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ANDRZEJ DROP

Types and patterns of contrast enhancement of hepatic tumours (hepatoma, hemangioma and metastasis) with dynamic computed tomography

Sequential dynamic computed tomography of the liver, in conjunction with bolus intravascular administration of contrast medium, is useful in the diagnosis of liver diseases (1,2,5,7,9,12,13). Focal hepatic lesions have several distinct patterns on contrast-enhanced CT scans. When CT is performed within 2-3 minutes after administration of a bolus of contrast material, the lesion-to-liver contrast is improved. This technique furthermore permits the recognition of different patterns of tumour enhancement. The purpose of this study was to compare the appearances of hepatomas, hemangiomas and metastases on dynamic CT scans to determine the value of this technique in the differential diagnosis of the lesions.

MATERIAL AND METHODS

Sequential computed tomography of the liver was performed in 69 patients with histopathologic findings of hepatoma, 62 patients with hemangioma and 78 patients with proved 134 liver metastases. The size of tumour as measured on CT scan were 2 cm or less (59 lesions), 2-4 cm (76 lesions), or more than 4 cm (130 lesions) – Table 1.

All CT scanning was performed with a scanner somatom DRH (Siemens) by using a 2-second scanning time and a 6-second interscanning delay. Contiguous 8 mm sections were obtained, beginning at the diaphragm. Scanning began 30-40 seconds following the administration of the intravenous contrast material bolus. Each patient received a different dose of contrast medium, up to 125 ml of 60% uropolina.

Dynamic enhancement in HCC, hemangiomas and metastases was analysed during the (early) nonequilibrium phase (30-150s), and (delayed) equilibrium phase (2.5-7min) using the following classification of tumours: totally hyperdense, peripherally hyperdense, centrally hyperdense, mixed density, totally isodense and totally hypodense (according to H o n d a), 7.

Tab. 1. Number of tumours of each histologic type by tumour size

Histologic type	Tumor diameter (cm)			Total
	= 2	2 – 4	> 4	
Hepatoma	1	5	63	69
Hemangioma	6	14	42	62
Metastasis	52	57	25	134
Total	59	76	130	265

RESULTS

Table 2 shows the enhancement pattern of each of the tumours on the early and delayed –phase images. Among 17 tumours that appeared to be totally hyperdense in early phase , 10 (14%) were hepatomas (Fig. 1, 4). The 4 metastases that were totally hyperdense in the early phase were from sarcoma, melanoma, ca renis and leiomyosarcoma of the stomach. 49 (79%) of tumours that were peripherally hyperdense on the early phase images were hemangiomas (Fig. 3). Also 43 (32%) that were peripherally hyperdense in the early phase images were metastases. 14 (20%) hepatomas had mixed density in early phase images. Of the 131 tumours that appeared to be totally hypodense in the early phase 8 (13%) were hemangiomas , 40 (57%) were hepatomas and 83 (62%) were metastases.

Tab. 2. Enhancement pattern of each tumour on two phase images

Phase/Pattern	No. of findings %		
	Hepatomas n = 69	Hemangiomas n = 62	Metastases n = 134
Early (30-150 s)			
Totally hyperdense	10 (14)	3 (5)	4 (3)
Peripheraly hyperdense	4 (5)	49 (79)	43 (32)
Centraly hyperdense		2 (3)	4 (3)
Mixed density	14 (20)		
Totally isodense	3 (4)	8 (13)	
Totally hypodense	40 (57)		83 (62)
Delayed (2.5-7 min.)			
Totally hyperdense		17 (26)	
Peripheraly hyperdense		3 (6)	
Centraly hyperdense		1 (1)	
Mixed density			
Totally isodense	4 (6)	29 (47)	4 (3)
Totally hypodense	65 (94)	12 (20)	130 (97)

Of the 17 (26%) tumours that appeared to be totally hyperdense in the delayed phase were hemangiomas. In the 69 hepatomas total hypodensity was the most common pattern in the early phase, seen in 40 (57%) of 69 cases, followed by mixed density in 14 (20%), total isodensity in 3 (4%). In the delayed phase, total hypodensity was the most common pattern, seen in 65 cases (94%) (Fig. 2), followed by total isodensity in 4 (6%). No hepatoma appeared to have peripheral hyperdensity and total hyperdensity in the delayed phase.

