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Enhancement pattern and appearance of hepatocellular carcinoma through triple-phase MDCT

Busaba Jiruppabha*

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Introduction : *Hepatocellular carcinoma (HCC) is the most common cancer in Southeast Asia. It was the first cause of death in cancer patient in Thailand. Over the decade Multidetector computed tomography (MDCT) had been used in clinical practices.This technique allows three to seven times faster scan of the liver than single detector helical CT scanner, so uniform hepatic enhancement can be achieved during hepatic arterial and portal venous phases. There are few authors who study HCC characteristics while others focus on the improvement of lesion conspicuity using multiple phase scans.*

Objective : *To describe enhancement patterns, appearance of HCC using triple-phase MDCT and association between HCC appearance and tumor size.*

Setting : *Bangkok Metropolitan Administration General Hospital.*

Research design : *A retrospective descriptive study.*

Patients : *Thirty-five patients with HCC whose triple phase MDCT study was available between June 2007 and February 2009 at BMA General Hospital.*

* Bangkok Metropolitan Administration General Hospital, Bangkok 10100, Thailand

Methods : *The triple-phase MDCT imaging (nonenhanced or NECT, hepatic arterial or HAP and portal venous phases or PVP) and clinical data of 35 patients with 58 HCC were reviewed in the aspects of HCC enhancement pattern and appearance. The diagnosis of HCC was confirmed by pathological results in 20 cases, by high level of serum alpha-fetoprotein and characteristic angiographic findings in 15 cases.*

Results : *Most frequent enhancement pattern of HCC was heterogeneous hyperattenuation on HAP and became heterogeneous hypoattenuation on PVP (47%). Almost all tumors revealed contrast washout on PVP (93%). Seventy-two percent of HCC had hypervascular component. Ninety-five percent of HCC were isoattenuation or hypoattenuation on NECT. Abnormal internal vessels were found in 31%. Venous invasion, tumor capsule and calcification were evidenced in 26%, 24% and 2%, respectively. Abnormal internal vessels and heterogeneous appearance of HCC were more common in large tumor size ($p = 0.007$, $p = 0.001$, respectively). No association between contrast washout on PVP and tumor size.*

Conclusion : *The most frequent enhancement pattern of HCC using triple-phase MDCT is heterogeneous hyperattenuation on HAP and heterogeneous hypoattenuation on PVP, the same findings as found on single detector helical CT scanner apart from increased incidence of hypervascular HCC, contrast washout on PVP and abnormal internal vessels. There are statistical associations between abnormal internal vessels, heterogeneous appearance of HCC and the tumor size.*

Keywords : *Hepatocellular carcinoma, Triple-phase MDCT, Enhancement pattern of hepatocellular carcinoma, CT appearance of hepatocellular carcinoma.*

Reprint request: Jiruppabha B. Bangkok Metropolitan Administration General Hospital, Bangkok 10100, Thailand.

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บุษบา จิรัปปภา. รูปแบบการติดสารทึบรังสีและลักษณะรอยโรคของมะเร็งตับจากการตรวจด้วยเอกซเรย์คอมพิวเตอร์ 3 ระยะชนิด MDCT. จุฬาลงกรณ์เวชสาร 2552 พ.ค.- มิ.ย.; 53 (3): 185 - 98

บทนำ : *มะเร็งตับเป็นสาเหตุการเสียชีวิตอันดับหนึ่งของผู้ป่วยมะเร็งในประเทศไทย มีการนำเครื่องเอกซเรย์คอมพิวเตอร์ความเร็วสูงชนิด Multidetector (Multidetector Computed Tomography; MDCT) มาใช้ ทำให้การตรวจ ตับได้ภาพที่คมชัดตรงตามระยะที่ต้องการตรวจ (phase) แต่การทำวิจัยที่ ศึกษารูปแบบการติดสารทึบรังสีและลักษณะของมะเร็งตับยังมีไม่มาก วิจัย ส่วนใหญ่จะมุ่งเน้นศึกษาการเพิ่มประสิทธิภาพการตรวจพบรอยโรค*

เป้าหมาย : *เพื่อแสดงรูปแบบการติดสารทึบรังสีและลักษณะรอยโรคของมะเร็งตับจากการตรวจด้วยเอกซเรย์คอมพิวเตอร์ 3 ระยะชนิด Multidetector (Triple– phase MDCT) และหาความสัมพันธ์ระหว่าง ลักษณะรอยโรคของมะเร็งตับกับขนาดของมะเร็งตับ*

