JOURNAL OF BASHIR INSTITUTE OF HEALTH SCIENCES

RESEARCH ARTICLE

OPEN ACCESS

ARTICLE INFO
*Date Received:*
*July 26, 2024*
*Date Revised:*
*December 01, 2024*
*Date Published Online*
*December 30, 2024*

# Triphasic Computed Tomography for Characterization of Liver Lesions Identified on Ultrasonography

[a] Rohail Akbar, [b]Afaq Ahmed, [c]Saeeda Javid

[a] *Lecturer Department of Radiology Technology, Medical Imaging Technology, Allied Health Sciences, Bashir Institute of Health Sciences, Bhara Kahu, Islamabad, Pakistan*
[b] *Interventional Radiology Technologist, Shifa International Hospital Islamabad, Pakistan*
[c] *Radiology Technologist, Cardiac Surgery Hospital Muzaffarabad, Azad Jammu and Kashmir*

*CORRESPONDENCE
Rohail Akbar
Lecturer Department of Radiology Technology, Medical Imaging Technology, Allied Health Sciences, Bashir Institute of Health Sciences, Bhara Kahu, Islamabad, Pakistan
E-mail: rohailakbar27@gmail.com
Phone: +92- 348 5398956

ABSTRACT

**Background:** Liver disease is the leading cause of death in Pakistan and Asia. Liver carcinoma is the most prevalent cancer in the world. Identification of cancer at an early stage can help in better management of the disease and improved prognosis. Computed tomography can perform scans at different phases after contrast is administered. It is the most effective tool for the diagnosis of tumors and different types of lesions. Our objective of the study was to characterize the liver lesions identified on ultrasonography and differentiate between benign and malignant lesions at Bilal Hospital Rawalpindi. **Methods:** This cross-sectional quantitative study was conducted at Bilal Hospital, Rawalpindi, Pakistan, to evaluate liver lesions using triphasic CT. Data from 50 reports were analyzed, focusing on hepatic lesions, hepatomegaly, cirrhosis, and portal hypertension identified through ultrasonography. Patients over 30 were included, while those under 30, pregnant, contrast-allergic, or with abnormal renal function tests were excluded. Triphasic CT scans were performed with a 64-slice scanner, capturing arterial, portal venous, and delayed phases after contrast injection. Radiologists reported the scans, and data were analyzed using SPSS-25, ensuring patient consent, confidentiality, and privacy. **Results:** In this study, 28% of patients had benign liver lesions, with focal nodular hyperplasia (14%) being the most common, followed by hepatic cysts (4%) and hemangiomas (10%). Malignant lesions were observed in 62% of patients, with hepatocellular carcinoma (36%) being the most prevalent, followed by secondary metastases (10%), cholangiocarcinoma (8%), and focal hepatic lesions (8%). The most frequently observed condition was hepatocellular carcinoma. **Conclusions:** The study concludes that there is a significant prevalence of both benign and malignant liver lesions in patients over 30 years, with hepatocellular carcinoma being the most common malignancy and focal nodular hyperplasia, the most frequent benign lesion. The findings emphasize the crucial role of triphasic CT in accurately diagnosing and differentiating liver lesions, aiding in effective treatment planning.

**Keywords:** Triphasic, Computed Tomography, Liver Lesions, Ultrasonography, Liver Disease, Liver Carcinoma.

## INTRODUCTION

Focal hepatic lesions could be specified as almost any lesion in the liver apart from usual parenchyma with or without causing functional and structural malformations of the hepatobiliary system, and they may differ in size [1]. They may be benign and

sometimes may be malignant [2]. Furthermore, hepatic focal lesions might be categorized into three classes initially: benign conditions where no medication was needed, such as Focal Nodular Hyperplasia (FNH), haemangiomas, benign hepatic cysts, etc. The second one was benign conditions where medication was needed, such as adenomatosis, abscess of the liver, biliary cystadenoma, inflammatory Pseudo tumour, and adenoma of the liver. The cancerous mass abnormalities where medication is always necessary if possible, such as a liver progression from any other initial site, angiosarcomas of the liver, cholangiocarcinoma, lymphomas, HCC, etc. FNH and liver adenoma, which occur mainly in younger and middle-aged people, are mostly incidental findings. The distinction is important for various clinical approaches [3]. Previous studies indicated that FNH is not a malignancy but a hyperplastic reaction of functional tissue to an already present vessel disorder. Compared to FNH, the adenoma of the liver is a malignancy comprising usual or aberrant hepatic cells, mostly deficient in bile ducts and Kuffer cells. Incidental hepatic lesions are most frequently detected because of improvements in imaging procedures.

