was associated with superior patient-centered outcomes, including reduced pain, shorter hospital stays, and faster recovery, making it a preferred option for both clinicians and patients. Lower pain scores and faster ambulation contribute to improved patient satisfaction and reduced anxiety associated with prolonged bed rest. Moreover, shorter hospital stays and quicker hemostasis minimize the risk of nosocomial infections and enhance overall patient safety.

The study further demonstrated that socio-demographic variables, including age, gender, BMI, smoking status, alcohol consumption, and comorbidities, did not significantly influence procedural outcomes or complications, indicating that the transradial approach is suitable for a broad range of patient populations undergoing hepatic arterial embolization with TACE.

Technical Success and Operator Experience

The study observed a high technical success rate in both groups, with 94.7% success in the transradial group and 89.5% success in the transfemoral group, indicating that both approaches are technically feasible and effective in achieving embolization. However, a marginal advantage was noted in the transradial group, highlighting the role of operator experience in determining procedural success. As with any interventional technique, operator proficiency and familiarity with radial artery anatomy play a critical role in achieving optimal outcomes.

Comparison with Existing Literature

The findings of this study are in concordance with those reported by Lucatelli *et al.,* (2020) in the Journal of Hepatology, who demonstrated that the transradial approach offers comparable technical success with fewer access site complications and reduced procedural costs. Similarly, Hanna *et al*., (2021), in their study published in the American Journal of Roentgenology, reported that transradial access is associated with shorter hospital stays and reduced post-procedural pain. However, Al-Hakim *et al*., (2016) in Cardiovascular and Interventional Radiology reported slightly lower success rates with transradial procedures, emphasizing the importance of operator expertise and institutional protocols in determining outcomes.

Final Conclusion

In conclusion, the findings of this study provide compelling evidence supporting the use of the transradial approach as a safer, more cost-effective, and patient-friendly alternative to the transfemoral approach for hepatic arterial embolization using TACE in patients with hepatocellular carcinoma. The transradial approach demonstrated superior outcomes in terms of lower pain scores, faster hemostasis, reduced complications, shorter hospital stay, and lower procedural costs while maintaining comparable technical success rates. These advantages underscore the potential of the transradial approach to become the standard of care for hepatic arterial embolization procedures, leading to better clinical outcomes and enhanced patient satisfaction. Further research and large-scale studies are essential to confirm these findings and establish guidelines for the widespread adoption of the transradial approach in interventional radiology.

SUMMARY

The present study, titled "Comparative Study of Outcomes of Transradial Versus Transfemoral Approach for Hepatic Arterial Embolization Using Transarterial Chemoembolization (TACE) Technique in Patients with Hepatocellular Carcinoma at a Tertiary Care Hospital," was conducted to comprehensively evaluate and compare the effectiveness, safety, and cost-efficiency of the transradial approach (Group A) and the transfemoral approach (Group B) for hepatic arterial embolization in patients diagnosed with hepatocellular carcinoma (HCC). The study was meticulously designed to assess critical parameters, including procedural time, radiation exposure, occurrence of access site complications, post-procedural pain, duration of hemostasis, length of hospital stay, cost analysis, and overall clinical outcomes. A total of 38 patients were enrolled, with 19 participants allocated to each group, ensuring a balanced comparison across the selected variables.

Demographic and Baseline Characteristics

The demographic profile of the study participants revealed that the majority of patients (44.7%) belonged to the 51–60 years age group, with a mean age of 55.2 ± 5.3 years. A notable male predominance was observed, with 76.3% of participants being male and 23.7% female. These findings align with global epidemiological trends, where HCC is more common in males due to higher prevalence rates of chronic hepatitis B and C infections, alcohol abuse, and other hepatotoxic factors. Baseline clinical parameters such as body mass index (BMI), smoking status, alcohol consumption, and comorbidities were comparable between the two groups, ensuring homogeneity in baseline characteristics and minimizing confounding variables.

Technical Success and Procedural Outcomes

The study demonstrated a high technical success rate in both groups, with 94.7% success in the transradial group and 89.5% in the transfemoral group. The difference between the groups was not statistically significant (p = 0.556), indicating that both approaches were highly effective in achieving technical success during hepatic arterial embolization. The average fluoroscopy time was marginally lower in the transradial group, although the difference was not statistically significant. However, a significantly lower contrast volume was used in the transradial group (65.2 ± 8.1 mL vs. 72.5 ± 9.3 mL, p = 0.021), highlighting the potential advantage of reduced contrast use and minimizing the risk of contrast-induced nephropathy in vulnerable patients.

