

Triphasic Spiral CT in Hepatocellular Carcinoma Timing Optimization for Increasing Detectability

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ABSTRACT

The role of CT imaging in detection of hepatocellular carcinoma is well established and many strategies for optimizing data acquisition to improve CT detection of HCC were tried. Helical CT is an ideal method that fulfills the requirements of rapid scanning during the short interval of maximum hepatic enhancement. The aim of this work was to establish the optimal protocol for contrast injection and image acquisition to achieve maximum liver to tumor contrast in cases of HCC. Thirty-five patients with pathologically proven HCC were examined by triphasic spiral CT of the liver; they were divided into two groups, utilizing a different injection protocol in each group. It was found that 97.9% of the lesions were detected during arterial phase in both groups, while 85% of the lesions were seen in delayed phase and only 68% were detected in portal venous phase. It was also noted that maximal tumor enhancement occurs at a longer delay time and a higher rate of contrast injection. We concluded that in dynamic helical CT of the liver, high injection rate and short delay time provide higher and faster enhancement of the hepatocellular carcinoma and hence increase lesion detectability.

Key Words: *Triphasic spiral CT - Hepatocellular carcinoma.*

INTRODUCTION

Recent studies of dynamic CT suggest that the arterial phase of enhancement may be useful in detecting small hepatomas [16]. Fast imaging has become possible with helical CT technology, which is now widely available. Recent advances, including flexibility of scanning software and greater heat capacity of X-ray tubes, have made multiple-phase helical CT technique feasible [20]. Scan time less than 20 sec in single breath-hold helical CT permits examination of the entire liver during the arterial phase, portal-venous phase and equilibrium phase (delayed phase). However, most researchers have focused on optimizing the bolus of contrast material and timing image acquisition

during the portal-venous phase of hepatic enhancement to facilitate detection of less vascular lesions such as hepatic metastases [9,15]. The value of two helical passes through the liver with the first during the arterial phase and the second during the portal-venous phase, is well recognized in hypervascular tumors [10].

The liver receives a dual blood supply, with about 25% of total liver blood flow being supplied from the hepatic artery and 75% from the portal vein. However, hepatic neoplasms receive virtually 100% of their blood supply from the hepatic artery. These hemodynamic facts can be utilized with helical computed tomography (CT) to optimize both the detection and the characterization of hepatic neoplasms [4].

The aim of the study is to investigate the optimal protocol for contrast material injection to establish the timing of helical CT acquisition time that provides maximum liver-tumor contrast in cases of hepato-cellular carcinoma.

PATIENTS AND METHODS

Study population: This study included 35 patients. They were (28 males and 7 females), their age ranged from 40 to 70 years with a mean age of 51 years. All patients were known to have a pathologically proven hepatocellular carcinoma by either CT or US guided biopsy.

They were all subjected to US examination and spiral CT of the abdomen with special emphasis on the liver.

Technique of the spiral CT: Precontrast and triphasic liver CT protocols were performed using a whole body spiral CT scanner (Somatom

plus 4, Siemens, Erlangen, Germany) with a 3.7 megaheat unit tube and scanning parameters of 280 MAs and 120 Kvp. The entire liver was scanned in precontrast, arterial, early portal venous and delayed equilibrium phases. Digital scout view was obtained and the precise area to be scanned was selected, precontrast scan view was first obtained, then 150 ml non-ionic contrast material, (Ultravist 300 mg I/ml) was injected using a power injector which is generally preferable to manual injection because higher injection rates are difficult to be achieved homogeneously by hand. Antecubital flexible cannula with a diameter of 1 mm (20 Gauge) was used in all cases.