Some studies have detected incidental focal liver lesions in approximately 33% of radiological research. It hit more than 50% of autopsy cases [4]. History and physical inspection were the core of assessing the patients with liver lesions. Patients who have a family background of past cancers or serious liver illness must be considered for a differential diagnosis of Hepatocellular Carcinoma (HCC) vs metastases. In a stable population with no serious health history, the differential diagnosis should provide greater options for malignant and benign patients [5]. The emergence of computed tomography must be considered, as it greatly facilitated the detection of hepatic lesions. Besides that, the main argument is why liver cancers that could be diagnosed by computer tomography have gained attention [6]. Spiral CT quickly became the favourable CT procedure for regular hepatic examination. It offers image acquisition at optimum hepatic parenchymal enhancement even with only one breath-hold [7]. Rapid data acquisition facilitates the sequential scanning of the whole liver at varying moments after contrast media injection, thereby providing the likelihood of multiphasic hepatic computed tomography [8].

Furthermore, some studies have documented advancements in lesion identification when arterial phase imaging is conducted after portal venous imaging, particularly when hyper vascular cancer such as HCC [9]. In a previous study, a triphasic CT procedure was identified that enabled hepatic scanning in the arterial phase, portal phase, and equilibrium phase for comparing CT findings to root factors [10]. In multiphase CT, the Arterio-portal shunt is mostly concerned with haemangiomas, particularly in the rapid-fill form [11]. Correlation with arterio-portal shunt is commonly assumed to be a defining feature of malignancy. Conversely, in minor tumours whose diameter is less than 3 cm, arterio-portal shunt is generally more common in haemangioma as compared to hepatocellular carcinoma [12]. Gradually enhancing haemangiomas with chronic hypo attenuation of triphasic computed tomography can be troublesome in patients with cancer. Awareness of the bright dot symbol and tiny enhancement dots inside these haemangiomas, which do not advance to typical globular enhancement due to the limited-sized lesion and the potential for gradual filling, is useful in detecting this kind of haemangioma [13]. Characterizing focal liver lesions remained the focus of investigation in literature, considering the comparative study of contrast-enhanced ultrasound versus spiral computed tomography. It was performed from October 10, 2005, to August 9, 2006. This study compared the diagnostic accuracy of contrast-enhanced ultrasound (CEUS) with spiral computed tomography (SCT) for the characterization of focal liver lesions (FLL). It determined the degree of correlation between the two techniques. The sensitivity, specificity, and diagnostic accuracy for malignancy were 91%, 90%, and 91%, respectively, for CEUS and 88%, 89%, and 88% for SCT. No statistically significant difference was found between CEUS and SCT in the characterization of FLL. They concluded that CEUS and SCT provide similar diagnostic accuracy in the characterization of FLL, with a good correlation between the two techniques [14].

Another study was done for the "Assessment of focal liver reaction by multiphasic CT after stereotactic single-dose radiotherapy of liver tumours." It was performed from January 3, 2003, to April 29, 2003, by Klaus K Herfarth K.K et al. A total of 131 multiphasic CT scans were performed in 36 patients before and after stereotactic radiotherapy for liver tumours. Every patient showed a focal radiation reaction on at least one follow-up examination. In 74% of the post-therapeutic scans, a sharply demarcated hypo-dense area surrounded the treated tumour in the non-enhanced scans. A focal radiation reaction occurs after stereotactic single-dose therapy in the liver. Stereotactic single-dose RT is a new and promising treatment option for patients with inoperable liver tumours. This treatment delivers a high focal dose to a partial liver volume. This method achieved a high local tumour control rate with low morbidity in the Phase I–II study. The therapy caused no major clinical side effects, and no patient developed clinical signs of RILD. However, a focal liver reaction was visible, which we have now characterized further [15].

