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Research Article

Study of Liver Diseases using Triple-phase Computed Tomography Scan protocol

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Abstract: This study was designed to study of liver diseases using triple-phase computed tomographic scan protocol in Sudanese patient whom presented to computed tomography scan department at Kuwaiti specialized hospital-Sudan, when the liver is investigated using computed tomography machine (CT). **Methodology:** 16 slice GE-Optima (2016) CT scanner was used to scan the 51 patient with liver disease, in period from April to August 2018 where the time and pattern of enhancement were assessed using stander triple phase protocols where the true angiographic phase was done using SMART prep option . The data was initially summarization into mean, stander deviation and percentage in a form comparison tables and figures**. Results:** Out of 51 examined samples (mean age of 54 years male and female ratio (30) (86.8%), (21) (41.2%) were (16) (21.3%) of patients have hepatocellular carcinoma to liver between disease. the accurate time of three phases in exposure time was (8.13-19.6-8.2s) and delay time was (5.16-22.11-359s). The Computed tomography enable detecting and characterization of liver diseases using the proper timing contrast and protocols.

Keywords: Computed Tomography, Liver Diseases, triple-phase protocols.

INTRODUCTION

CT offers the best spatial resolution and the ability to study the entire liver in a single breath-hold. It serves as an ideal screening examination for the entire abdomen and pelvis. Recent technological advances in CT technology, such as helical CT and multidetector row helical CT; have further improved the performance of CT scanners in terms of speed of acquisition, resolution, and the ability to image the liver during various phases of contrast enhancement more precisely than was possible previously. Advances in image post processing and reconstruction methods have enabled the acquisition of three-dimensional (3D) images of the liver vasculature (CT angiography) to map the liver vascular anatomy and to define the liver and tumor volume. Intravenous iodinated contrast media are routinely used in the imaging of the liver.

They improve the contrast-to-noise ratio between focal liver lesions and normal liver and thus aid in the detection of focal liver lesions. They also help to characterize liver lesions, based on the enhancement patterns of liver lesions during various phases of contrast circulation in the liver. When performed properly, CT suffices for most clinical indications. Its limitations include the need for a high radiation dose and a low sensitivity for the detection and characterization of lesions smaller than 1 cm. Contrast-enhanced CT is contraindicated in patients with a history of anaphylaxis from contrast agents and renal failure. CT fluoroscopy is a new tool that assists in performing biopsies of liver lesions. Current multiline CT fluoroscopy systems allow real-time monitoring of the needle during biopsies and may increase the yield of biopsies and decrease the time required for performing a biopsy, with an acceptable radiation dose (Maher, M. M. *et al*., 2004).

The prevalence of hypervascular hepatocellular carcinoma on MDCT images is higher than previously described on single-detector helical images and most lesions showed washout on portal venous MDCT images this was reported in study describe the appearances of hepatocellular carcinoma including intraregional contrast washout using a triple-phase liver protocol on an MDCT scanner. Fifty-one patients with newly diagnosed hepatocellular carcinoma underwent standardized triple-phase CT using a

multidetector scanner .the result of Correlation between tumor size and appearance was analyzed. The most common enhancement pattern for hepatocellular carcinoma was hypervascularity on hepatic arterial phase images with a mosaic pattern on both arterial and portal venous images; this finding was seen in 86% and 78% of lesions by the two observers, respectively. A hypervascular component was seen in 96% of lesions by both observers, and the observers recorded 86% and 63% of lesions as showing washout (Lee, K. H. Y. *et al*., 2004).

The Optimal delay time for the hepatic arterial-phase imaging maximizing the contrast enhancement of hypervascular HCCs was 21 s after arrival of contrast medium in the abdominal aorta. The main purpose of the study to describe Optimal scan timing of hepatic arterial-phase imaging of hypervascular hepatocellular carcinoma determined by multiphasic fast CT imaging technique. One hundred and one hypervascular HCCs in 50 patients were prospectively studied by 64-channel multidetector-row computed tomography (MDCT) with multiphasic fast imaging technique. By injected contrast media containing 600 mg iodine per kg/ body weight intravenously for 30 s. Six seconds after the contrast arrival in the abdominal aorta detected with bolus tracking, By placing regions of interest in the abdominal aorta, portal vein, liver parenchyma, and hyper vascular Timing of maximum tumor-to-liver contrast after the contrast arrival in the abdominal aorta was determined. The result mean time and value of maximum tumor-to-liver contrast after the contrast arrival were 21 s and 38.0 HU, respectively (Kagawa, Y. *et al*., 2013) .