Patients were divided randomly into two groups; in each group special protocol for contrast injection was used. The first group was injected at a rate of 2 ml/sec. while the second was injected at a rate of 4 ml/sec. The entire liver was completely examined within 20 seconds. Two scan timing protocols were employed for each injection protocol. After the start of the injection, helical scan of the entire liver began at either 30 sec. or 35 sec. for the 2 ml/sec. protocol and at either 20 sec. or 25 sec. for the 4 ml/sec protocol. We repeated (portal-venous phase) scan at 80 sec. for the 2 ml/sec. protocol and 60 sec. for the 4 ml/sec. protocol. Delayed phase scans were obtained at 240 sec. and at 180 sec. after the start of injections for the 2 ml/sec. and 4 ml/sec. protocols, respectively (Tables 1&2).

All scans were obtained in the go and return sequence, i.e. craniocaudal and in the reverse direction. Patients were asked to breath freely in between scans.

RESULTS

The peak enhancement of the aorta and that of the liver was judged visually by two radiologists. It was obtained in the aorta at 36 sec. and 24 sec. in the 2 ml/sec. protocol and the 4 ml/sec. protocol, respectively. Peak enhancement of the liver occurred at 90 sec. and 60 sec. in both protocols, respectively.

Tumor mass was seen as enhanced during the arterial phase and as hypodense relative to the surrounding liver during the portal venous and delayed scan.

In 27 patients solitary lesion was detected, while in 8 patients multiple focal lesions were

diagnosed as multicentric HCC. In 4 cases 2 lesions were detected, in 3 cases 3 foci were noted and four lesions were seen in only one case. Thus the total number of liver focal lesions in our patients were 48 (Table 3).

The number of lesions detected was greatest during the arterial phase in both injection protocols. Thirty two lesions (66.6%) were clearly depicted during early arterial phase as hyperdense lesions and as relatively hypodense in portal venous and delayed seen i.e. seen in all phases. In portal venous-phase, tumors were isodense to the surrounding liver, then they became hypodense in the delayed scan in 8 cases (16.6%). Seven lesions (14.5%) were visible only during the arterial phase and became isodense in portal venous and delayed phases. Only one lesion was not seen in the arterial phase (2%), this missed lesion was smaller than 2 cm (Table 4).

Tumors tend to enhance more when scanned at the delay time of 35 sec for 2 ml/sec protocol and 25 sec for 4 ml/sec protocol, with no significant differences noted regarding the portal venous phase and equilibrium phase, in both protocols (Table 5).

Table (1): The two protocols used for patients scanning.

Protocol	Group A (17 patients)	Group B (18 patients)
Dose of contrast	150 ml	150 ml
Rate of injection	2 ml/sec.	4 ml/sec.
Delay time	30 and 35 sec.	20 and 25 sec.

Table (2): Scan protocol (scan timing for each phase of enhancement).

Rate of injection/ scan delay	Arterial phase	Portal venous	Delayed phase
2 ml/sec. after 30 sec. n=8	30	80	240
2 ml/sec. after 35 sec. n=9	35	80	240
4 ml/sec. after 20 sec. n=9	20	60	180
4 ml/sec. after 25 sec. n=9	25	60	180

n: The number of patients in each protocol.

Table (3): Number of lesions in relation to number of patients.

No. of patients	27	4	3	1	Total No. of patients 35
No. of lesions	Single	2	3	4	Total No. of lesions 48

Table (5): Number of lesions detected with each protocol.

Contrast material injection/scan delay	No. of lesions detected during		
	Arterial	Portal venous	Delayed
2 ml/sec 30 sec.	9	6	8
2 ml/sec 35 sec.	12	8	10
4 ml/sec 20 sec.	12	9	12
4 ml/sec 25 sec.	14	10	11
Total = 48	47	33	41

Table (4): Lesion detection in different phases of hepatic enhancement.