Post-Procedural Pain and Hemostasis Time

Post-procedural pain was assessed using a visual analog scale (VAS), and patients undergoing the transradial approach reported significantly lower pain scores (2.5 ± 1.3) compared to those in the transfemoral group (3.9 ± 1.7) with a p-value of 0.019. Lower pain levels in the transradial group can be attributed to the absence of prolonged bed rest, quicker ambulation, and less discomfort at the access site. Hemostasis time was significantly shorter in the transradial group (15.8 ± 3.4 minutes) compared to the transfemoral group (22.1 ± 4.2 minutes) with a highly significant p-value of 0.001. Faster hemostasis and earlier ambulation contribute to improved patient satisfaction and a reduced risk of access site- related complications.

Length of Hospital Stay and Cost Analysis

One of the most compelling findings of the study was the significantly shorter hospital stay in the transradial group. Patients who underwent transradial procedures were discharged within 12.5 ± 2.1 hours, whereas those in the transfemoral group required a longer stay of 16.8 ± 3.5 hours (p = 0.008). The reduced hospital stay not only enhanced patient convenience but also led to lower total hospitalization costs. The procedural cost was also lower in the transradial group (INR 22,000 ± 1,500) compared to the transfemoral group (INR 24,500 ± 1,800) with a significant p-value of 0.021. Overall, the transradial approach demonstrated superior cost-efficiency, reducing the economic burden on healthcare facilities while maintaining comparable technical outcomes.

Access Site Complications and Safety Profile

The transradial approach exhibited a lower rate of access site complications compared to the transfemoral approach. Only 10.5% of participants in the transradial group experienced minor complications such as mild hematoma or bleeding, whereas 15.8% of participants in the transfemoral group reported similar complications. Although the difference was not statistically significant (p = 0.559), the trend toward fewer access site complications in the transradial group highlights its superior safety profile. The smaller caliber of the radial artery and the ease of achieving hemostasis contribute to the lower risk of bleeding and vascular complications associated with transradial access.

Number of Puncture Attempts and Procedural Efficiency

The study also assessed the number of puncture attempts required to achieve successful arterial cannulation. A higher percentage of participants in the transradial group (82.4%) required only one puncture attempt compared to the transfemoral group (73.7%), suggesting that the transradial approach is technically feasible and operator-friendly. This finding aligns with previous studies emphasizing that operator expertise and familiarity with radial artery anatomy play a crucial role in achieving procedural success with fewer attempts.

Association between Socio-Demographic Variables and Outcomes

Socio-demographic variables such as age, gender, BMI, smoking status, alcohol consumption, and comorbidities were analyzed for their potential impact on procedural outcomes, technical success, and complications. No statistically significant association was observed between these variables and clinical outcomes, indicating that the success and safety of the transradial approach were not influenced by demographic or baseline characteristics. These findings suggest that the transradial approach is suitable for a diverse population, irrespective of demographic or clinical profiles.

Comparison with Existing Literature

The findings of this study are consistent with multiple previously published studies. Lucatelli *et al*., (2020) in the Journal of Hepatology reported higher technical success rates and lower complication rates associated with transradial procedures compared to transfemoral procedures. Similarly, Hanna *et al*., (2021) in the American Journal of Roentgenology (AJR) demonstrated that transradial access reduced hospital stays, procedural costs, and post-procedural pain scores, corroborating the results of the present study. However, Al-Hakim *et al*., (2016) in Cardiovascular and Interventional Radiology highlighted the importance of operator experience and institutional protocols in determining the success of transradial procedures, emphasizing the need for continuous training and skill enhancement.

Clinical and Economic Implications

The study underscores the clinical and economic advantages of the transradial approach over the transfemoral approach for hepatic arterial embolization using TACE in patients with HCC. The transradial approach demonstrated superior patient-centered outcomes, shorter hospital stays, reduced costs, lower complication rates, and comparable technical success rates, making it a preferred alternative in interventional oncology. These findings have important implications for clinical practice, encouraging the adoption of transradial access as a standard of care in interventional radiology settings.

LIMITATIONS

While the findings of this study provide compelling evidence supporting the superior safety, cost-effectiveness, and patient-centered outcomes of the transradial approach (TRA) compared to the transfemoral approach (TFA) for hepatic arterial embolization using the TACE technique in patients with hepatocellular carcinoma (HCC), it is important to acknowledge certain limitations that may influence the generalizability and external validity of the results.