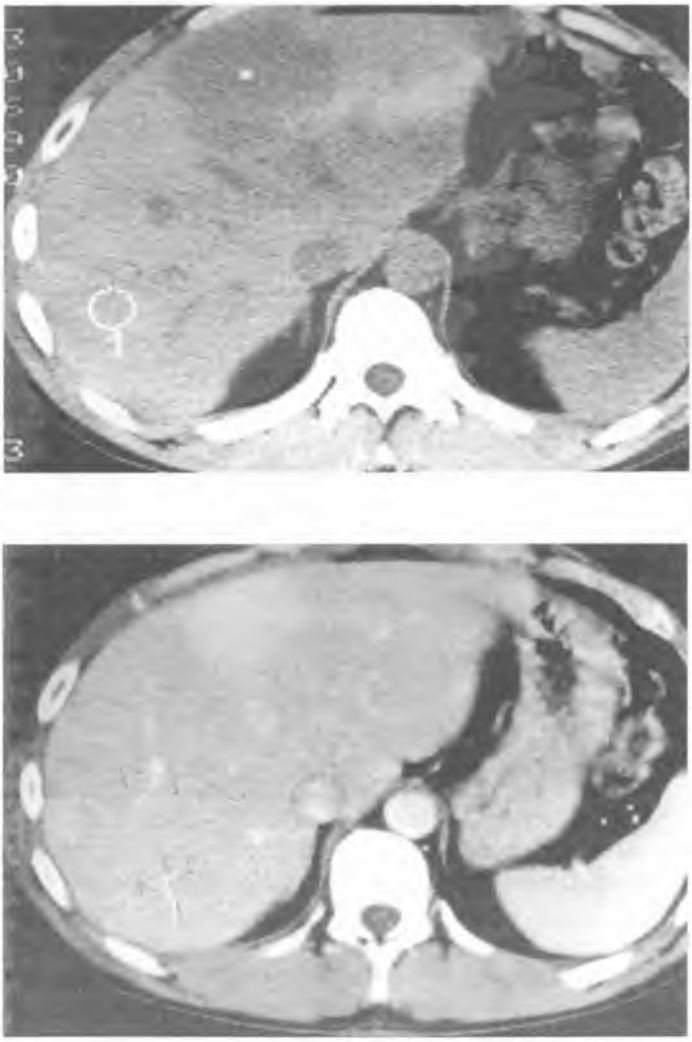

Fig. 1. 32-year-old man with hepatoma; A – non-contrast CT image scan shows 5 cm diameter hepatoma to be totally hypodense, B – early-phase dynamic CT scan shows hepatoma to be totally hyperdense

