Triphasic Computed Tomography Hounsfield and Pattern in Differentiation of Focal Liver Lesions

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Abstract:
Objective: To evaluate the diagnostic value of triphasic spiral Computerized Tomography (CT) Hounsfield (HU) and pattern in differentiating focal liver lesions.
Methods: The study was conducted in Department of Radiology:1) Fedail Hospital, 2)Alfaisal Hospital,3) Alzitona Hospital,3) Alturky Center.The study was obtained during the period spanned from January 2015up to August 2016.By convenient sampling, 99 patients who were found to have focal liver lesions were recruited and their triphasic CT scans findings were evaluated.
Results: Among the 99 cases of patients with liver lesions it was found to be: 21 hemangiomas, 13Cyst, 38 Metastases, 24 Hepatocelluler Carcinoma, 2 Ischemia and abscess were found in 3cases. All were diagnosed using the typical enhancement patterns and quantification method (HU) values. Based on the results, it could be judged that triphasic CT scan has a great value in diagnoses and differentiating focal liver lesions and the underlying causes significantly at p≤0.000.
Conclusion: Triphasic CT scan is a good non-invasive tool and can be used as first line imaging modality for differentiating focal liver lesions; therefore unnecessary biopsies can be avoided.
Keywords: Liver lesions, Triphasic, Hounsfield, heterogeneous, CT scan

I. Introduction

The advent of computed tomography (CT) has considerably facilitated the diagnosis of lesions of the liver. However, the underlying reasons why hepatic tumors are detectable by CT have received little attention [1]. CT investigations of such lesions have mostly been confined to pathologic evaluation, and no detailed reports have appeared on the correlation between the CT number and the types of lesions in the liver tissue. In the present investigation we measured, in liver lesions, the quantities of Hounsfield number which is a normalized value of the calculated x-ray absorption coefficient of a pixel a normalized index of x-ray attenuation used in CT imaging [2] that could contribute to the lesion character, and analyzed the correlation between the diagnosis, the CT number and then discuss the associated findings. Also, in liver with metastases, the contents CT HU were measured as an attempt to elucidate the factors underlying the detection of hepatic lesions as a high- or low-density area. Since no studies have correlated CT findings with actual Hounsfield quantification of different focal hepatic lesions, our aim is to discern whether or not enhanced and unenhanced CT determination of hepatic focal lesions based on image attenuation data (Hounsfield units) is significantly changed .Verified correlation of these radiologic parameters may facilitate the development of a reliable and noninvasive standard measurement of liver HU for both clinical and research objectives. As well in the current study, we evaluated a triphasic spiral computed tomogram technique that allowed imaging of the liver in arterial, portal and equilibrium phases and to correlate the CT findings with the underlying causes. Several studies have been done worldwide on the role of triphasic CT scan in characterizing and differentiating lesions. However, to the best of our knowledge, no data has been published locally, so purpose of this study was to describe the role of triphasic CT scan in focal liver lesions and to determine its diagnostic value.

II. Materials and Methods

2.1. Area, Duration and CT Machines

The study was completed at four hospitals in Khartoum State :1) Fedail Hospital, the CT scan machine manufactured by an Germany company (Siemens 16slices).The tube voltage used was 150kVp and 180-200mAs, 2)Alfaisal Hospital, CT scan machine manufactured by an Japanese company (Toshiba 4slice) ,The tube voltage used was 150 kVp and 180-200 mAs,3) Alzitona Hospital, CT scan machine manufactured by an Japanese company (Toshiba 64 slice) .The tube voltage used was 150kVp and 200-240mAs, 4) Alturky Center, CT scan machine manufactured by an Japanese company (Toshiba64).The tube voltage used was 150 kVp and 200-240 mAs .The study was obtained during the period spanned from January 2015 up to August 2016.