ประเภทโรงพยาบาล : *โรงพยาบาลกลาง สำนักการแพทย์ กทม. เป็นโรงพยาบาลขนาด 400 เตียง*

รูปแบบการวิจัย : *การศึกษาเชิงพรรณนา*

การคัดเลือกผู้ป่วย : *ผู้ป่วยมะเร็งตับที่เข้ารับการตรวจรักษาที่โรงพยาบาลกลาง และได้รับการตรวจช่องท้องด้วยเอกซเรย์คอมพิวเตอร์ 3 ระยะชนิด MDCT ในช่วงมิถุนายน 2550 ถึง กุมภาพันธ์ 2552*

วิธีการทำวิจัย : *ศึกษาภาพเอกซเรย์คอมพิวเตอร์ 3 ระยะ อันได้แก่ ภาพก่อนฉีดสารทึบรังสี ภาพหลังฉีดสารทึบรังสีระยะ hepatic arterial phase (HAP) และภาพระยะ portal venous phase (PVP) ของมะเร็งตับ 58 ก้อน จากผู้ป่วย 35 ราย ทาง ด้านรูปแบบการติดสารทึบรังสี และลักษณะรอยโรคของมะเร็งตับ หาความ สัมพันธ์ระหว่างลักษณะรอยโรค และขนาดของมะเร็งตับ*

ผลการศึกษา : *รูปแบบการติดสารทึบรังสีที่พบบ่อยในก้อนมะเร็งตับคือ เนื้อมะเร็งตับจะติดสี heterogeneous hyperattenuation ในระยะ HAP และติดสี heterogeneous hypoattenuation ในระยะ PVP (47%) ร้อยละ 93 ของมะเร็งตับแสดง contrast washout ในระยะ PVP ร้อยละ 72 ของก้อนมะเร็งแสดง hypervascular component ร้อยละ 95 ของก้อนมะเร็งตับ จะมีสีเหมือนหรือ hypodense กว่าเนื้อตับทั่วไปในระยะก่อนฉีดสารทึบรังสี พบหลอดเลือดผิดปกติภายในก้อนมะเร็งตับร้อยละ 31 พบภาวะมะเร็งตับลุกลามหลอดเลือดดำ capsule รอบก้อนมะเร็งตับและหินปูนภายในก้อนมะเร็งตับร้อยละ 26, 24 และ 2 ตามลำดับ หลอดเลือดผิดปกติภายในก้อนมะเร็งและลักษณะเนื้อก้อนมะเร็งไม่เรียบ มักพบในก้อนมะเร็งขนาดใหญ่ ไม่พบความสัมพันธ์ระหว่างcontrast washout กับขนาดก้อนมะเร็งตับ*

สรุป : *รูปแบบการติดสารทึบรังสีที่พบบ่อยของมะเร็งตับ เมื่อตรวจด้วยเอกซเรย์คอมพิวเตอร์ 3 ระยะชนิด MDCT เหมือนกับลักษณะมะเร็งตับที่ตรวจด้วยเอกซเรย์คอมพิวเตอร์ชนิด Single detector helical CT แต่การตรวจด้วยเอกซเรย์คอมพิวเตอร์ 3 ระยะชนิด MDCT จะพบมะเร็งแบบ hypervascular, contrast washout ในระยะ PVP และหลอดเลือดผิดปกติภายในก้อนมะเร็งมากกว่า ลักษณะเนื้อก้อนมะเร็งไม่เรียบ และการพบหลอดเลือดผิดปกติภายในก้อนมะเร็งมีความสัมพันธ์ทางสถิติกับขนาดของก้อนมะเร็ง*

คำสำคัญ : *มะเร็งตับ,การตรวจด้วยเอกซเรย์คอมพิวเตอร์ 3 ระยะชนิด MDCT, รูปแบบการติดสารทึบรังสีของมะเร็งตับ, ลักษณะรอยโรคของมะเร็งตับจากการตรวจด้วยเอกซเรย์คอมพิวเตอร์.*

Hepatocellular carcinoma (HCC) is a common cancer and found worldwide. In Southeast Asia is an endemic area of hepatitis, and HCC is the most common cancer.[1] According to the 1994 report of the Ministry of Public Heath of Thailand, HCC was the first cause of death in cancer patients in the country. Diagnosis of HCC, besides serum alpha-fetoprotein, CT scan of the liver is the best investigation in patient suspected of HCC.[2] The appearance of HCC on single detector helical CT has been well described by many authors.[3 - 9] Over the decade, Multidetector computed tomography (MDCT) has been used in clinical practices. MDCT uses many contiguous detectors which producing 4 - 64 images per one rotation with high spatial resolution. This technique allows three to seven times faster scan of the liver than a single detector helical CT scanner. This allows uniform hepatic enhancement to be achieved during hepatic arterial and portal venous phases. There are only few authors who study HCC characteristics[4,9] while others focused on improvement of lesion conspicuity using multiple phase scans.[10]

The present study was aimed to describe enhancement patterns and appearance of HCC using triple-phase MDCT and also associations between HCC appearance, enhancement pattern and tumor size.