Another study describe Optimal arterial phase imaging for detection of hypervascular hepatocellular carcinoma determined by continuous image capture on 16-MDCT.estimate the optimal time delay before the initiation of arterial phase scanning for detection of hypervascular hepatocellular carcinoma (HCC) on 16-MDCT when a rapid bolus injection of contrast medium is administered25 patients with pathologically confirmed HCC were included. 16-MDCT imaging was performed in using 70 mL of nonionic iodinated contrast medium (300 mg I/mL) at an injection rate of 7 mL/s. 5-mm-thick slices at the maximum diameter of the HCC were selected as the region of interest. Time-attenuation curves were generated by region of interest drawn on the aorta, tumor, and liver. Qualitative assessments of conspicuity for contrast medium wash-in, peak, and wash-out of aorta and tumor were performed. The conclusion: When using 70 mL of 300 mg I/mL of contrast medium with an injection rate of 7 mL/s in 16-MDCT scanning, the optimal time to initiate scanning for HCC is 26.3 +/- 2.9 seconds (range, 24.0-34.5 seconds) after contrast medium administration (Ma, X. *et al*., 2008).

Study describe the optimizing scan delays of fixed duration contrast injection in contrast-enhanced biphasic multidetector-row CT for the liver and the detection of hypervascular hepatocellular carcinoma**.** To determine the optimal scan delay required for fixed duration contrast injection in contrast-enhanced biphasic multidetector-row CT for the liver and the detection of hypervascular hepatocellular carcinoma (HCC). CT images (2.5-mm collimation, 5-mm thickness with no intersectional gap) were obtained after an intravenous bolus injection of 2 mL/kg of nonionic iodine contrast material (300 mg I/mL) for fixed 30-second injection in 206 patients. The conclusion For the detection of hypervascular HCCs, the optimal scan delay after a 30-second contrast injection of the hepatic arterial phase, was found to range from 5 to 10 seconds, and that of the portal venous phase was 35 seconds or somewhat long (Kanematsu, M. *et al*., 2005).

Triphsic spiral computed tomography is the golden stander examination used to evaluated the liver tumor(malignant _benign)that's because it gives us pathology at different phases (arterial .port venous .delay)appearance enhancement by time(homogenous and heterogeneous)and the vascularity of tumor (speed wash in and wash out)reconstruction imaged should be 2 mm interval. Recommended that Spiral ct scan used with stander protocol for evolution tumor because it gives clearly image of normal liver parenchyma and any pathology effect it contrast media should given by its significant doses. scan delay should be 35 sec after injection for more enhancement for better result ministry of health must provider better and updated ct scan .

METHODOLOGY

1. Patient preparation: Asses the clinical problem and medical history includes the indication of the study, contrast allergies ,renal impairment etc**.**

2. Contarst Media: oral contrast negative (neutral) and positive contrast .and nonionic intravenous contrast media the injection rate was 5cc/sec through an 18 gauge the total amount of contrast is automatically calculates the contrast medium dose based on the weight of each patient by using weight factor dosing method calculated from the following formula: Contrast volume (ml) =patient weight *1.5.

3. CT Technique: Scan area from the lower border of diaphragm to symphysis pubic, patient lays supine ,feet first and rise hands above head. Scan is performed during normal inspiration .,gantry angle zero ,10 mm slice thickness are selected through the entire abdomen. All patients underwent both unenhanced and enhanced CT scans during hepatic arterial phase (HAP) and portal venous phase (PVP). According to HAP and PVP in this present study started at 35 s and65 s, respectively, after the contrast injection, from the level of diaphragm

to inferior hepatic edge. The patients receive the same contrast medium with omnipaque concentration of 300 mgI / mL injected at a flow rate of 5 mL.

4. PHASE :arterial phase conducted at (30_35sec) after contrast injection and port venous(late arterial after (50_60 sec) after bolus tracking and delay after (5 _10min) after contrast inject using SMART PREP to get the optimum Hounsfield (HU) from the region of interest (ROI) the arterial phase is taken after 5.2s after 100HU then the mean exposure time used to scan the liver from lower chest to the iliac crest is 8.13s and the mean for PV phase to scan the whole abdomen and pelvis is 19.6s where the optimization of the time to reach the 55 sec (optimum time for PV) is achieved when adding the delay time for arterial phase to the exposure time of arterial phase to the exposure time of the PV phase minus 55s, showing the mean delayed time of PV equal to 22.11s then adding all the above mentioned time to the exposure time of delayed phase together to 350s in order to obtain the time of 6-10 min after contrast injection.