No. of lesions T=48	Arterial phase	Portal venous phase	Delayed phase
32	+	+	+
8	+	-	+
7	+	-	-
1	-	+	+

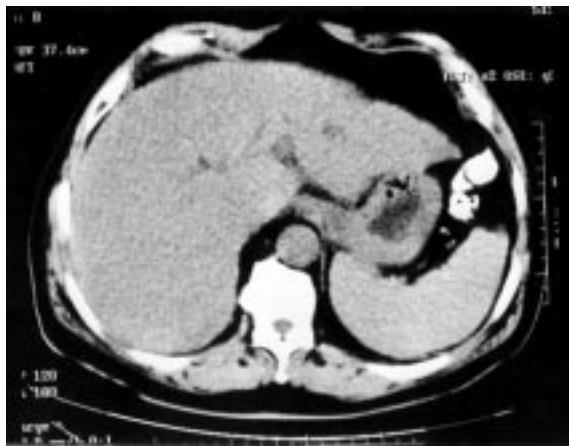


Fig. [1-a]



Fig. [1-b]

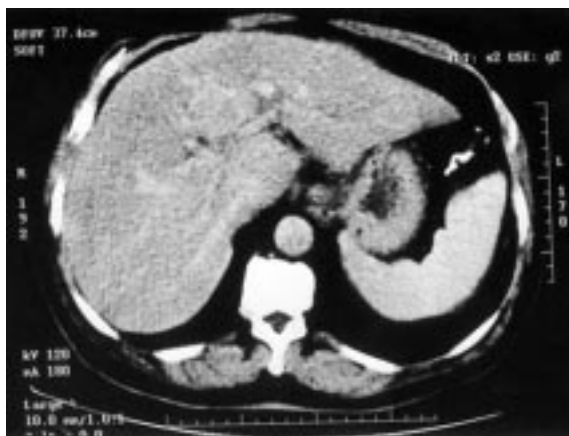


Fig. [1-c]

Fig. (1):

- A- No focal lesion in non contrast study.
- B- Triphasic study (2 ml/sec). arterial phase at 30 second: Densely enhancing focal lesion with evident arterial supply.
- C- The lesion is not seen in portal phase.

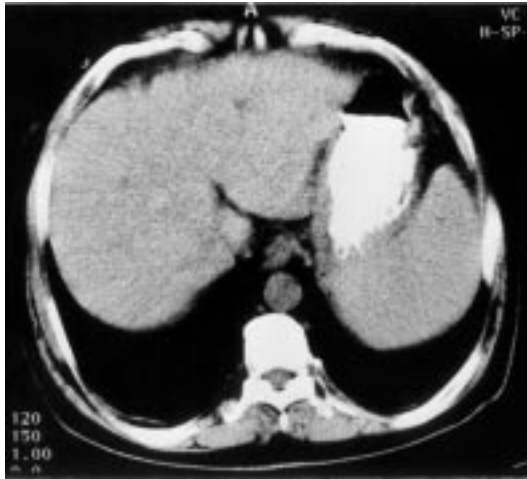


Fig. [2-a]

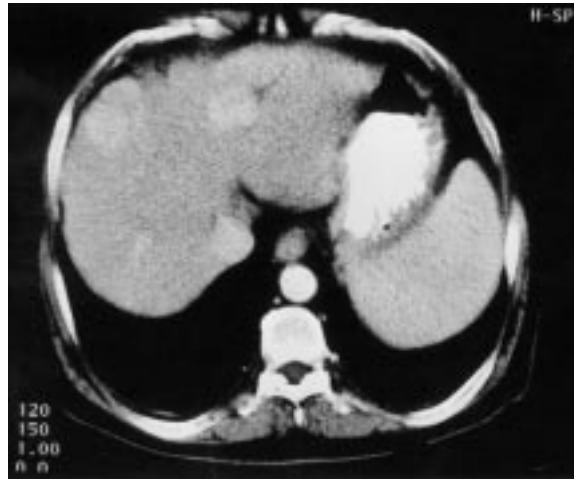


Fig. [2-b]