Furthermore, a study was conducted from November 9, 1998, to January 5, 1999, to determine "Focal Liver Lesions: Pattern-based Classification Scheme for Enhancement at Arterial Phase CT". The purpose was to present early experience with a classification scheme for categorizing focal liver lesions based on the enhancement patterns exhibited in the arterial phase of computed tomography (CT) and to determine whether enhancement patterns suggest diagnoses. They reviewed arterial phase CT images in 100 consecutive patients with focal liver lesions, excluding simple cysts. Lesions without enhancement were recorded separately. The result was that 92% of the 100 lesions demonstrated arterial phase enhancement. Patterns associated with positive predictive values of 82% or greater and specificity of 80% or greater included abnormal internal vessels or variegated (hepatocellular carcinoma), peripheral puddles (haemangioma), and complete ring (metastasis). They concluded that the appearance of hepatic lesions in the arterial phase of enhancement has potential use in determining specific diagnoses [16].
A study performed by Saima Hafeez 1, Muhammad Shahbaz Alam, Zafar Sajjad, Zahid Anwar Khan, Waseem Akhter, and Fatima Mubarak from Feb 2006 to Feb 2007 aimed to reveal the role of the Triphasic computed tomography (CT) scan in focal tumoral liver lesions. Among 45 patients, 136 liver lesions (11 benign and 125 malignant) were detected with the help of different enhancement patterns. Of these, 37 (82.2%) patients had malignant lesions, while 8 (17.8%) had benign lesions. Based on these 80%, positive predictive value of 94.5%, negative predictive value of 100%, and diagnostic accuracy of 95.5% in differentiating benign from malignant liver lesions. Hence, a triphasic CT scan is a good, non-invasive tool for characterizing and differentiating benign from malignant liver lesions [17].
Furthermore, A case report study was conducted from March 29, 2014, to October 27, 2014, to propose the split-bolus multidetector-row computed tomography technique as an alternative to the conventional triphasic technique in the detection and characterization of focal nodular hyperplasia to reduce the radiation dose to the patient by Scialpi, M., Pierotti, L., Gravante, S., et al. The case of focal nodular hyperplasia of the liver in a 53-year-old Caucasian woman (weight 75 kg) with a colorectal adenocarcinoma was histologically confirmed. An innovative split-bolus multidetector-row computed tomography technique was used by splitting intravenous contrast material in two boils combined two phases (hepatic arterial phase and portal venous phase) in a single pass; a delayed (5 minutes) phase was obtained to compare the findings with that of triphasic multidetector-row computed tomography. They concluded that Split-bolus multidetector-row computed tomography could show the same lesion appearance as the triphasic multidetector-row computed tomography technique [18]. The present study aimed to characterize ultrasonography and identify liver lesions utilizing triphasic computed tomography.

## MATERIALS AND METHODS

This cross-sectional quantitative study was conducted at Bilal Hospital, Rawalpindi, Pakistan, focusing on reports from 70 cases reviewed during the study period. Data from 50 reports meeting the inclusion criteria were analysed, including triphasic computed tomography (CT) scans and ultrasonography reports that identified liver lesions. These imaging techniques were used to characterize liver lesions and differentiate between benign and malignant conditions using triphasic CT. Patients aged above 30 years were included in the study, specifically those diagnosed with hepatic lesions, hepatomegaly, cirrhotic liver, portal hypertension, or space-occupying lesions during ultrasound evaluations. Exclusion criteria encompassed patients under 30 years, pregnant women, individuals allergic to contrast material, and those with abnormal renal function tests.
The triphasic CT scans were performed using a 64-slice CT scanner, and all scans were reviewed by radiologists. Data analysis was conducted using SPSS-25. Participants provided verbal consent, and their medical histories were documented while ensuring confidentiality and anonymity. Patients were informed of the non-invasive nature of the procedure and their right to withdraw from the study at any time. Their identities were kept confidential and excluded from any publications arising from the research.
The imaging protocol involved performing each scan in a single breath-hold using a craniocaudal orientation.
An initial scout image was followed by an unenhanced liver scan. Contrast material (100 ml) was administered via a power injector at a rate of 1.5–2 ml/sec. The liver was then scanned during three key phases: the arterial phase at 20–22 seconds after contrast injection, the early portal venous phase at 45–50 seconds, and the late portal venous phase at 70–80 seconds. A 20-second pause was allowed for the patient to breathe before maintaining the scanning position cephalic to the liver for the final delayed or "washout phase," performed 10 minutes after contrast injection. This systematic approach ensured accurate imaging and comprehensive evaluation of liver lesions, facilitating a clear distinction between benign and malignant conditions.

## DATA COLLECTION PROCEDURE

Data was collected from Triphasic Computed Tomography reports of 50 patients. The data collection was commenced after the ethical approval of the institutional review board and the informed consent of the hospital and participants.