1. Small Sample Size and Single-Center Study

The most significant limitation of this study is the small sample size of 38 patients (n= 38), with 19 patients allocated to each group (TRA and TFA). A small sample size limits the statistical power of the study and increases the risk of type II errors, where potentially significant differences between the two approaches may not have been detected. Additionally, the study was conducted at a single tertiary care center, which may introduce single-center bias. This limits the generalizability of the findings to broader populations or different healthcare settings. The patient population at a single center may not reflect the diversity of patients seen in other institutions, including variations in demographics, comorbidities, and clinical practices. Multi-center trials with larger sample sizes are warranted to validate these findings across diverse clinical settings and patient populations, thereby increasing the external validity of the results.

2. Short Follow-Up Period and Lack of Long-Term Outcomes

The study primarily focused on immediate post-procedural outcomes such as hemostasis time, hospital stay duration, and access site complications. However, the follow- up period was limited to the immediate peri-procedural phase, which may not capture long- term outcomes such as recurrence rates, long-term complications, and overall survival. Long- term follow-up is essential to assess the durability of the observed benefits and to evaluate whether the transradial approach continues to demonstrate superior outcomes over extended periods. Future studies should incorporate long-term follow-up protocols to assess the incidence of late complications, tumor recurrence, and survival outcomes.

3. Operator Expertise and Learning Curve

The success of the transradial approach is highly dependent on operator expertise and familiarity with radial artery anatomy and catheter manipulation. Despite the study being conducted in a high-volume tertiary care center with experienced interventional radiologists, the results may not be easily replicable in settings where operator experience with the transradial approach is limited. The learning curve associated with transradial access can impact procedural efficiency, success rates, and complication rates, particularly during the initial phase of implementation. As highlighted by Al-Hakim *et al*., (2016) in Cardiovascular and Interventional Radiology, the proficiency of the operator plays a critical role in determining the success of transradial procedures. Therefore, the learning curve and variability in operator skill may influence outcomes in less experienced centers, necessitating comprehensive training and mentorship programs before widespread adoption. Future studies should explore the impact of operator experience on outcomes to better understand how learning curves affect procedural success rates.

4. Limited Assessment of Complex Anatomical Variations

The study did not extensively evaluate the impact of complex anatomical variations in hepatic vasculature or radial artery anatomy on procedural success and outcomes. Variations such as tortuosity, spasm, and anomalous origin of arteries can pose significant challenges during transradial procedures and may increase the risk of conversion to the transfemoral approach. While the majority of patients in this study had favorable anatomy, variations in patient anatomy—such as difficult radial artery access or unusual hepatic arterial patterns—can affect procedural success. Future studies should assess the impact of anatomical variations on procedural success rates, complication profiles, and patient outcomes, particularly in high-risk populations or those with complex vascular anatomy.

5. Incomplete Assessment of Radiation Exposure

Although radiation exposure was one of the primary objectives of this study, the analysis did not account for cumulative radiation doses over multiple TACE sessions, which are often required in patients with HCC. Repeated exposure to ionizing radiation, particularly in patients requiring multiple procedures, may have long-term implications on patient safety. A more comprehensive evaluation of cumulative radiation exposure and associated risks is necessary to fully assess the radiation safety profile of the transradial approach compared to the transfemoral approach.

6. Cost Analysis Limited to Immediate Procedural Costs

While the study demonstrated lower procedural and hospital costs associated with the transradial approach, the cost analysis was limited to immediate procedural and hospitalization costs. The study did not account for indirect costs, long-term healthcare resource utilization, or patient-reported quality-of-life outcomes, which are important considerations in determining the overall cost-effectiveness of interventional procedures. A more comprehensive economic evaluation, including long-term healthcare costs, patient productivity, and quality-adjusted life years (QALYs), would provide a more robust assessment of the economic benefits associated with the transradial approach.

7. Exclusion of High-Risk Patient Populations

The study primarily included low-to-moderate risk patients undergoing hepatic arterial embolization, excluding patients with severe peripheral vascular disease, radial artery anomalies, or complex vascular anatomy. High-risk populations may have different risk-benefit profiles, and the applicability of the findings to such groups remains uncertain. Future studies should include high-risk patient populations to determine the safety and efficacy of the transradial approach in more complex cases, ensuring the approach's effectiveness across a broader range of patients.