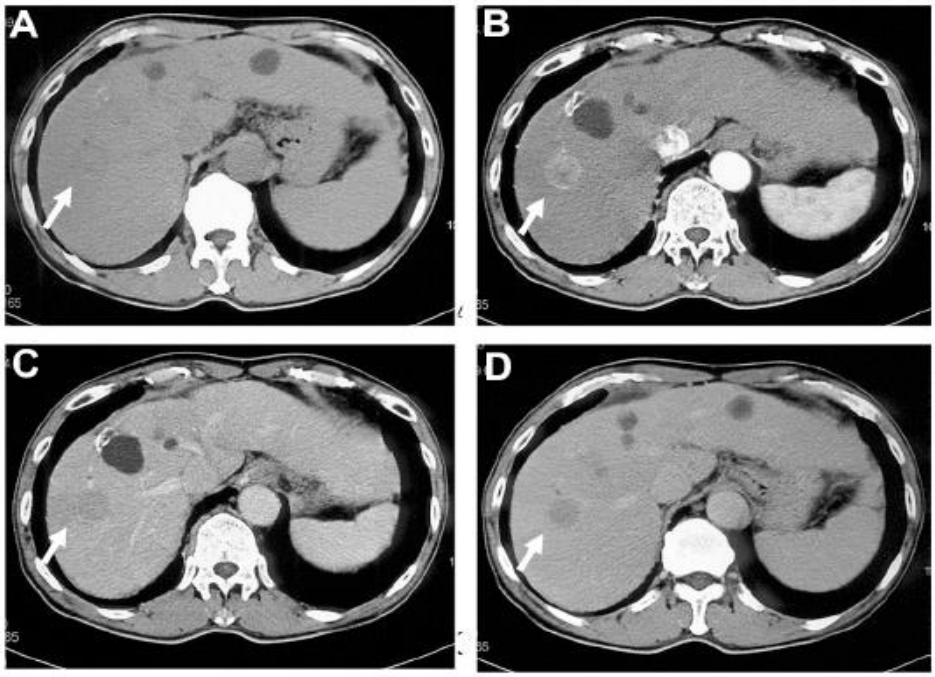

Fig 1: A 68-year-old man with a hepatocellular carcinoma in segment 8. Notes: (A) A noncontract CT image cannot clearly depict a liver nodule (arrow). (B) Arterial-phase CT image (performed with an iodine concentration of 300 mg I/mL) shows a hyper attenuating nodular lesion in segment 8 (arrow). (C) On portal-phase CT imaging, the lesion is depicted as hypo attenuating nodule (arrow). (D) An equilibrium-phase CT image shows a discrete hypo attenuating nodule (arrow). On combination of four-phase image sets, the lesion is definitely diagnosed as typical hyper vascular hepatocellular carcinoma.

RESULTS

Table 1. Shows statistical parameters for the age .weight. length to all patients

Variables	Min	Max	Mean	Std. D
Age	30.0	86.0	54.098	12.9325
Weight	18.0	98.0	65.922	13.2964
Length	140.0	198.0	163.627	12.8109

Table 2. Statistical parameters for the(arterial. port venous. delay) exposure time and contrast volume to all patient

Variables	Min	Max	Mean	Std. D
Arterial exposure time	5.5	10.9	8.13	1.2
Portal venous exposure time	12	24.5	19.6	2.6
Delay exposure time	4.8	12.3	8.2	1.3
Contrast volume	75.0	144.0	92.7	12.9

Table 3. Statistical parameters for the(arterial .Porto venous .delay) delay time and density of portal and hepatic vein to all patient

Variables	Min	Max	Mean	Std. D
DART	**4.3**	**6.7**	**5.165**	**0.4655**
DPVT	**14.0**	**24.0**	**22.11**	**2.3309**
DTD	**330.0**	**370.0**	**359.412**	**10.6605**
DPV	**0.0**	**411.0**	**164.353**	**57.2635**
DHV	**0.0**	**396.0**	**136.686**	**81.0381**