Material and Methods

The ethics committee of our hospital has approved this retrospective study. About 58 patients with a diagnosis of HCC were identified by online medical database between June 2007 and February 2009. All of the diagnosed HCC patients who underwent triple-phase MDCT of the liver at BMA General Hospital (35 patients) were finally recruited in this study.

In 20 of the 35 patients, the diagnosis of HCC was established by percutaneous biopsy. In 15 patients HCC was diagnosed on a high level of serum alpha-fetoprotein and characteristic angiographic findings. The characteristic angiographic findings were defined as tumor vascular proliferation, tumor stain and A-V shunt formation.

The recorded clinical data were, namely: age and gender of the patients, the presence of the risk factors for HCC (hepatitis B and hepatitis C viral infection) and the level of serum alpha-fetoprotein.

CT Technique

All scans were obtained by using a 40-MDCT scanner (Somatom Sensation 40, Seimens medical, Erlangen,Germany). The IV contrast material (1.Ultravist 370, Iopromide, Bayer Schering, Korea; 2. Telebrix 350, Sodium and Meglumine Ioxitalamate, Guerbet, France) 80-100 ml was given at the anticubital vein by a power injector (MCT PLUS; Medrad, Pittsburgh) at the rate 3ml/sec. The scanning parameters were: collimation 1.2 mm; reconstruction interval 8mm; pitch 0.8; gantry rotation time 0.37 second; 120 kV and 250 mAs. The scanning sequences were nonenhanced or NECT, arterial or HAP (35 sec after IV contrast injection) and portal venous or PVP (80 sec after IV contrast injection) phases in the craniocaudal direction from the lung base to the lower poles of the kidneys.

Imaging Analysis

MDCT images were retrospectively reviewed on Workstation (Syngo CT 2007S, Seimens). In the process, the dominant lesion and at least one smaller

lesion were characterized when the disease was multifocal.

The CT appearances of HCC were recorded as size, location, number, margin, capsule, calcification, abnormal internal vessels and venous involvement. The capsule was defined as either complete or incomplete hypoattenuating rim on nonenhanced images. Venous involvement was defined as unenhancing intraluminal material in the portal vein, the hepatic vein or the inferior vena cava. Cirrhosis was recorded when nodular surfaced liver, enlarged left hepatic lobe and atrophy of the right hepatic lobe were evident.

Enhancement patterns

The HCC enhancement patterns and the presence of contrast washout were analyzed. Contrast washout was defined as a decrease in the attenuation of the tumor when compared to the adjacent liver parenchyma from HAP to PVP.

The enhancement patterns were assessed objectively and subjectively by using the method described by Loyer *et al.*[9]

In the objective analysis, the CT attenuation coefficients of the tumor were measured in all obtained phases. In the heterogeneous enhancement, the ROI was placed in the area of more homogeneous. The measurements of the solid component of the tumor, the normal liver parenchyma and the aorta were obtained from the same areas during the three different phases. By using all these data, time attenuation curves and a curve of the difference in attenuation between the tumor and liver parenchyma were established.

In the subjective analysis, tumor attenuation was graded with respect to the surrounding liver parenchyma. The images were evaluated with both narrow (window width, 100HU; window level, 60 – 90 HU) and soft tissue (window width, 400HU; window level, 70 – 90 HU) window settings. The grading was classified into three categories according to their conspicuity: 1. barely visible against the surrounding liver parenchyma; 2. intermediately obvious; 3. extremely obvious. Consequently, the following categories were defined: hyperattenuating 3; hyperattenuating 2; hyperattenuating 1; isoattenuating; hypoattenuating 1; hypoattenuating 2; and hypoattenuating 3.

The numerable results were presented in range, mean and percent. The Chi-square with Fisher's exact test was used to analyze the relationships between tumor appearance, enhancement pattern and tumor size: and p value that was less than 0.05 was considered significant.

Results

Clinical data

There were 35 patients included in the review. Twenty-seven (77%) were male and eight (23%) were female. Their ages ranged from 34 to 79 years old (mean = 55 years). Only 27 patients (77%) had laboratory test for underlying hepatitis viral infection, 21 patients (60%) had positive hepatitis B viral infection and 1 patient (3%) had positive hepatitis C viral infection. All patients had serum alpha-fetoprotein (AFP) assay; 24 patients (69%) had high rising AFP (> 400 ng/ml), 7 patients (20%) had low raising AFP (> 7 to 400 ng/ml) and 4 patients whose percutaneous biopsy had shown to be HCC (7%) revealed normal AFP (<= 7 ng/ml).