## STATISTICAL ANALYSIS

The data was analysed by using the frequency distribution analysis through a Statistical Package of Social Sciences SPSS version 25. The outcomes of the analysis were presented in tabulated form in terms of frequency and percentages.

## RESULTS

In our study, 33 male (66%) and 17 female (33%) reports were observed out of 50 reports. The male gender was dominant, having liver lesions. (Table 1).

**Table 1:** Demographic Analysis of Population

| | Frequency | Percent |
|---|---|---|
| Male | 33 | 66.0 |
| Female | 17 | 34.0 |
| Total | 50 | 100.0 |

The most dominant age of patients having liver lesions was between 46-60 years, which is 44% of total patients observed, while patients between 31-45 years were 20%, 61-75 years were 28%, and 76-90 years were 8% of the catalog (table-2)

**Table 2:** Patients are Distributed According to Age

| | Frequency | Percent |
|---|---|---|
| 31-45 Years | 10 | 20.0 |
| 46-60 Years | 22 | 44.0 |
| 61-75 Years | 14 | 28.0 |
| 76-90 Years | 4 | 8.0 |
| Total | 50 | 100.0 |

In the observed data, nine patients had no ultrasound findings (18%), 13 were presented with chronic liver disease (26%), 1 with portal hypertension (2%), 5 with space-occupying lesions (10%), six patients with cirrhosis(12%), 5 with hepatic lesions(10%), 6 with hepatomegaly (12%)and 5 with hepatic mass(10%). (Table 3).

**Table 3:** Patients are Distributed According to USG Findings

| | Frequency | Percent |
|---|---|---|
| No History Provided | 9 | 18 |
| Chronic Liver Disease | 13 | 26 |

| | | |
|---|---|---|
| Portal Hypertension | 1 | 2 |
| Space Occupying Lesion | 5 | 10 |
| Cirrhosis | 6 | 12 |
| Hepatic Lesion | 5 | 10 |
| Hepatomegaly | 6 | 12 |
| Hepatic Mass | 5 | 10 |
| Total | 50 | 100 |

Out of a total of 50 patients, 14 patients were observed with benign liver lesions, which is 28% of the total. Seven patients had Focal Nodular Hyperplasia (14%), two patients had hepatic cysts (4%), and 5 with hemangioma (10%). (Table 4)

**Table 4:** Distribution of Patients Having Benign Focal Liver Lesions

| | Frequency | Percent |
|---|---|---|
| Absent | 36 | 72 |
| Focal Nodular Hyperplasia | 7 | 14 |
| Hepatic cyst | 2 | 4 |
| Hemangioma | 5 | 10 |
| Total | 50 | 100 |

Thirty-one patients were observed with malignancy (62%).18 had hepatocellular carcinoma (36%), five patients were observed (10%) with secondary Mets (10%),4 with cholangiocarcinoma (8%), and 4 with focal hepatic lesions (8%) (Table-4). The most common malignancy in the current study was HCC.

**Table 5:** Distribution of Patients Having Malignant Focal Liver Lesions

| | Frequency | Percent |
|---|---|---|
| Absent | 19 | 38 |
| Hepatocellular carcinoma | 18 | 36 |
| Secondary Mets | 5 | 10 |
| Cholangiocarcinoma | 4 | 8 |
| Focal Hepatic Lesion | 4 | 8 |
| Total | 50 | 100 |

## DISCUSSION

On ultrasonography, liver lesions are identified, but malignancy of liver lesions is not characterized by ultrasonography. Malignant and benign focal liver lesions are well identified using triphasic Computed Tomography liver [10]. This helps with early diagnosis of liver diseases. The liver is scanned at various intervals after administration of iodinated contrast media using multiphasic liver computed tomography, which allows us to differentiate between malignant and benign lesions [13]. Here, we characterized the liver lesion detected in ultrasonography with the help of reports of triphasic CT liver. We have observed the reports of 50 patients who came to the radiology department for a triphasic liver CT scan and had been diagnosed with liver lesions on ultrasound. These reports were enrolled based on the inclusion criteria of the research. It was a cross-sectional study based on observations and all the patients were aged above 25 years. According to our results, more males were reported with liver lesions as compared to females; our results are related to a previous study performed in 2021 in Gujarat, Punjab, Pakistan, in which 60 reports were observed [1]. Out of which, 61% of patients were male and 39% were female. According to the analysis of our study, liver lesions were common in the age group 46-60 years, which was 44% of our total observed reports; a similar finding was reported by Gadgil et al. in 2019, in which a higher prevalence of liver lesions was observed in the age group of 40-60 years [19]. In our study,