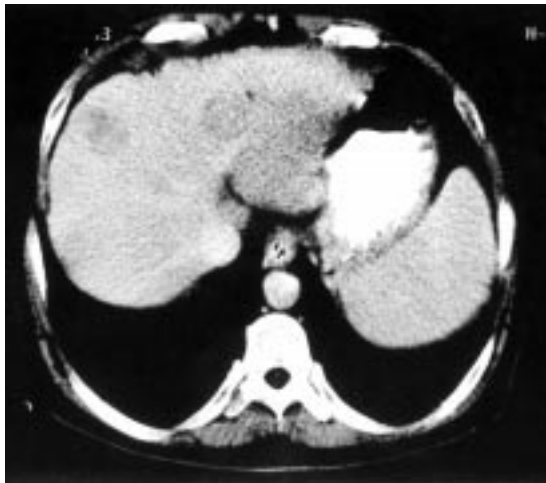


Fig. [2-c]

Fig. (2):

A- No focal lesions in the non contrast study.

B- Triphasic study (2 ml/sec). Arterial phase 35 seconds after contrast injection: Two faintly enhancing focal lesions in right and left lobes, turned to be hypodense lesions in the portal phase (Fig. C).

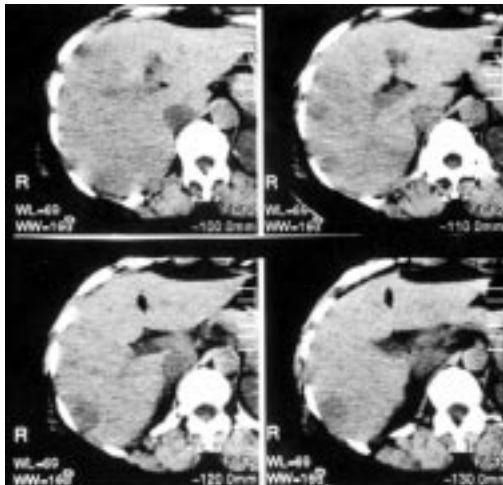


Fig. (3-a)

A- Right hepatic focal lesion in non contrast study.

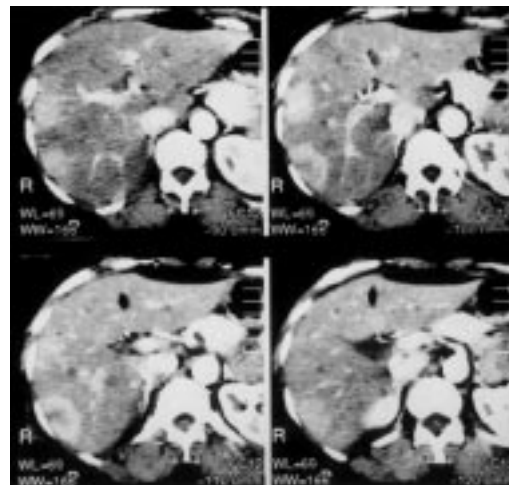


Fig. (3-b)

B- Triphasic study (4 ml/sec). Arterial phase at 20 seconds after contrast injection: 2 enhancing right hepatic focal lesions.

Fig. (3 c,d):
C- Portal phase: Enhanced liver parenchyma masking the lesions.
D- Delayed phase: One lesion hardly defined.

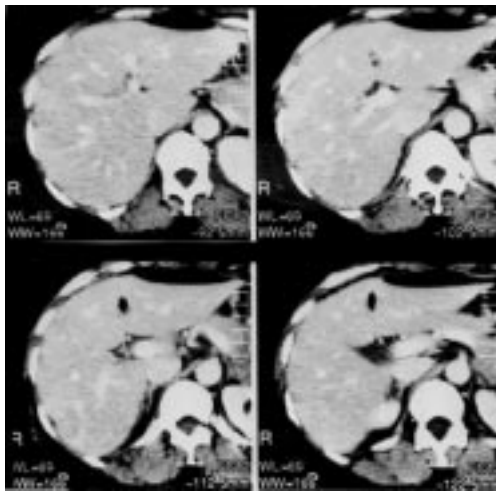


Fig. [3-c]