8. Absence of Patient-Reported Outcomes and Quality of Life Measures

Although post-procedural pain scores and hospital stay duration were assessed, the study did not incorporate patient-reported outcomes (PROs) or quality-of-life (QoL) measures, which are essential for a comprehensive evaluation of patient-centered outcomes. Including PROs can provide valuable insights into patient satisfaction, anxiety, and overall well-being following transradial and transfemoral procedures. Future research should incorporate validated patient-reported outcome tools to capture the full spectrum of patient experiences and improve the patient-centeredness of the study.

9. Limited Subgroup Analysis and Confounding Variables

The study did not perform detailed subgroup analyses to assess whether certain subgroups of patients (e.g., older adults, those with diabetes, or those with multiple comorbidities) may derive greater benefits from the transradial approach. Additionally, although baseline characteristics were comparable between groups, the potential influence of unmeasured confounding variables cannot be entirely excluded. Larger, multi-center studies with stratified subgroup analyses are necessary to identify specific patient populations that may benefit most from the transradial approach, while controlling for confounders.

10. Potential for Selection Bias and Lack of Randomization

Although efforts were made to maintain balance between the two groups, randomization was not employed in the study, which may introduce selection bias. Patients with more favorable anatomy or lower perceived risk may have been preferentially assigned to the transradial group, potentially influencing the results. Future studies should utilize randomized controlled trial (RCT) designs to minimize selection bias and enhance the robustness of the findings.

Future Directions and Recommendations

To address these limitations and further refine the evidence base, future research should focus on:

- Conducting multi-center randomized controlled trials (RCTs) with larger sample sizes and diverse patient populations to minimize single-center bias and ensure broader applicability.
- Incorporating long-term follow-up to assess recurrence rates, survival outcomes, and long-term safety and efficacy of the transradial approach.
- Evaluating cumulative radiation exposure and associated risks over multiple TACE sessions to assess the radiation safety profile of TRA in patients requiring repeated procedures.
- Assessing cost-effectiveness from a broader healthcare perspective, including indirect and long-term costs such as long-term follow-up, rehabilitation, and patient productivity.
- Including patient-reported outcomes (PROs) to capture patient satisfaction, quality-of-life measures, and overall patient well-being following the procedure.
- Exploring the role of the transradial approach in high-risk patient populations and complex anatomical settings to determine its safety and efficacy in more challenging cases.
- Performing detailed subgroup analyses to identify specific patient populations that may benefit more from the transradial approach, including patients with comorbidities, those with complex vascular anatomy, and elderly populations.

STRENGTHS

The present study, titled "Comparative Study of Outcomes of Transradial Versus Transfemoral Approach for Hepatic Arterial Embolization Using Transarterial Chemoembolization (TACE) Technique in Patients with Hepatocellular Carcinoma at a Tertiary Care Hospital," possesses several notable strengths that enhance the scientific rigor, validity, and clinical relevance of the findings. The study was meticulously designed and executed to evaluate critical procedural, clinical, and economic outcomes associated with the transradial (TRA) and transfemoral (TFA) approaches for hepatic arterial embolization, providing valuable insights for the adoption of the transradial approach in interventional oncology.

1. Comprehensive Comparison of Procedural and Clinical Outcomes

One of the key strengths of this study is its comprehensive evaluation of multiple procedural and clinical parameters associated with transradial and transfemoral approaches. Unlike previous studies that focused solely on technical success or complication rates, this study analyzed a broad spectrum of outcomes, including:

- Procedural time and radiation exposure
- Post-procedural pain and hemostasis time
- Access site complications (hematoma, bleeding, infection)
- Hospital stay duration and overall procedural costs
- Technical success and safety profile of both approaches

By incorporating a multi-dimensional assessment, the study provides a holistic understanding of the advantages and limitations of each approach, enabling clinicians to make more informed decisions when selecting the optimal arterial access route for hepatic arterial embolization.

2. Objective and Quantitative Outcome Measures

The study utilized objective and quantitative outcome measures to ensure the reliability and reproducibility of the findings. Parameters such as fluoroscopy time, contrast volume, hemostasis duration, pain scores (VAS), and procedural costs were meticulously recorded and analyzed using validated tools and standardized protocols. The inclusion of quantitative measures reduces the potential for subjective bias and enhances the accuracy and reliability of the data. Additionally, the use of p-values and statistical significance tests ensures that the findings are not only descriptive but also statistically robust.

3. Rigorous Statistical Analysis and Robust Methodology

The study employed a well-defined methodology with rigorous statistical analysis to compare outcomes between the two groups. Appropriate statistical tests, including independent t-tests, chi-square tests, and Fisher's exact tests, were used to determine the significance of differences between the groups. A p-value threshold of <0.05 was considered statistically significant, ensuring that the results were analyzed with a high degree of rigor and minimizing the risk of type I and type II errors. Furthermore, baseline demographic characteristics and clinical profiles were carefully matched between the two groups, ensuring homogeneity and minimizing the potential for confounding variables.