2.2 Patients

99 patients: 48 (48.5%) were males and 51(51.5%) were females. All were examined with a triphasic liver CT protocol. The patients data were registered: including (age, gender, type of examination, Liver lesion CT number in addition to final radiological findings) .Patients were included if focal liver disease was suspected clinically or if previous imaging studies depicted hepatic lesions with a nonspecific appearance. The patients ages were classified as ages ranged between <10 and >60 years : Frequency and percentage were detected as follows <10 were 2(2%),11-20 were 2(2%),21-30 were 6(6.1%) , 31-40 were 6(6.1%) , 41-50 were 12(12.1%),51-60 were 42(42.4%) and ages>60 were 29(29.3%). Liver Lesions were found to be: hemangiomas in 21 patients, Cyst in 13, Metastases in 38, Hepatocelluler Carcinoma in 24, Ischemia in 2 and abscess were found in 3cases.   Among those 67 patients were found to have different associated findings. The associated findings existing with different Liver Lesions presented as :Out of the 67patients :9(13.5%)have Ca uterus,3(3.5%)haveRCC,4(6.0%)have Lung metatsteses,5(7.5%)have spleen metastases,8(12.0%)have Ca pancreas,2(3.0%) have Ca breast and adrenal,10(14.9%) were with lung mass, 2(3.0%) have gallbladder mass,9(13.5%) have spleenomegly,8(11.9%)were with Ascites,5(7.5%)with renal cyst and 1(1.5%) were with Ca stomach .

2.3CT Acquisition

A triphasic liver CT protocol was developed in which we used a spiral CT scanner .With the triphasic liver CT protocol, the entire liver was scanned successively in arterial, portal, delay and equilibrium phases. After obtaining a scout view, an unenhanced scan of the liver was acquired with 10 mm/sec table speed, 10-mm collimation. On the unenhanced scan, the craniocaudal extent of the liver was measured. 5-mm collimation and 5 mm/sec table speed were used acquisition in arterial and portal phases together were 50 rotations. The craniocaudal extent of the liver determined the number of required rotations in portal phase. The remaining number of rotations was used for the arterial phase, and table speed and collimation were adjusted to cover the entire liver. Depending on the craniocaudal extent of the liver, 5-mm collimation with 10 mm/sec table speed and 10-mm collimation with 20 mm/sec table speed were used in the arterial phase. Patients were positioned in supine position with head first, center between xiphoid process to iliac crest. The longitudinal alignment light in the midline and the horizontal one passes just below the lower costal margin .A total of 50 mL of nonionic contrast material [Omnipaque], was injected with a power injector (into an antecubital vein).Flow rate 3.5 contrast, the entire livers was scanned in arterial phase. After the end of the arterial phase, the liver was scanned in portal phase, the patient was asked to breathe in and to reposition the scan plane cephalad to the liver. The scan obtained in the equilibrium phase, was 15 min after injection of contrast material.

2.4Image Interpretation

Images were reviewed on films. Comparison of the sections at the same anatomic level in the three different phases of contrast enhancement was done. Each study was interpreted by one radiologist. The enhancement characteristics of each phase were assessed by grading the attenuation of the arterial and portal venous system in comparison to liver parenchyma. The arterial, portal, and equilibnum phase images were reviewed for the presence of liver lesions. The appearance of each lesion in each phase was described on the basis of the homogeneity of the lesion in comparison to surrounding parenchyma in that phase .Additional features, defined by typical CT number (Hounsfield unit)of the lesion were used .This method was also been used in other previous studies [3-7]

The diagnosis was based on the radiology reports .All of the lesions did not have pathologic confirmation (Biopsy). This allowed us to analyze lesions with classic imaging features and is not biopsied; Lesions had to meet all of the standard diagnostic criteria based on the CT appearance of the liver.

2.5Statistical analyses

All data obtained in the study were documented and analyzed using SPSS program version16. Descriptive statistics, including frequency and percentage were used. T-test was applied to test the significance of differences, p-value of less than 0.05 was considered to be statistically significant.

2.6Ethical considerations

Special consideration was given to the right of the confidentiality and anonymity for all participants. Anonymity was achieved by using number for each participant to provide link between the collected information and the participants. Justice and human dignity was considered by teaching the selected participant equally when offering them an opportunity to participate in the research. Permission for conducting the study was obtained from head of the radiology department at Khartoum hospitals.

III.   Results

Table (1): Liver lesions CT (Hounsfield) at different scanning phase and *p-value.*

	Equilibrium Phase CT(HU)	Arterial Phase CT(HU)	Venous Phase CT(HU)	Delay Phase CT(HU)
* Hemangiomas	37.26±24.5	44.22±16.01	53.50±29.7	48.44±24.9
Cyst	32.62±72.5	34.57±69.7	38.54±71.2	37.86±67.2
***Metastases	46.95±47.2	53.24±46.4	64.45±47.7	59.14±37.2
Abscess	-128.59±286.3	-196.04±423.3	-132.09±312.6	-209.17±506.2
Ischemia	39.20±0.0	44.30±0.0	51.50±0.0	42.60±0.00
** (HCC)	48.20±53.8	59.80±48.6	64.70±49.6	61.86±46.5
P-value	0.001	0.000	0.000	0.000