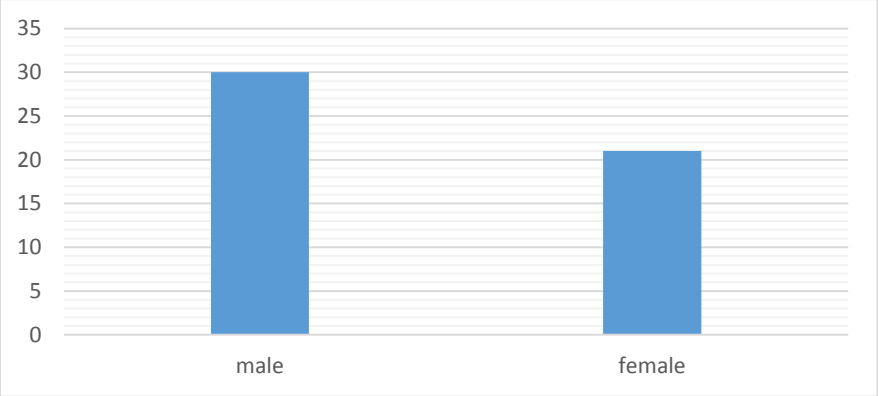

Fig 2. Frequency distribution for sex among population sample

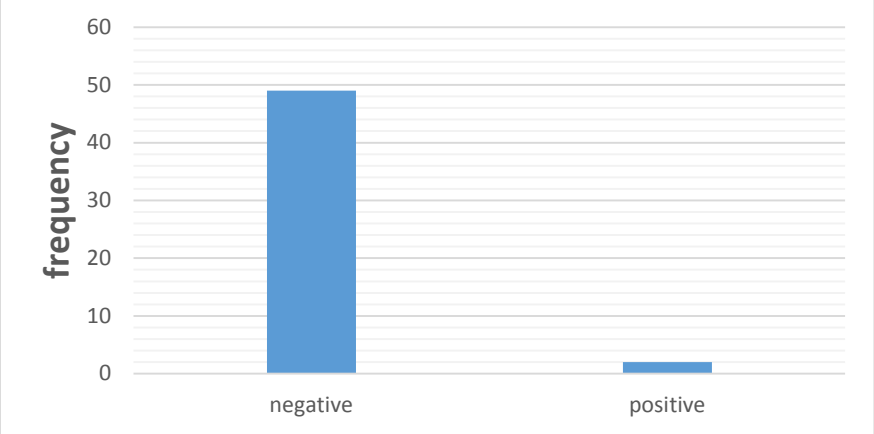

Fig 3. Distribution for type of oral contrast

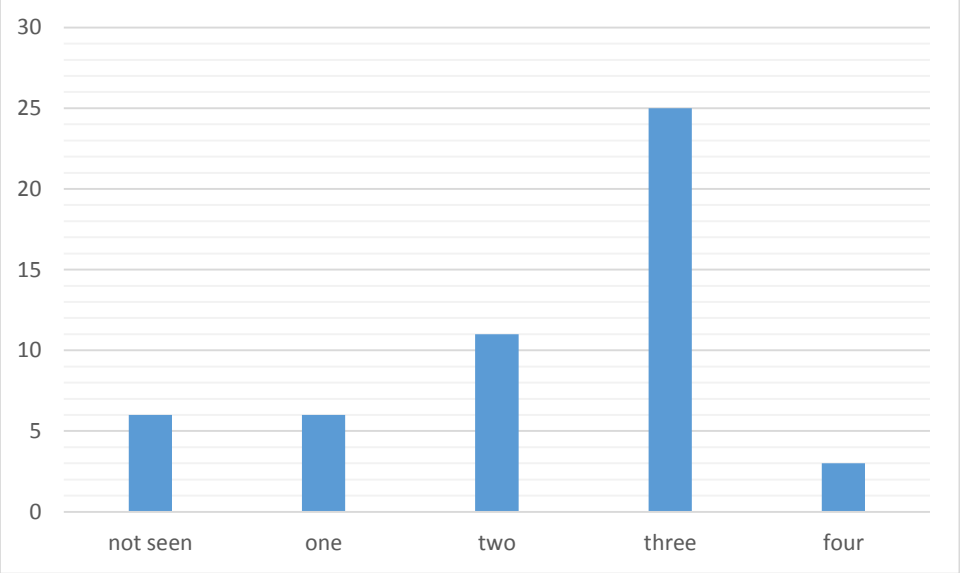

Fig 4. Distribution for number of hepatic vein

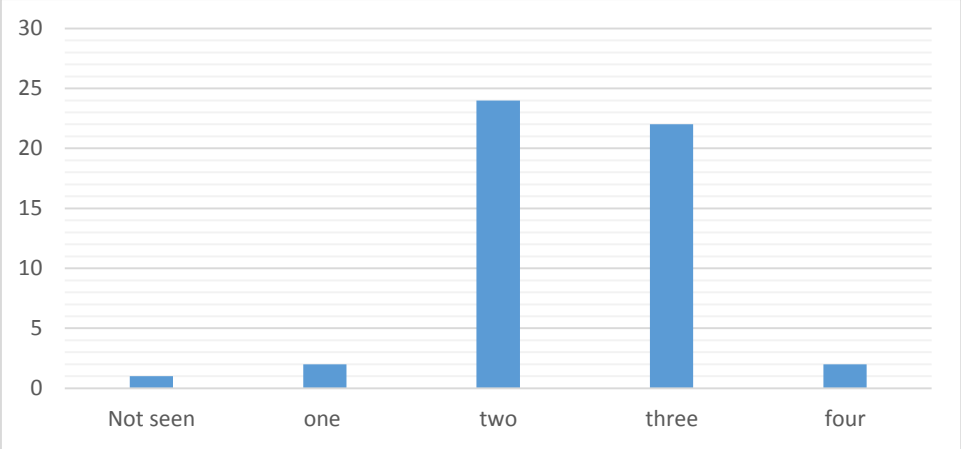

Fig 5. Shows distribution for number of portal vein

Table 4. Shows frequency distribution of pathology finding:

Finding	Frequency	Percent
Cancer prostate	**7**	**13.7**
Liver lesion	**3**	**5.9**
Gall Bladder stone	**3**	**5.9**
Pancreatic cyst	**1**	**2.0**
Ampullary mass	**1**	**2.0**
HCC	**16**	**21.3**
Hemangioma	**3**	**5.9**
Liver cirrhosis	**1**	**2.0**
Renal cyst	**1**	**2.0**
Obstruction	**3**	**5.9**
Colorectal ca	**2**	**3.9**
portal polyp	**1**	**2.0**
Metastasis	**1**	**2.0**
liver transplants	**1**	**2.0**
Normal	**4**	**7.8**
Hepatitis HB	**1**	**2.0**
Jaundice	**1**	**2.0**
Pancreatitis	**1**	**2.0**
Total	**51**	**100.0**

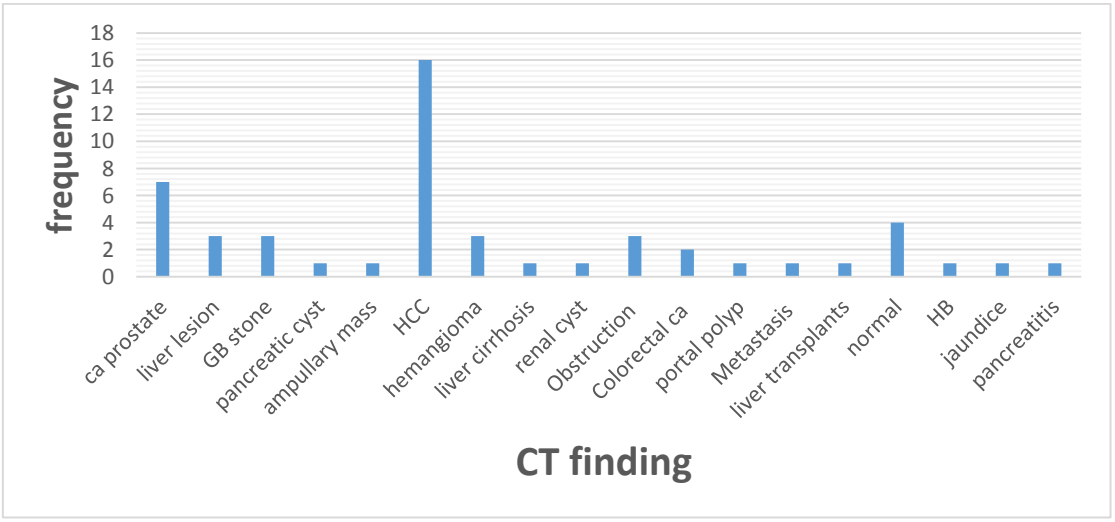

Fig 6. Shows frequency distribution of pathology finding

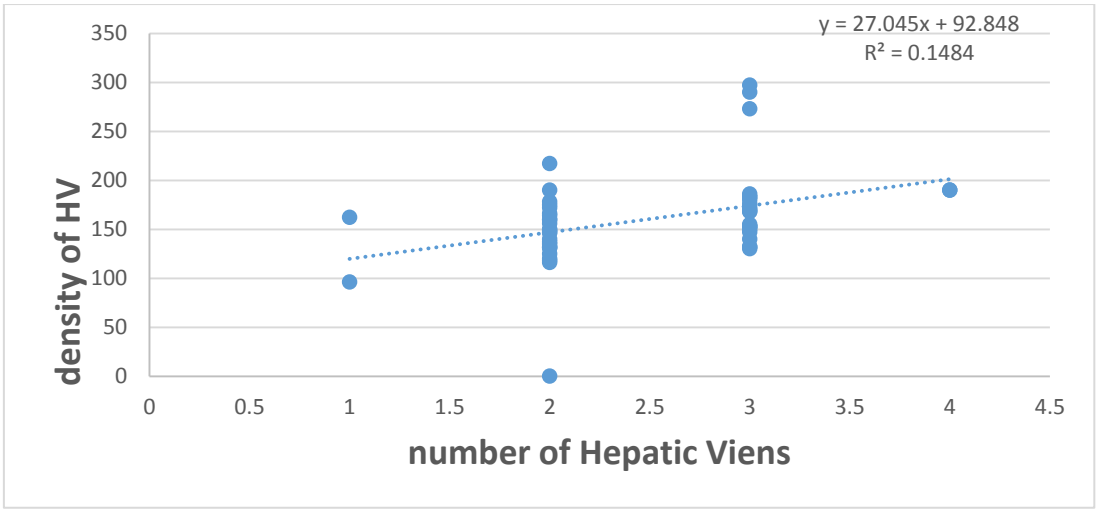

Fig 7. Shows a correlation between density of hepatic vein and number of hepatic vein