CT appearance of HCC

Fifty-eight HCC lesions were analyzed in 35 patients. The CT appearances of HCC are summarized in Table 1. There were solitary mass in twenty-two patients (63%) and multiple masses in thirteen patients (37%). Thirty-four lesions (59%) were 5 cm or larger, 18 lesions (31%) were 2cm or larger but smaller than 5 cm, and 6 lesions (10%) were smaller than 2cm. The 41 lesions (71%) were located in the right hepatic lobe, 16 lesions (27%) in the left hepatic lobe and 1 lesion (2%) in the caudate lobe. Twenty-eight lesions (48%) showed smooth margin and lobulated margin appeared in 30 lesions (52%).

Table 1. CT Appearances of 58 HCC.

CT Appearance of HCC	% (n)
Tumor Number	
Solitary (case)	63 (22)
Multiple (case)	37 (13)
Tumor size	
Mean diameter(cm.) (range)	6.2 (1.6-17)
<2 (cm.)	10 (6)
2-<5 (cm.)	31 (18)
>=5 (cm.)	59 (34)
Location	
Right hepatic lobe	71 (41)
Left hepatic lobe	27 (16)
Caudate lobe	2 (1)
Margin	
Smooth	48 (28)
Lobulated	52 (30)
Contrast washout	93 (54)
Venous involvement *(case)	26 (9)
Abnormal internal vessels	31 (18)
Presence of capsule	24 (14)
Calcifications	2 (1)
Cirrhosis (case)	66 (23)

n= number of lesion, Venous involvement* = portal, hepatic vein or IVC thrombosis.

Venous involvement was seen in 9 patients (26%). Portal vein thrombosis was seen in 8 patients (Fig 1). Right hepatic vein thrombosis was detected in 1 patient: IVC thrombosis was noted in 2 patients. Abnormal internal vessels were found in 18 lesions (31%). Tumor capsule was identified in 14 lesions (24%). Tumor calcification was seen in only 1 lesion (2%). Twenty- three patients (66%) revealed cirrhosis on CT imaging.

Enhancement pattern

In the objective analysis, mean attenuation coefficients of the tumor, liver, aorta and tumor to liver difference are plotted in Fig 2. The mean attenuation coefficients of the tumor on HAP was 81 HU and slightly increased to 86 HU on PVP. Thirty-eight lesions (65%) of the tumors showed maximal attenuation coefficient on PVP. The mean attenuation coefficient of the liver parenchyma on HAP and PVP were 61 HU and 86 HU, respectively. The mean attenuation coefficients of the aorta on HAP was 208 HU and decreased to 108 HU on PVP. The mean different attenuation coefficients between the tumor and liver parenchyma on HAP were 20 HU and 0.5 HU on PVP.

In the subjective analysis, the most frequent enhancement pattern of HCC was heterogeneous hyperattenuation on HAP and became heterogeneous hypoattenuation on PVP which were found in 27 lesions (47%), Fig 3. The enhancement patterns and enhancement characteristics of 58 HCC are summarized in Table 2 and 3.

Almost all of the tumors revealed either isoattenuation or hypoattenuation on NECT (55 lesions, 95%). Only 3 lesions (5%) showed hyperattenation on NECT. Forty-two lesions (72%) were hyperattenuation on HAP. All these hypervascular lesions (100%) show

contrast washout. Sixteen lesions (28%) were either iso or hypoattenuation on HAP showing contrast washout in 13 lesions (81%).

Association

Heterogeneous appearance of HCC associated with large tumor size (P = 0.001). There was no association between contrast washout and tumor size (p = 1.0),Fig.4. Abnormal internal vessels are associated with large tumor size (p = 0.007), Fig.5. Frequencies of CT appearance of HCC with respect to the tumor size are summarized in Table 4.