***The essential** criteria of evaluation of liver hemangiomas CT images are as follows:hypodense or isodense lesion on precontrast CT images;early peripheral nodular ring enhancement in arterial phase with centripetal fill-in in portal venous phase; and isodense lesion in the delayed phase. Based on these criteria our study considers the findings.*

** Valuable *sign in differential diagnosis of hemangioma and malignant liver lesion is peripheric hypodense rim at the periphery of the mass. It indicates malignant neoplasm and is never seen in hemangiomas.*

*** Liver *metastases may be hypovascular or hypervascular*

Table (2): Liver lesions characteristics/pattern as homogeneous (HM) and heterogeneous (HT) at different scanning phase and p-value.

Final Diagnosis	Equilibrium Phase		Arterial Phase		Venous Phase		Delay Phase	
	HM	HT	HM	HT	HM	HT	HM	HT
Hemangiomas	18(18.2%)	3(3.0%)	16(16.2%)	5(5.1%)	16(16.2%)	5(5.1%)	17(17.2%)	4(4.0%)
Cyst	10(10.1%)	2(2.0%)	10(10.1%)	2(2.0%)	9(9.1%)	3(3.0%)	10(10.1%)	2(2.0%)
Metastases	16(16.2%)	22(22.2%)	7(7.1%)	31(31.3%)	4(4.0%)	34(34.3%)	6(6.1%)	32(32.3%)
Abscess	1(1.0%)	3(3.0%)	1(1.0%)	3(3.0%)	1(1.0%)	3(3.0%)	1(1.0%)	3(3.0%)
Ischemia	2(2.0%)	0(0.0%)	0(0.0%)	2(2.0%)	2(2.0%)	0(0.0%)	2(2.0%)	0(0.0%)
HCC	4(4.0%)	18(18.2%)	2(2.0%)	20(20.2%)	1(1.0%)	21(21.2%)	3(3.0%)	19(19.2%)
Total	51(51.5%)	48(48.5%)	36(36.4%)	63(63.6%)	33(33.3%)	66(66.7%)	39(39.4%)	60(60.6%)
P-value	0.000		0.000		0.000		0.000	

Table (3) The Associated findings existing with different liver lesions presented as cross tabulation

Associated findings	Final Diagnosis of the Liver						Total
	Hemangiomas	Cyst	Metastases	Abscess	Ischemia	HCC	
Uterine Cancer	9(13.5%)	0(0.0%)	0(0.0%)	0(0.0%)	0(0.0%)	0(0.0%)	9(13.5%)
Renal cell carcinoma	0(0.0%)	0(0.0%)	3(4.5%)	0(0.0%)	0(0.0%)	0(0.0%)	3(4.5%)
Lung Metastases	0(0.0%)	1(1.5%)	1(1.5%)	0(0.0%)	0(0.0%)	2(3.0%)	4(6.0%)
Spleen Metastases	0(0.0%)	0(0.0%)	5(7.5%)	0(0.0%)	0(0.0%)	0(0.0%)	5(7.5%)
Pancreatic Cancer	0(0.0%)	0(0.0%)	8(12.0%)	0(0.0%)	0(0.0%)	0(0.0%)	8(12.0%)
Breast / Adrenal Cancer	0(0.0%)	0(0.0%)	0(0.0%)	0(0.0%)	0(0.0%)	2(3.0%)	2(3.0%)
Lung mass	0(0.0%)	0(0.0%)	7(10.4%)	0(0.0%)	0(0.0%)	3(4.5%)	10(14.9%)
Gallbladder mass	0(0.0%)	0(0.0%)	3(4.5%)	0(0.0%)	0(0.0%)	0(0.0%)	3(4.5%)
Splenomegly	0(0.0%)	1(1.5%)	3(4.5%)	1(1.5%)	0(0.0%)	4(6.0%)	9(13.5%)
Ascites	1(1.5%)	0(0.0%)	2(3.0%)	0(0.0%)	2(3.0%)	3(4.5%)	8(11.9%)
Renal cyst	2(3.0%)	2(3.0%)	0(0.0%)	1(1.5%)	0(0.0%)	0(0.0%)	5(7.5%)
Ca stomach	0(0.0%)	0(0.0%)	0(0.0%)	0(0.0%)	0(0.0%)	1(1.5%)	1(1.5%)
Total	12(17.9%)	4(6.0%)	32(47.8%)	2(3.0%)	2(3.0%)	15(22.4%)	67(100.0%)
P-value	The correlation between the CT findings in the liver and other associated findings is found to be significant at p≤0.005. p=0.000						