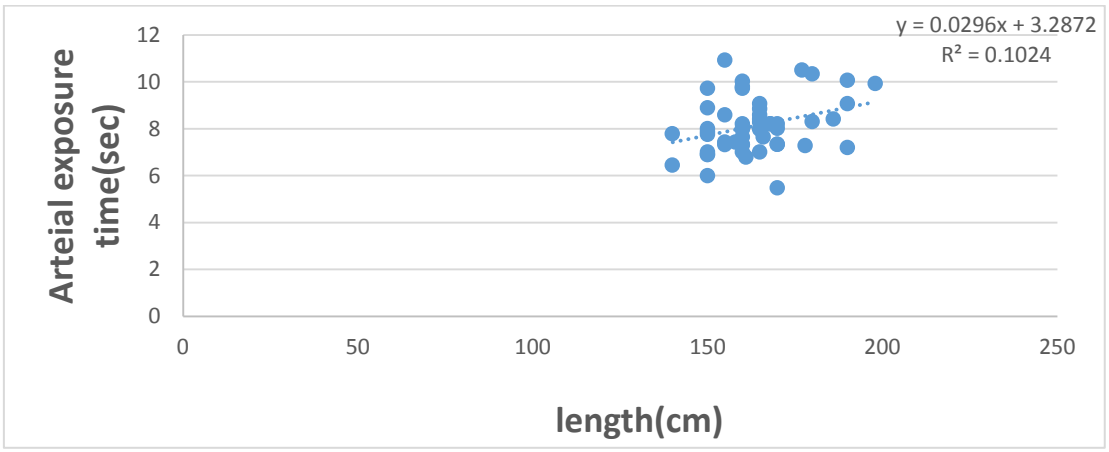

Fig 8. Shows correlation between density of arterial exposure time and patient length