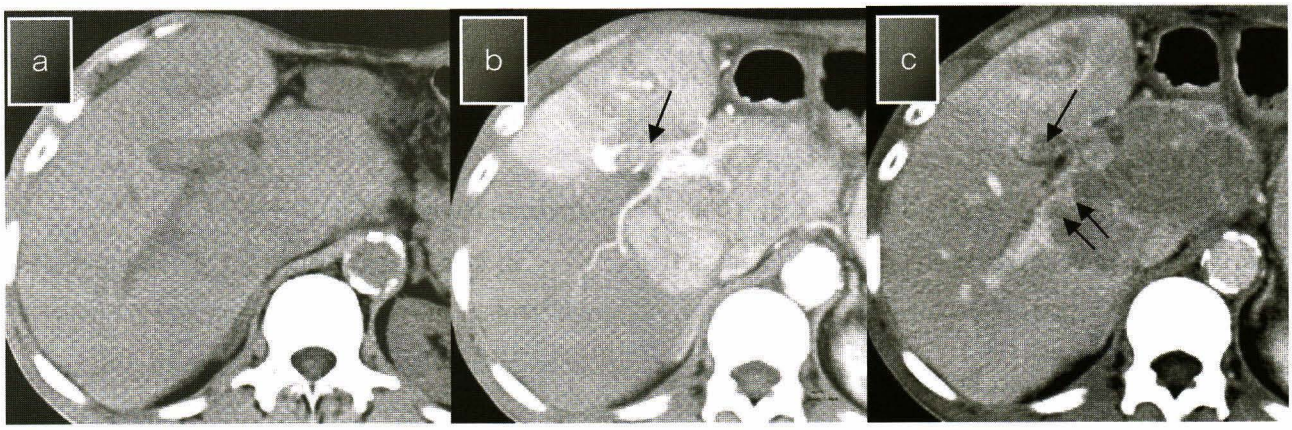
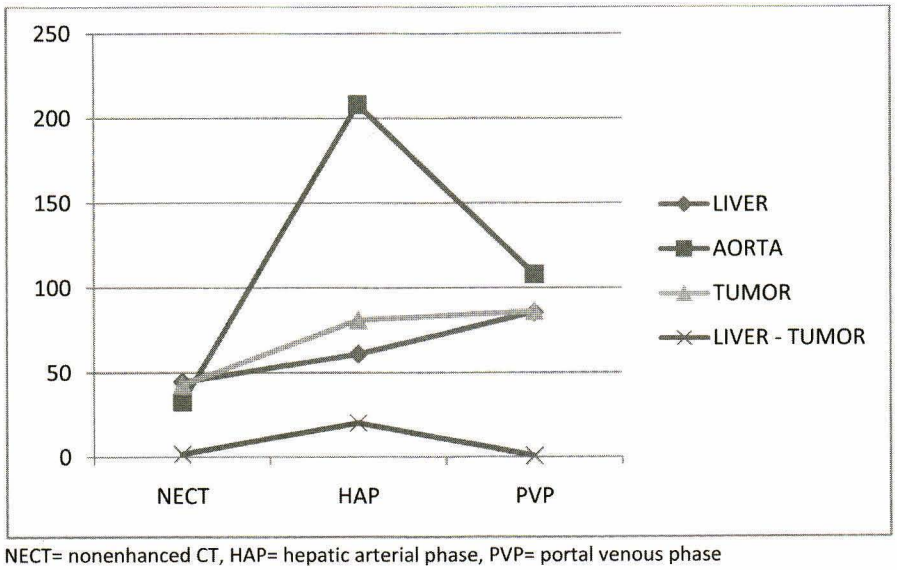


Figure 1. A known case of HCC and hepatitis B viral infection s/p Lt. lobe hepatectomy showing recurrent HCCs: a) NECT, one tumor at the anterior segment of the Rt. hepatic lobe and one at caudate lobe showing isoattenuation and hypoattenuation, respectively: b) HAP, HCCs revealed heterogeneous hyperattenuation 3 with the anterior branch of the right portal vein thrombosis(arrowed): c) PVP, the right hepatic lobe HCC became heterogeneous hyperattenuation 2 and HCC at the caudate lobe became heterogeneous hypoattenuation 2. The anterior branch of the right portal vein thrombosis (arrowed) and the posterior branch of the right portal vein thrombosis were evident(double-arroweds)



NECT= nonenhanced CT, HAP= hepatic arterial phase, PVP= portal venous phase

Figure 2. Graphic illustration of the mean attenuation coefficients of tumor, liver, liver-tumor difference and aorta on nonenhance, arterial and portal venous phases.