all patients had ultrasound scans following inclusion criteria along with them for comparison. The most common ultrasound findings were a chronic liver disease, i.e. 26% of the total, and liver cirrhosis is present at 12%, while other findings are different but small. In many Asian countries, CLD is commonly found in liver lesions and is detected on ultrasonography [20]. Triphasic Computed tomography is performed to characterize the lesions detected on ultrasonography, so the above study shows that the frequency of benign liver lesions was lower than malignant liver lesions; only 28% of total reports observed were diagnosed with benign lesions. (Table: 4). Focal Nodular Hyperplasia was the most common benign lesion observed in the study; our results as the same as the previous study performed by Khalid et. [21]. No wonder that chronic liver disease is the fifth most common reason for morbidity and mortality in the country, and Pakistan has been perhaps accurately called a "cirrhotic state" [22]. Hence majority of such patients are at risk of developing HCC. 62% of lesions were malignant, with hepatocellular carcinoma being the most observed malignant lesion. Arterial phase of the triphasic CT scan, HCC enhances relative to the parenchyma of the liver. In contrast, in the portal venous phase, it shows washout of contrast, and in delayed carcinomas was hypo dense. Many HCC lesions do not follow this pattern; a few of the hyper vascular lesions don't show washout in portal venous and the delayed phase. All other tumours manifest washout [23]. Our study shows that CT triphasic can distinguish benign liver lesions from malignant liver lesions so that invasive procedures such as biopsy can be prevented. It can also detect hyper vascular lesions, which are frequently shown on CT scans [24]. The findings of our study suggest that for patients with liver disease, the treatment plan should be created after the characterization of liver lesions with the help of triphasic computed tomography. Diagnosis based upon ultrasonography of the liver requires further evaluation with Triphasic CT liver to characterize liver lesions accurately [25, 26]. Furthermore, this technique can also serve as an alternative to invasive procedures for the characterization of liver malignancies.

## LIMITATIONS AND RECOMMENDATIONS

We worked with a small group of patients at a single centre; a large-scale multicentre trial would broaden insight into the subject. Further, a follow-up cohort study may identify the long-term outcomes and complications associated with the two procedures compared.

## CONCLUSION

Our study concludes that among the liver lesions detected through ultrasonography, the most common malignant liver lesion was hepatocellular carcinoma. In contrast, focal nodular hyperplasia was commonly observed as a benign lesion when characterized by Triphasic Computed Tomography. Triphasic liver CT enables the characterization of a wide range of focal liver lesions. This technique is the best alternative to invasive procedures like tissue biopsy to distinguish benign and malignant liver lesions.

## CONFLICT OF INTEREST

The authors declared no conflict of interest.

## AUTHOR CONTRIBUTION

RA complied with and conducted the whole research process from problem identification, literature review, research gap extraction, data analysis, result interpretation, and conclusion. AA helped in the data collection and data analysis process. SJ grammatically reviewed and corrected the whole research discretion and helped in the data analysis procedure due to her expertise in IBM SPSS.

## ACKNOWLEDGEMENT

We acknowledge the highly literate and scholarly competitive environment of the Bashir Institute of Health Sciences, which provides opportunities to continue academic and research activities for valuable contributions to medical literature.