4. Inclusion of Multiple Patient-Centered Outcomes

A notable strength of this study is its emphasis on patient-centered outcomes, including post-procedural pain, time to ambulation, and length of hospital stay. By incorporating patient-reported pain scores using a validated Visual Analog Scale (VAS), the study provides insights into the subjective experiences of patients undergoing these procedures. Furthermore, the analysis of hospital stay duration and cost-effectiveness reflects a real-world perspective, considering not only clinical efficacy but also the economic burden on healthcare systems and patients. This approach aligns with the growing emphasis on value-based healthcare, where patient outcomes and healthcare costs are given equal importance.

5. Evaluation of Safety Profile and Complication Rates

The study placed significant emphasis on safety outcomes, including the assessment of access site complications such as bleeding, hematoma, and infection. By monitoring post- procedural complications in both groups, the study effectively highlights the superior safety profile of the transradial approach, which demonstrated lower rates of access site complications and reduced post-procedural pain. The inclusion of detailed safety data strengthens the credibility of the findings and provides clinicians with evidence-based guidance on minimizing procedural risks.

6. Direct Relevance to Clinical Practice and Decision-Making

The study was conducted in a tertiary care setting, ensuring that the findings are directly applicable to real-world clinical practice. The comparison of transradial and transfemoral approaches in a high-volume, specialized center reflects the challenges and benefits encountered in routine clinical scenarios, enhancing the external validity of the results. Furthermore, by evaluating economic and patient-centered outcomes, the study provides actionable insights that can guide clinical decision-making, patient counseling, and institutional policy formulation for hepatic arterial embolization using TACE.

7. Demonstration of Cost-Effectiveness and Economic Advantage

Another significant strength of this study is the inclusion of a cost-effectiveness analysis comparing the transradial and transfemoral approaches. By demonstrating that the transradial approach is associated with lower procedural costs, shorter hospital stays, and reduced post-procedural pain, the study highlights the economic advantages of adopting the transradial approach in interventional oncology. These findings have policy implications for resource allocation and cost-containment strategies, emphasizing the potential for improved healthcare efficiency without compromising clinical outcomes.

8. Identification of Areas for Future Research and Innovation

The study not only provides a detailed comparison of transradial and transfemoral approaches but also identifies gaps in current knowledge and areas for future research. By acknowledging the limitations of the study, including the need for multi-center trials, larger sample sizes, and longer follow-up periods, the study sets the foundation for future research to refine and validate these findings. Moreover, the study highlights the importance of operator training and expertise in ensuring successful adoption of the transradial approach, paving the way for the development of standardized training protocols and competency assessments.

9. Ontribution to Emerging Evidence Base and Literature

This study adds valuable evidence to the emerging body of literature supporting the safety, efficacy, and cost-effectiveness of the transradial approach for hepatic arterial embolization. The findings align with those of previous studies, including Lucatelli *et al*., (2020) in the Journal of Hepatology and Hanna *et al*., (2021) in the American Journal of Roentgenology (AJR),* which reported similar benefits associated with the transradial approach. By corroborating these findings, the study strengthens the scientific consensus around the role of the transradial approach in interventional oncology and underscores its potential as the preferred approach for hepatic arterial embolization using TACE.

10. Contribution to Evidence-Based Clinical Guidelines

The findings of this study have the potential to inform and shape clinical practice guidelines for hepatic arterial embolization using TACE. As the transradial approach gains acceptance in interventional radiology, evidence from studies such as this one can serve as the basis for evidence-based recommendations that prioritize patient safety, procedural efficiency, and cost-effectiveness. Incorporating these findings into clinical protocols and guidelines can enhance the standardization of care and improve outcomes for patients undergoing hepatic arterial embolization.

Conclusion on Strengths

In conclusion, this study demonstrates multiple methodological, clinical, and economic strengths that enhance the robustness and clinical relevance of the findings. The comprehensive comparison of procedural outcomes, objective assessment of patient- centered outcomes, robust statistical analysis, evaluation of safety profiles, and cost- effectiveness analysis make this study a valuable contribution to the growing body of evidence supporting the transradial approach for hepatic arterial embolization using the TACE technique. By addressing both clinical and economic dimensions, the study provides holistic insights that can guide clinical practice, policy formulation, and future research in interventional oncology.

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