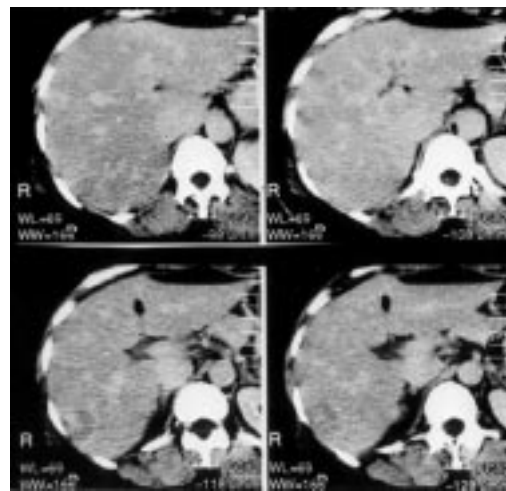


Fig. [3-d]

Fig. (4):
A & B- Non contrast study with no focal lesions. Elevated AFP.
C & D- Triphasic study (4 ml/sec) Arterial phase 25 second after contrast injection: Two densely enhancing focal lesions in right lobe; seen only in the arterial phase not seen in the portal phase E & F and delayed phase G & H.

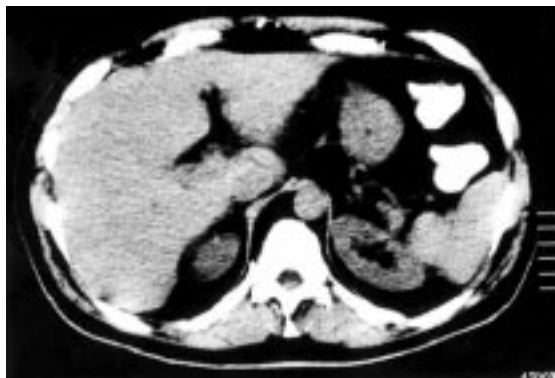


Fig. [4-a]



Fig. [4-b]



Fig. [4-c]



Fig. [4-d]



Fig. [4-e]



Fig. [4-f]



Fig. [4-g]



Fig. [4-h]

DISCUSSION

The revolution in imaging technique over the past few decades has created a wide spectrum of choices for investigating patients with different hepatic problems. In particular, advances in ultrasound, isotopic scanning, computed tomography and magnetic resonance have led to improved detection and characterization of hepatic lesions to reach a definitive diagnosis and an optimum therapeutic policy [18]. HCC is one of the most common malignancies in the world. In Egypt, it contributes about 2.3% of all cancers with a median age of 35 years and a male predominance of 5:1 [6]. HCC must be differentiated from other hyper-vascular lesions especially those found in cirrhotic liver, which include among others, small hemangiomas and hyper-vascular metastases [12,17]. Spiral CT provides image acquisition at the peak of hepatic parenchyma during a single breath hold. It also leads to improvement of the quality of three-dimensional reconstruction facilitating pre-surgical planning. Successive

scanning of the entire liver at different phases of contrast injection, allows multiphase hepatic imaging [2], which may add important data for lesion detection [13] and characterization [5]. Dynamic CT with a bolus of contrast material has played an important role in detection of HCC as most of them are pathologically hyper-vascular [11]. Most hepatic CT imaging protocols focused on optimizing the portal venous phase of enhancement to maximize the attenuation difference between normal liver parenchyma and the relatively hypo-vascular neoplasms such as metastatic tumors [9], even though many primary hepatic neoplasms and hyper-vascular metastases can become isodense during portal venous phase. Hyper-vascular neoplasms are better imaged during the arterial phase of hepatic enhancement [8]. Helical CT allows scanning of the entire liver in the arterial phase that was not possible with conventional CT [20].

The rationale of performing a multiple-phase examination is to maximize detection of hyper-

vascular neoplasms with an arterial phase scan without compromising the quality of the portal-venous and equilibrium phases [9].