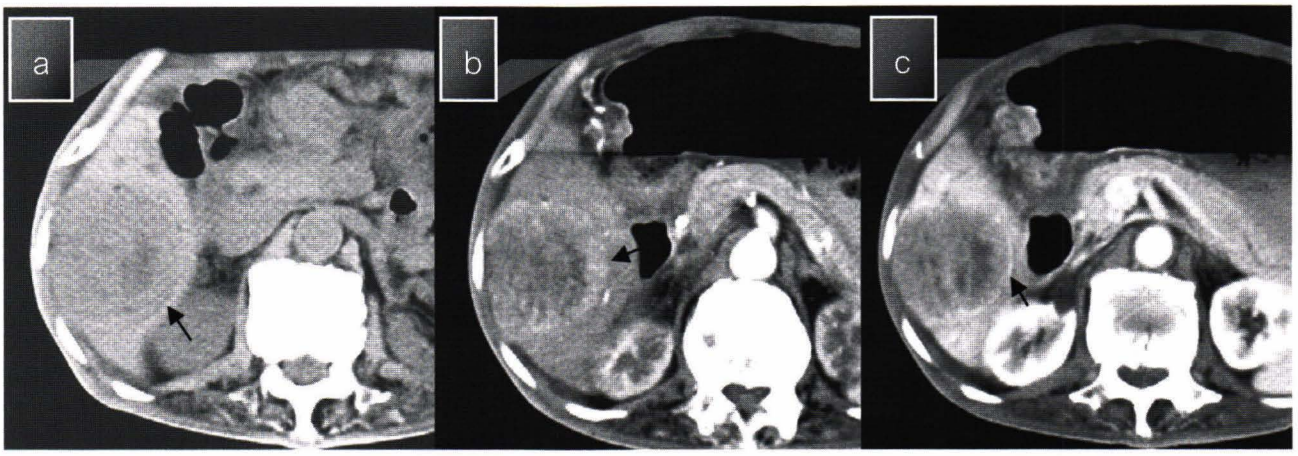


Figure 3. a) NECT, a right hepatic lobe HCC was judged to be heterogeneous hypoattenuation 1 with hypodense capsule (arrowed): b) HAP, the tumor was seen as heterogeneous hyperattenuation 2 with hypodense capsule (arrowed): c) PVP, the tumor shows contrast washout and became heterogeneous hypoattenuation 2: enhancing capsule was noted (arrowed).

Table 2. Enhancement patterns of 58 HCC.

	HCC Enhancement patterns		
	HAP	**PVP**	**%(n)**
Heterogeneous	Hyper	Hypo	47 (27)
	Hyper	Iso	5 (3)
	Hyper	Hyper	9 (5)
Homogeneous	Hyper	Hypo	9 (5)
	Hyper	Iso	3 (2)
Heterogeneous	Iso	Hypo	15 (9)
	Iso	Hyper	3 (2)
Homogeneous	Iso	Hypo	2 (1)
Heterogenous	Hypo	Iso	2 (1)
Homogeneous	Hypo	Hypo	5 (3)
Total			100 (58)

n= number of lesion, hyper= hyperattenuation, iso= isoattenuation, hypo=hypoattenuation

Table 3. Enhancement characteristics of 58 HCC.

	Enhancement characteristics of HCC		
Relative tumor attenuation	**Unenhanced phase %(n)**	**Hepatic arterial phase %(n)**	**Portal venous phase %(n)**
Hyperattenuation	5 (3)	72 (42)	17 (10)
Homogeneous	2 (1)	12 (7)	2 (1)
Heterogeneous	3 (2)	60 (35)	15 (9)
Isoattenuation	24 (14)	21 (12)	9 (5)
Homogeneous	7 (4)	2 (1)	4 (2)
Heterogeneous	17 (10)	19 (11)	5 (3)
Hypoattenuation	71 (41)	7 (4)	74 (43)
Homogeneous	9 (5)	5 (3)	14 (8)
Heterogeneous	62 (36)	2 (1)	60 (35)
Total	100 (58)	100 (58)	100 (58)

n = number of lesion

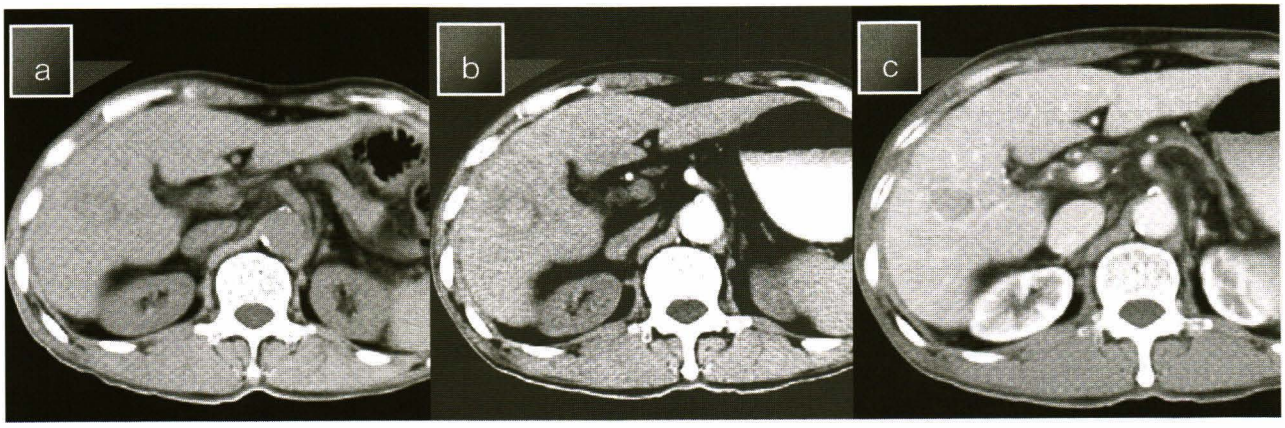


Figure 4. A 64-years-old male patient with history of alcoholic drinking: a) NECT, a small homogeneous isoattenuation HCC with hypodensity capsule was seen at the right hepatic lobe. Hepatic cirrhosis was also noted: b) HAP, the tumor was judged to be homogeneous hyperattenuation 1: c) PVP, the tumor revealed contrast washout and turned to be homogeneous hypoattenuation 2.: enhancing capsule was noted.