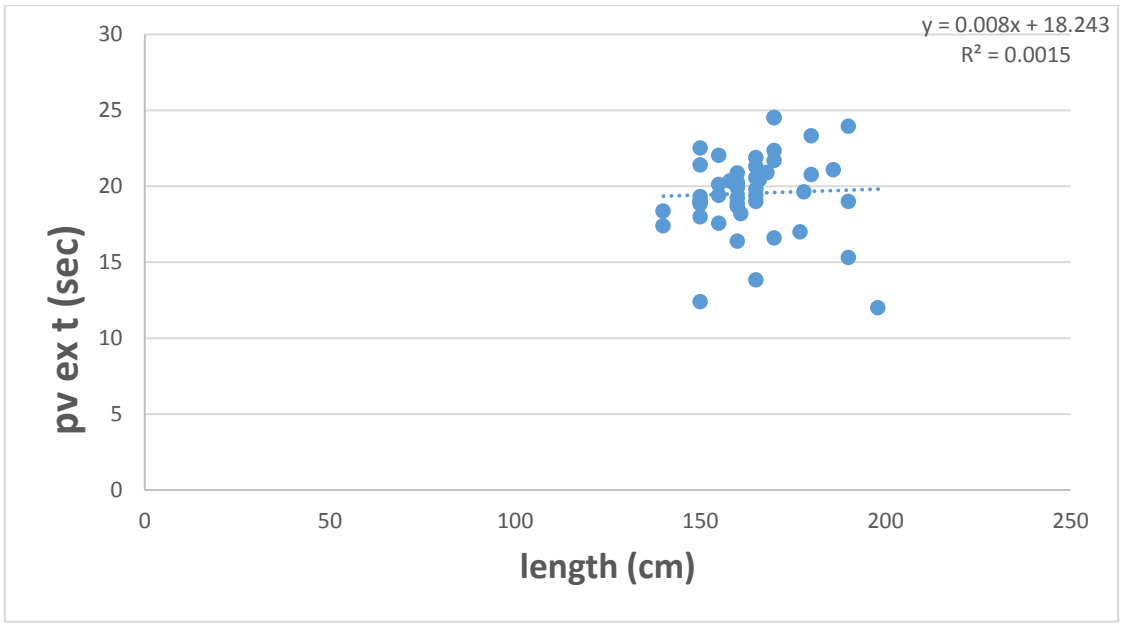

Fig 9. Correlation between patient length and Porto venous exposure time

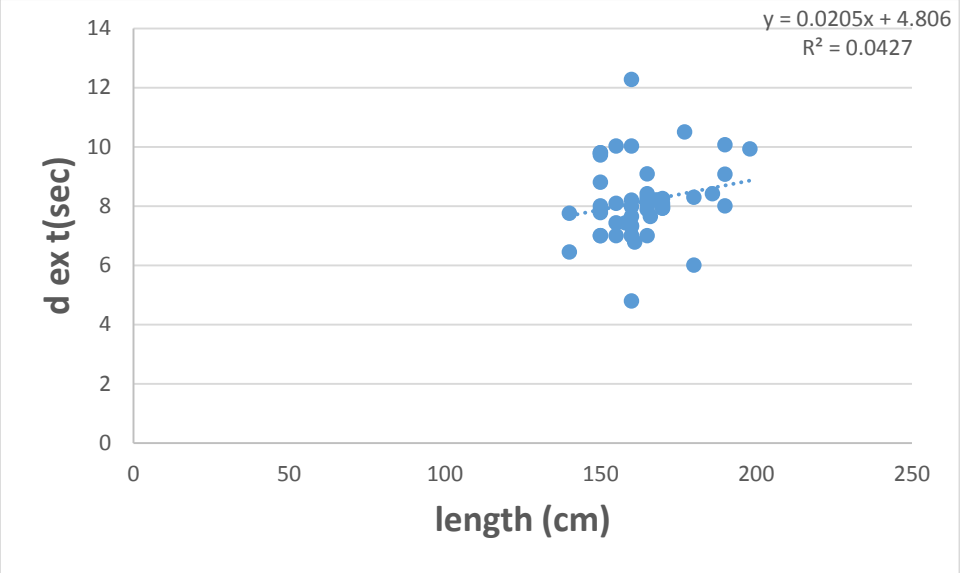

Fig 10. Correlation between delay exposure time and patient length

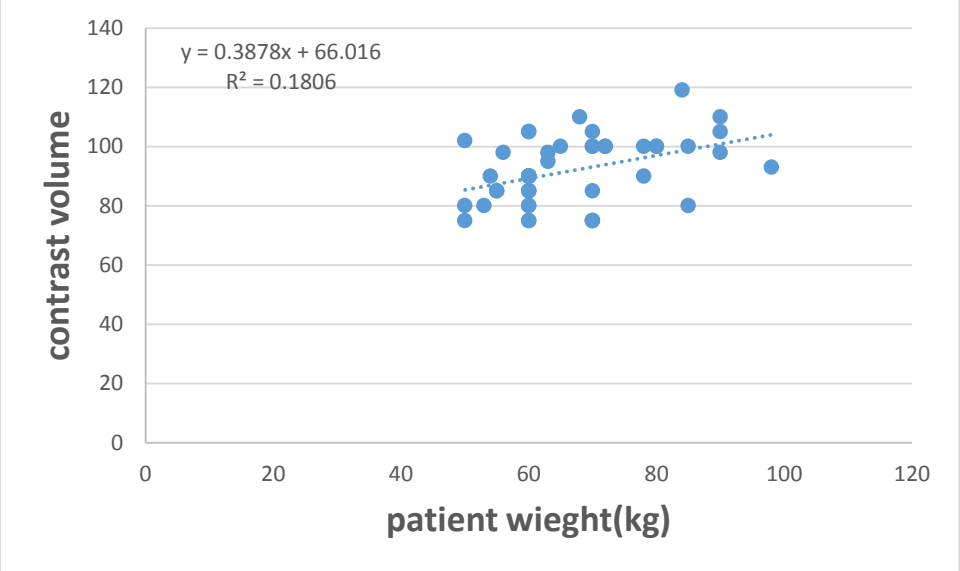

Fig 11. Correlation between contrast volume and patient weight

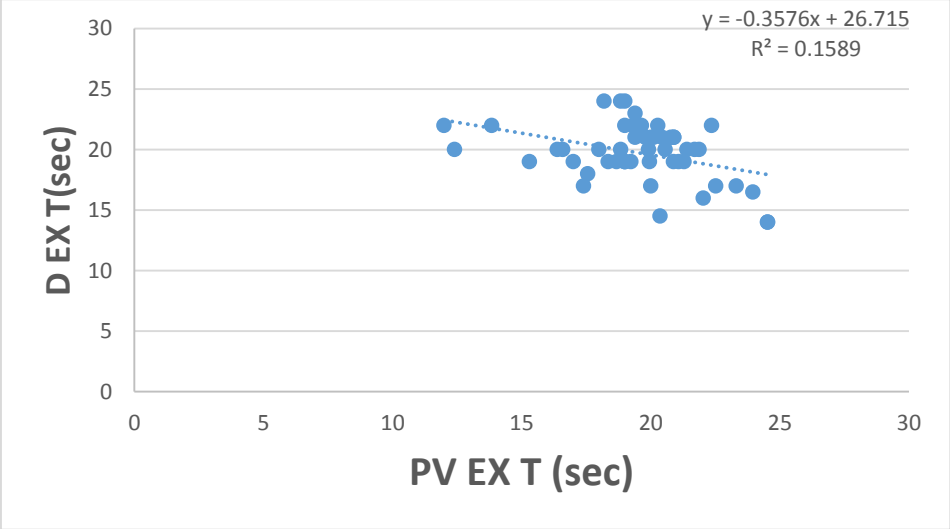

Fig 12. Correlation between delay exposure time and Porto venous exposure time

DISCUSSION

The appearance of hepatocellular carcinomas was originally described using conventional and single-detector helical CT scanners (Stevens, W. R. et aal., 1994; Hollett, M. D. *et al*., 1995) . On single-detector CT, most hepatocellular carcinomas have hypervascular components on arterial phase imaging and are hypoattenuating relative to the liver parenchyma on portal venous phase imaging. This study serves to update the appearance of hepatocellular carcinoma using multidetector technology.Similar enhancement patterns are described in our study, with the most common appearance of hepatocellular carcinoma being hypervascular in the arterial phase with a heterogeneous mosaic pattern in both the arterial and portal venous phases . This was analytical study conducted to assess the Triphsic protocol for abdomen (liver) in order to manage the accurate timing for contrast study. This can lead to misdiagnosis of lesions assess by the uptake of contrast. The most important factor that affect the contrast enhancement of abdominal organs is the timing of contrast injection through the different phase of contrast, triphsic CT abdomen is the protocol used for scanning of the liver and its related pathology mostly include (arterial phase, portal venous phase in addition to the delayed phase) this procedure aimed to demonstrate the liver parenchyma where the portal vein, hepatic veins and its branches totally well opacified by the contrast in addition liver tissue in all phase of contrast the first phase aimed to identify the liver vasculature and relative organs vasculature and the PV phase used to perfuse the abdominal organs totally with contrast (negative).

Most of data population was male accounting for (30) (58.8%) and female accounting (21) (41.2%), fig 2 where most of published articles stated that the male predominance in live tumor and disease is higher than female [9].While CT study revealed that most of the finding was include CA prostate (7) (13.7 %) liver lesion (3) (5.9%). GB stone (3) (5.9%).Pancreatic cyst (1) (2%.) Ampulla mass (1) (2%). Hepatocellularcarcinoma (16) (21.3%) Hemangioma (3)(5.9%). Liver cirrhosis (1) (2%) Renal cyst (1) (2%). Obstruction (3 (5.9%). Collaterals (2) (3.9%). portalpylus (1) (2%). Metastasis (1) (2%) .Liver transplant (1) (2%). Hepatitis (1) (2%). Jaundice (1) (2%). Pancreatitis (1)Normalcase (4) (7.8%) .Table (4). Most of the CT study of the liver suggested that hepaticellurcarcinoma have high incidence in male. Most common finding was hepatocellular carcinoma (16) (21.3%) according to literature review problem effect male more than female (hepatocellular carcinoma represents the fifth most common cancer worldwide and account for 90% of primary liver