Although conventional CT detects most hyper-vascular lesions, many other lesions may become isodense with the liver parenchyma after administration of contrast material, particularly when the acquisition time is not optimized. Ohashi et al., [10] were the first to report the value of multiple phase dynamic CT in detection of HCC [16]. They used a biphasic dynamic incremental CT using a conventional CT unit, which was relatively slow, requiring a 1-sec. scan time and 2-sec. inter scan delay, taking approximately 43 sec. to scan the entire liver. However, to image the liver in the arterial phase of contrast enhancement, the scanner must be capable of imaging the entire liver in a shorter time usually less than 20 seconds for visualizing the hyper-vascular lesions.

In our study, hepatocellular carcinomas were usually more conspicuous during the arterial and equilibrium phases. In equilibrium phase, hyper-vascular tumors became hypodense relative to the surrounding liver because of early washout of the contrast material from the tumor. The value of portal venous phase images appeared to be limited for hepatoma detection unlike detection of most metastatic tumors. This goes with the results obtained by Mitsuzaki et al. [14]. They stated that small hepatomas are clearly seen during the arterial and equilibrium phases and that in the portal venous phase the liver-tumor contrast was low because tumor enhancement decreased and liver parenchymal enhancement increased.

Small hyper-vascular hepatomas included in this series, showed low contrast in the portal venous phase because tumor enhancement diminished and liver parenchymal enhancement increased. The only lesion that was missed in the arterial phase was less than 2 cm in diameter, we suggest that it belongs to hypovascular type of HCC. Conversely, other researchers have described metastatic tumors and some hypovascular hepatomas in which liver tumor contrast was maximized during the portal venous phase [15&19].

Therefore, imaging protocols must be modified to fit the disease background. In patients with suspected metastatic tumors scanning during the portal venous phase may be necessary.

To screen patients with suspected hepatomas CT during arterial and delayed phase is mandatory [3].

Protocols for using helical CT to evaluate hyper-vascular liver tumors would benefit from optimal opacification of tumor vascularity instead of hepatic parenchymal enhancement. However, the optimal time to visualize hyper-vascular tumors is usually short, similar to the arterial enhancement of tumors [7].

In this series, we evaluated the peak of hepatic and aortic enhancement on visual bases, since there were considerable variations in the circulation time and scan delay time may have to be even twice longer in some patients (as in those with circulatory insufficiency). We compared two injection protocols with two scan delays to choose the optimal timing for imaging in the three enhancement phases. We found that enhancement of the aorta and HCC differed significantly at various rates of contrast injection. Injection rate at 4 ml/sec. provided higher and earlier enhancement of aorta and HCC than did 2 ml/sec rate.

The aortic peak enhancement was obtained at the end of the injection. In tumors imaged at a delay time of 20 sec in the 4 ml/sec protocols, the contrast between the tumors and the surrounding parenchyma was minimal. Enhancement became more conspicuous in tumors imaged at a delay of 25 sec. When contrast material was injected at a rate of 2-ml/sec., tumor enhancement was more conspicuous after a delay of 35 sec. Many investigators tried those protocols of injection and almost similar results were obtained [3,14,19].

Several potential limitations were noticed. First no time of absolute peak of enhancement could be standardized. Second, lack of pathological correlation with individual lesions imaged. Several potential draw-backs to the multiple-phase helical CT technique were reported including radiation over exposure to patients, additional tube loading and film costs [9]. As a result, clinical background of each patient should be considered when such a technique is to be employed. It is most valuable in selected patients with known or suspected HCC and other hyper-vascular tumors.

We have concluded that, for helical CT of the liver an injection rate of 4 ml/sec provided

higher and faster enhancement of aorta and HCC than did 2 ml/sec, although no significant difference in the liver parenchymal enhancement was detected. Arterial-phase helical CT in combination with the equilibrium phase improved the conspicuity of HCC. However, rapid injection rates required appropriate adjustment of the scan time. Scanning during the portal venous phase had little value in detecting HCC.

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