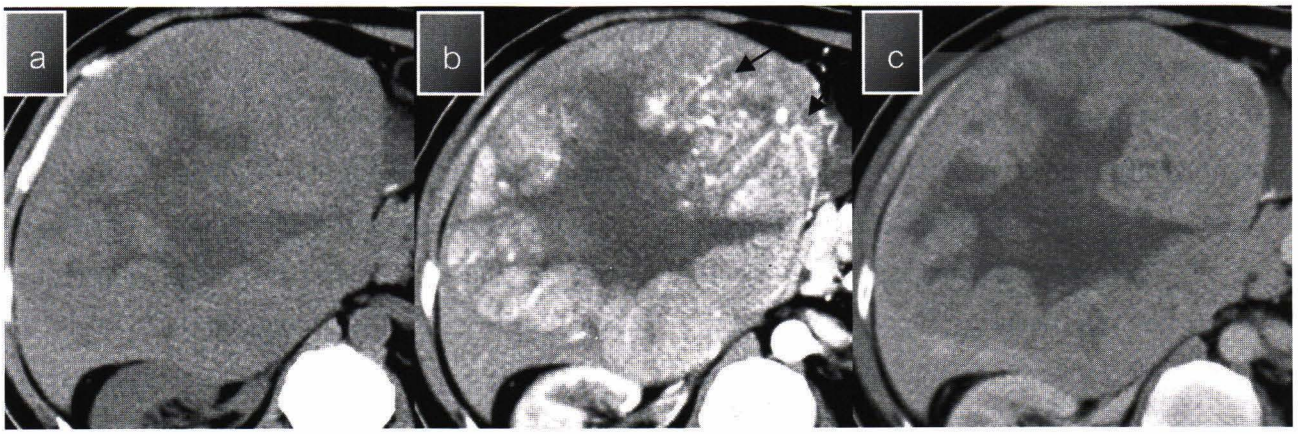


Figure 5. A case of hepatitis B viral infection with large HCC: a) NECT: a tumor was judged to be hypoattenuation 1 on subjective analysis. b) HAP: the tumor was judged to be heterogeneous hyperattenuation 2 with abnormal internal vessels (arrowed) and central necrosis. C) PVP: the tumor revealed contrast washout and became heterogeneous hypoattenuation 1.

Table 4. Frequency of CT appearances of HCC with respect to tumor size.

CT appearances of HCC	Tumor size % (n)		
	< 2 cm.	2-<5cm.	>=5cm.
	10 (6)	31 (18)	59 (34)
1. Heterogeneous appearance	4.3 (2)*	27.7 (13)*	68.1 (32)*
2. Homogeneous appearance	36.4 (4)	45.5 (5)	18.2 (2)
3. Contrast washout	11.1 (6)	31.5 (17)	57.4 (31)
4. Abnormal internal vessels	0 (0)*	11.1 (2)*	88.9 (16)*

n=number of lesion, *=percentages indicate statistically significant values ($p<0.05$)

Discussion

In this study, the enhancement pattern and appearance of HCC on triple-phase MDCT were presented. The enhancement pattern was characterized by density (hyper, iso or hypoattenuation relative to the liver parenchyma), spatial distribution of contrast material (homogeneous or heterogeneous appearance) and contrast washout on PVP.

The most frequent enhancement pattern of HCC was heterogeneous hyperattenuation on HAP and heterogeneous hypoattenuation on PVP, the same as Kim *et al.*[11] reported, using both single detector helical CT and MDCT. As in this study heterogeneous hyperattenuation on HAP (60%, 35 lesions) was also reported as a common feature of HCC on single detector helical CT by previous authors.[4,6] Almost all HCC revealed isoattenuation or hypoattenuation on NECT, similar to the study of Kim *et al.*[11] There was an association between heterogeneous appearance of HCC and tumor of large size. The same finding was reported by Steven *et al.*[3] who used single detector

helical CT. The heterogeneous appearance may reflect the presence of a viable tumor interspersed with necrosis, suggested by some previous authors.[12,13] This association may be applicable to tumors of large size which were more common to have necrosis.