cancer .men have higher prevalence than women. the sex ratio varies between 2:1 and 4:1Patients take the oral contrast negative (neutral) (49)(96.1 %) .positive contrast (2)(3.9%) . Oral contrast is one of the most important type of contrast used to study the abdomen where the GIT relative to other abdominal versa can be evaluated and assessed, there was many type can be used in CT triphsic protocol while it depend on the relative patient condition need to assess in which have two type (positive and negative contrast).By Negative contrast mean (neutral)contrast which is also two type: oral water or Manitoul oral water is given on for assessment of stomach wall and its disease and the other type is used for assessment of small bowel lesion and the water can be given rectally to assess the large bowel or depending on time of oral contrast the we have to Waite for more than for hour to reach the large bowel (Lee, C. H. *et al*., 2016).

Correlation was investigate the relationship between the patient length and portovenouse exposure time because the length of exposure time is significant according to patient length at (R2 =0.0015) where direct correlation .indicate that exposure time at portovenouse phase increase by 0.008 second for every one centimeter increase in pt length y=0.008x+18.243 fig9.

A correlation was investigate the relationship between the patient length and delay exposure time .because the length of exposure time is significant according to pt length that R2=0.0427 WHERE DIRECT CORLATION .indicate that the exposure time at delay phase increase by 0.0205 seen for every one centimeter increase in patient length y=0.0205x+4.806 fig10.

A correlation was investigate the relationship between the patient length and arterial exposure time .because the length of exposure time is significant according to pt length that R2=0.1024 WHERE DIRECT CORLATION .indicate that the exposure time at delay phase increase by 0.0296 seen for every one centimeter increase in patient length y=0.0296x+3 .2872 fig11.

A correlations was investigate the relationship between the contrast volume and patient weight .because the weight of patient is significant according to contrast volume R2=0.1806 WHERE DIRECT CORLATION. Indicate that the contrast volume increase by 0.3878 for every one kg in patient weight y=0.3878x+66.016 fig12.

A correlation was investigate the relationship between the density of Hepatic vein and number of hepatic vein .because the number of hepatic vein is significant according to number of hepatic vein R2=0.1484 WHERE DIRECT CORLATION. Indicate that the increase by 27.045 for every one kg in patient weight y=27.045x+92.484 fig13

A correlation was investigate the relationship between the port venous exposure time and delay exposure time .because the port venous exposure time is significant according to R2=0.1589 WHERE REVERS CORLATION. Indicate that the increase of exposure time by 0.3576 lead to decrees delay exposure time y=0.3576x+26.715 fig14.

CONCLUSION

The Computed tomography enable detecting and characterization of liver diseases using the proper timing contrast and protocols.

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