IV.   Discussion

Triphasic spiral liver computed tomography (CT) is a standardized procedure for the detection and characterization of a large variety of liver lesions. Spiral computed tomography has gained acceptance as the preferred computed tomography technique for liver evaluation because it provides image acquisition at peak enhancement of liver parenchyma during a single breath hold.[8,9] In addition fast data acquisition allows successive scanning of the entire liver at different intervals after injection of the iodinated contrast material, thus creating the possibility of multiphase liver computed tomography.[10,11]

Attenuation of different liver findings in equilibrium phase and three contrast enhanced phases was shown in table (1). From the table we can notice that there were significant differences between attenuation values of lesions in arterial, venous and delay phase. The results of attenuation dynamics of hepatocellular carcinoma (HCC) are higher in all of the scanning phases when compared with hemangiomas, while it is similar to the attenuation of the metastatic lesions.The causes of increased the Hounsfield value for the (HCC) is that the (HCCs)are usually hyper vascular lesions that derive most of their blood supply from the hepatic artery with the portal venous contribution decreasing as the grade of malignancy increases. And it's associated altered portal venous blood flow may help reveal more lesions on the hepatic arterial phase than on the portal venous phase. This is what we found in our study. In our study, most the (HCC) presented as heterogeneous; and were better seen in portal phase. These findings are in keeping with the well-known hyper vascularity of (HCC). This was similar to what was previously mentioned [12,13] The significance and the importance of caring about the phase of enhancement is the fact that lesions seen during only the hepatic arterial phase may require biopsy and patients with hyper vascular malignancies may respond to therapy.[14]

Most metastases to the liver are hypo vascular and consequently are best detected during the portal venous phase. Hypervascular primary malignancies (HCC)and certain metastases (pancreatic carcinomas, pheochromocytomas) have a proportionately greater hepatic arterial blood supply and, as a result, may be visible only on hepatic arterial phase images.[15]Regarding this fact the Hounsfield measured a high attenuation values in all of the scanning phase and this fact is consistent to our associated findings is that the 8(12.0%) of the cases of liver metastases; were found to have pancreas cancer and 2(3.0%) of the cases with HCC have adrenal tumor table (3).

The current study with spiral CT allows more rapid image acquisition and allows greater separation of arterial and venous phase. Our results differ from earlier study [16] in that the hypervascular liver tumors were superiorly presented on venous phase images (64.70±49.6HU) rather than early arterial phase images (59.80±48.6HU). Our findings regarding tumor conspicuity is similar to those of tumor-to-parenchyma differences reported by Foley et al [17] .In previous study; tumor to liver contrast difference occurred in late arterial phase, as regards portal venous phase was found to be superior to or equivalent to late arterial phase. These findings are similar to results of Foley et al. [8]
Because of the high frequency of benign focal liver lesions such as cysts, hemangiomas [17], characterization of these lesions is essential.

Liver hemangiomas is a benign well-defined vascularized lesion. Hemangioma is composed of multiple vascular channels surrounded by endothelium cells with thin fibrotic stroma. Our study findings showed that 3(3.0%) out of 21 cases of hemangiomas were found to be heterogeneous in the equilibrium phase while 5 (5.1%) were found to be heterogeneous in both arterial and venous phase and 4(4.0%) in delay phase, this was presented in table (2) .Many hemangiomas have non-homogenous structure because of fibrosis, necrosis, and cystic zones. On unenhanced CT scans hemangiomas are hypo dense with well-defined boarders. Performing contrast enhanced CT peripheral nodular enhancement with centripetal fill in was observed as well as globular enhancement in hemangiomas was seen; this was found similar to another author [18].Most of the hemangiomas enhance rapidly and intensively in arterial phase. This sign makes it more difficult to differentiate hemangiomas from other hyper vascular tumors as HCC. This enhancement gives it feature of high HU in arterial phase, this was presented in table (1)

Our study demonstrated that some metastases cases showed the same enhancement pattern, another previous studies have mentioned the same findings is that up to 8% of all cases of metastases can be similar to hemangiomas[18] This is the value of using HU in differentiating the metastases from hemangiomas as seen in table (1).