On a single detector helical CT, 39% to 63% of HCC had hypervascular component on HAP.[4,6,7,9] In this study 72% (42 lesions) of HCC revealed hypervascular component on HAP which was higher than that of single detector helical CT. This difference could be explained by an ability of MDCT in rapid scanning through the liver. MDCT requires 5 to 10 sec. whereas a single detector CT requires approximately 20 sec to complete liver scanning. With this longer scanning times of single detector helical CT, the contrast material might had already been washed out from the lesion. Murakami *et al.*[10], using MDCT reported 81 to 89% hypervascular components of HCC, which was higher than that of the present study. This could simply be due to the fact that they used higher rate of contrast material injection, 5ml/sec. The rate of 3 ml/sec contrast injection was used in this study in order to avoid the potential complication of higher flow rate. Ninety-two percent (54 lesions) of HCC in this study showed contrast washout. In the study of Loyer *et al.*[9] using single detector helical CT scanner and slower injection rate, 2.5ml/sec, than the present study, found 67% contrast washout on PVP. This lower rate of contrast washout in PVP in their study could be due to the slower contrast injection rate that caused slower peak enhancement of the lesion and might lead to slower contrast washout (delayed phase contrast washout). No significant association between the contrast washout and the size of the tumor.

In the objective analysis, the mean attenuation coefficients of the HCC was 82 HU during the arterial phase whereas Loyer *et al.*[9] reported a 61 HU mean attenuation coefficients of HCC on HAP. The higher mean attenuation coefficients of HCC in this study was likely due to the more rapid image acquisition of MDCT. The mean attenuation coefficients of HCC on PVP was 86 HU which is approximately similar to that of Loyer *et al.*[9] 90 HU. Sixty-five percent (38 lesions) of HCC showed maximal attenuation on PVP but in subjective analysis 74% (43 lesions) of tumors appeared hypoattenuation on PVP. This discordance between the objective and subjective evaluations canbe explained. The subjective analysis evaluated the difference attenuation between the tumor and the liver parenchyma, the maximal attenuation of the tumor on PVP, but it is lower than that of the adjacent liver parenchyma. Therefore, the tumor appears to be hypoattenution.

The different attenuation between the tumor and the liver parenchyma was maximum during HAP while Loyer *et al.*[9] found the maximal difference during PVP. This difference was likely due to the faster image acquisition of MDCT and the higher rate of injection in the present study.

Abnormal internal vessels were seen in 31% (18 lesions) in this study which is slightly higher than 29% (9/31) vis-a'-vis that reported by Nino Murcia *et al.*[11] who was using single detector helical CT and higher rate of injection, 5ml/sec. This higher incidence of abnormal internal vessels in this study was due to a more rapid scanning time during HAP. There was association between abnormal internal vessels and tumors of large size

Regarding venous involvement, tumor capsules were not common, and calcification was rarely seen in this study. These were similar to the findings detected by single detector CT scanner. Steven *et al.*[3] using single detector helical CT, reported the prevalence of venous invasion, tumor capsule and calcification as 33%, 31% and 9%, respectively. Kim *et al.*[11] found the prevalence of portal vein thrombosis and tumor capsule 6% and 23%, respectively.

In some circumstances, lesion characterization rather than detection is critical. In the present study, the incidence of hypervascular tumor, contrast washout on PVP and abnormal internal vessels were found higher on the triple-phase MDCT than that which was run on single detector helical CT scanner. As these appearances are characteristics of HCC[3,4,6,7,9,10,14], the findings on triple-phase MDCT may help radiologists to establish their correct diagnosis in patients who are suspected of HCC.

The present study, however, contains some limitations. Firstly, it has small sample size which was due to the low incidence of the disease at the hospital. Secondly, pathologic correlation was not performed on every tumor mass. Even though CT findings were correlated with the elevation of serum alpha-fetoprotein more than 400 ng/ml and characteristic angiographic findings, the possibility of false positive results may still exist. However 73% of the patients in this group (15/35) had hepatitis B, C viral infection or cirrhosis which were all at risk of HCC. If the false positives did exist, they would be relatively small in number.

Conclusion

The most frequent enhancement pattern of HCC is heterogeneous hyperattenuation on HAP and it becomes heterogeneous hypoattenuation on PVP. The same findings were found on single detector helical CT scanner. But in this study, higher incidence of hypervascular HCC, contrast washout on PVP and abnormal internal vessels are evident. This could be so due to a more rapid, more optimal image acquisition on each phase of MDCT and also the higher injection rate of the contrast material. Therefore, triple-phase MDCT with the high injection rate of contrast material technique is recommended in patient who are suspected of HCC. There are statistical associations between heterogeneous appearance of HCC, abnormal internal vessels and the tumor size.

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