## FINDING SOURCE

No funding was received for this work

## REFERENCES


1. Naqvi, S.M.A., et al., Triphasic Computed Tomography Scan as a Non-Invasive Imaging Tool in Differentiating Benign and Malignant Focal Liver Lesion. 2021.
2. Hasan, N.M.A., et al., *Benign versus malignant focal liver lesions: Diagnostic value of qualitative and quantitative diffusion weighted MR imaging.* The Egyptian journal of radiology and nuclear medicine, 2016. **47**(4): p. 1211-1220.
3. Ruppert-Kohlmayr, A.J., et al., *Focal nodular hyperplasia and hepatocellular adenoma of the liver: differentiation with multiphasic helical CT.* American Journal of Roentgenology, 2001. **176**(6): p. 1493-1498.
4. Boutros, C., S.C. Katz, and N.J. Espat, *Management of an incidental liver mass.* Surgical Clinics, 2010. **90**(4): p. 699-718.
5. Algarni, A.A., et al., *Focal liver lesions found incidentally.* World journal of hepatology, 2016. **8**(9): p. 446.
6. Ueda, J., et al., *Distribution of water, fat, and metals in normal liver and in liver metastases influencing attenuation on computed tomography.* Acta Radiologica, 1988. **29**(1): p. 33-39.
7. Bluemke, D.A. and E. Fishman, *Spiral CT arterial portography of the liver.* Radiology, 1993. **186**(2): p. 576-579.
8. Hollett, M., et al., *Dual-phase helical CT of the liver: value of arterial phase scans in the detection of small (< or= 1.5 cm) malignant hepatic neoplasms.* AJR. American journal of roentgenology, 1995. **164**(4): p. 879-884.
9. van Leeuwen, M.S., et al., *Focal liver lesions: characterization with triphasic spiral CT.* Radiology, 1996. **201**(2): p. 327-336.
10. Ibrahim, A.K.A. and C.E. Ayad, *Triphasic computed tomography Hounsfield and pattern in differentiation of focal liver lesions.* IOSRJDMS, 2017. **16**(1): p. 120-25.
11. Yu, J.-S., et al., *Transient peritumoral enhancement during dynamic MRI of the liver: cavernous hemangioma versus hepatocellular carcinoma.* Journal of computer assisted tomography, 2002. **26**(3): p. 411-417.
12. Byun, J.H., et al., *Arterioportal shunt: prevalence in small hemangiomas versus that in hepatocellular carcinomas 3 cm or smaller at two-phase helical CT.* Radiology, 2004. **232**(2): p. 354-360.
13. Jang, H.-J., H. Yu, and T.K. Kim. *Imaging of focal liver lesions*. in *Seminars in roentgenology*. 2009. Elsevier.
14. Catala, V., et al., *characterization of focal liver lesions: comparative study of contrast-enhanced ultrasound versus spiral computed tomography.* European radiology, 2007. **17**(4): p. 1066-1073.
15. Herfarth, K., et al., *assessment of the focal liver reaction after stereotactic single dose radiation therapy of liver tumors by multiphasic CT.* Int J Radiat Oncol Biol Phys, 2003. **57**: p. 444-451.
16. Nino-Murcia, M., et al., *Focal Liver Lesions: Pattern-based Classification Scheme for Enhancement at Arterial Phase CT.* Radiology, 2000. **215**(3): p. 746-751.
17. Hafeez, S., et al., *Triphasic computed tomography (CT) scan in focal tumoral liver lesions.* Journal of the Pakistan Medical Association, 2011. **61**(6): p. 571.
18. Scialpi, M., et al., *Split-bolus versus triphasic multidetector-row computed tomography technique in the diagnosis of hepatic focal nodular hyperplasia: a case report.* Journal of Medical Case Reports, 2014. **8**(1): p. 425.
19. Gadgil, S.B., et al., *Role of Computerized Tomographic Findings in Cases of Focal Hepatic Lesions.* MVP Journal of Medical Sciences, 2020. **6**(2): p. 210-220.

20. Zarzour, J.G., et al., *Contrast-enhanced ultrasound of benign liver lesions.* Abdominal Radiology, 2018. **43**(4): p. 848-860.

21. Tazeen, A., et al., *Frequency of Different Types of Focal Hepatic Lesions on Triphasic Computed Tomography Scan in Adult Patients.* 2020.

22. Parkash, O. and S. Hamid, *Next big threat for Pakistan hepatocellular carcinoma (HCC).* Journal of Pakistan Medical Association, 2016. **66**(6): p. 735.

23. Choi, B.I. and J.M. Lee, *Advancement in HCC imaging: diagnosis, staging and treatment efficacy assessments.* Journal of hepato-biliary-pancreatic sciences, 2010. **17**(4): p. 369-373.

24. Hong, X., et al., *Gastrointestinal stromal tumor: role of CT in diagnosis and in response evaluation and surveillance after treatment with imatinib.* Radiographics, 2006. **26**(2): p. 481-495.

25. Leen, E., et al., *Prospective multicenter trial evaluating a novel method of characterizing focal liver lesions using contrast-enhanced sonography.* American journal of roentgenology, 2006. **186**(6): p. 1551-1559.

26. Befeler, A.S. and A.M. Di Bisceglie, *Hepatocellular carcinoma: diagnosis and treatment.* Gastroenterology, 2002. **122**(6): p. 1609-1619.