Most of the hemangiomas appear heterogenic lesions that enhance normally table (2).In the delay phase hemangiomas become isodense to surrounding liver parenchyma. This is one of the most important signs in differential diagnostics of hemangioma (it becomes 48.44±24.9 after 53.50±29.7) with slight peripheral enhancement was seen. This way of contrast uptake is typical of hemangioma that, according to some authors, is the last stage of the development of hemangioma. The preferred liver CT technique should combine multiple phases for lesion detection with a good ability for lesion characterization as well as to differentiate lesions that do need further diagnostic tests or treatment therefore a triphasic spiral CT technique was used to image the entire liver in arterial, portal, and equilibrium phases.

In our study the heamangioma and cysts appear homogeneous in all of the scanning phase; this was presented in table (2) while abscess was found to have very low attenuation values in all phases.In the current study, metastatic lesions were either heterogeneous or homogenous table (2). Most of the hyper vascular metastatic lesions were best visualized on venous phase images rather than on arterial or delay phase. Most of them become iso or hypo in equilibrium phases making it difficult to diagnose on single phase thus signifying the importance of both arterial and delay phase images.

Liver is the second most common organ, where different malignant tumors metastasize. 80% patients with extrahepatic tumor are expected to have liver metastases. Our study showed that 32(47.8%) out of 67 patients having liver metastases have also associated findings: 3(4.5%) have renal cell carcinoma (RCC),1(1.5%) have lung metasteses,5(7.5%) spleen metastases,8(12.0%) pancreatic cancer, 7(10.4%) have lung masses, 3(4.5%) have gallbladder mass,3(4.5%) have splenomegly and 2(3.0%)are with ascites as seen in table (3).

In our cases metastases look different; the justification of that appearance is due to variations in cellular differentiation, fibrosis, necrosis, hemorrhage, and blood supply as mentioned by Kristina. et al; (2012) [18] . This appearance was seen in metastases from (RCC), and some types of lung cancer this also was consistent with the same study [18]

Hyper vascular liver metastases (HU) is 53.24±46.4 in the arterial phase and 64.45±47.7(HU) in venous phase was found to be higher than the equilibrium phase, and were found in most of the cases. This was mentioned in previous studies that primary tumors that are the most likely to metastasize to the liver are pancreatic (70-75%), breast, gall-bladder and extra hepatic bile ducts, colon and rectal (about 60%), and stomach (about 50%)[18].

On contrast enhanced CT images characteristic of enhancement of liver metastases is determined by the primary tumor. Hypo vascular liver metastases look hypo dense on CT images, while hyper vascular liver metastases look hyper dense (greater than liver parenchyma)[18]

The borders of metastases may be sharply defined, ill-defined, or nodular, and their shape may be ovoid, round, or irregular[18] this is why our result findings showed 22(22.2%) heterogeneous pattern in equilibrium phase and 31(31.3%) in arterial and 34(34.3%) in venous phase and 32(32.3%) in the delay phase with few cases of homogeneous pattern in all enhancement phases as seen in table (2)

The triphasic CT examination can create certain diagnostic quandary, including the inability to specifically quantification difference of some lesions seen only on the hepatic arterial phase and not on the equilibrium or portal venous phase ,although good results were noted in our results. Lesions were labeled to have high (HU) was considered as malignant or metastases; because of hyper vascularity and the consistency with the patient's history of renal cell carcinoma (RCC) and gastrointestinal malignancy (Ca Stomach)table(1) and table(3).

Regarding the results, the typical CT features and the (HU) may help in differentiating liver lesions significantly table(1) and (2). There are significant relationship between the (HU) and the CT diagnosis as hemangiomas, cyst, metastases, abscess, ischemia, hepatocelluler carcinoma(HCC), in equilibrium phase, arterial phase, venous phase, delay phase at p=0.001,0.000,0.000,0.000 respectively. The correlation between the CT findings in the liver and other associated findings is found to be significant at p≤0.005.

Our study has some limitations like small sample size especially for benign lesions. Interobserver agreement for interpretation of CT images was not calculated. Other potential limitation is that scans were performed on different CT Scanners.

V.   Conclusion

Triphasic CT scan is an acknowledged non-invasive imaging technique and can be used as first line imaging modality for differentiating focal liver lesions using this quantification method and its homogeneity in all of the scanning phases. Benign lesions like haemangioma can be reliably differentiated from malignant liver lesion using the texture and HU values.

It is also particularly supportive for hyper vascular lesions which can be easily overlooked on routine CT scanning; therefore unnecessary biopsies can be avoided.

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