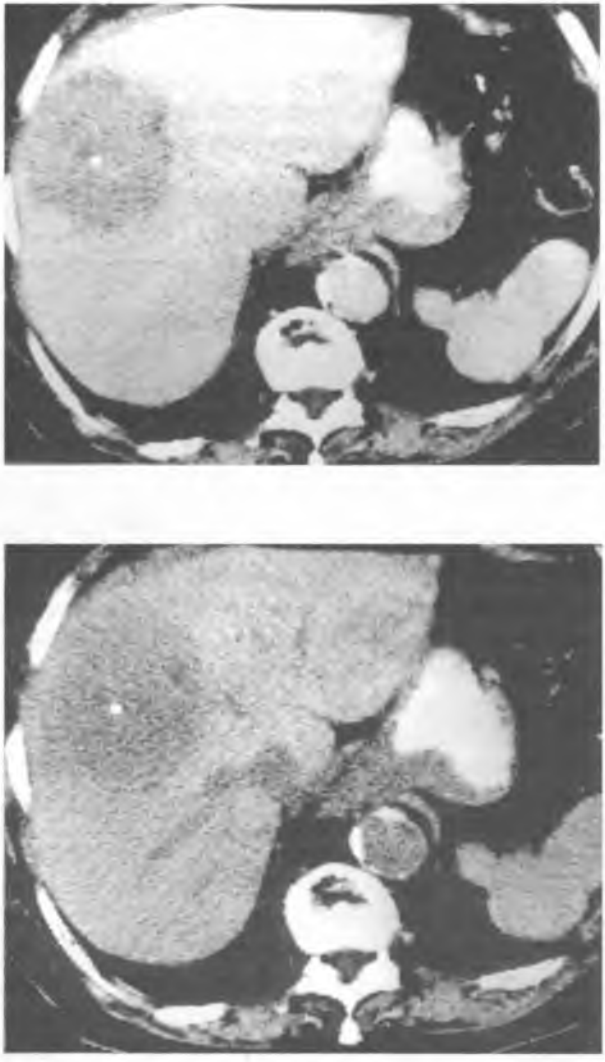

Fig. 2. 82-year-old woman with hepatoma; A and B – early-A and delayed-B-phase d-CT scan shows hepatoma 6 cm in diameter to be totally hypodense

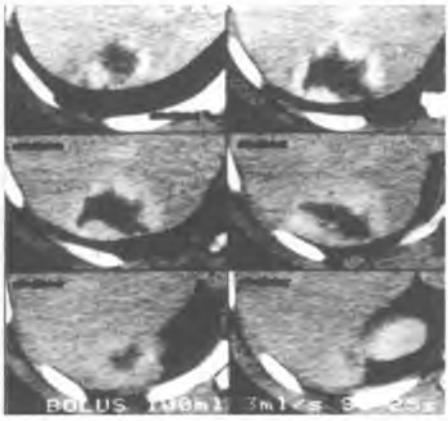

Fig. 3. 46-year-old man with hemangioma; multiscan-d-CT shows hemangioma to be totally peripherally hyperdense in early phase and totally hyperdense in delayed phase

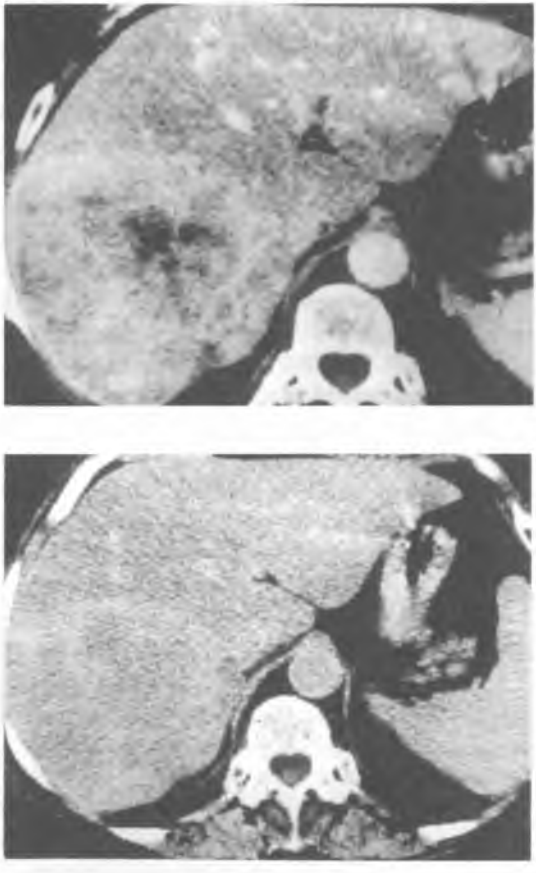

Fig. 4. 73-year-old woman with hepatoma; A – early phase d-CT scan shows hepatoma 7 cm in diameter to be totally hyperdense (necrosis in the centrum), B – delayed phase d-CT scan shows tumour to be totally isodense. In scan only hyperdense fibrous capsules are visible

In the 71 hemangiomas, peripheral hyperdensity was the most common pattern in the early phase, seen in 49 (79%) of 71 cases, followed by total hypodensity in 8 (13%), central hyperdensity in 2 (3%), total hyperdensity in 3 (5%). In the delayed phase, total isodensity was the most common pattern, seen in 29 (47%) of 71 hemangiomas, followed by total hyperdensity in 17 (26%), peripheral hyperdensity in 3 (6%) and total hypodensity in 12 (20%).

In the 134 metastases total hypodensity was the most common pattern in the early phase, seen in 83 (62%) of 134 cases, followed by peripheral hyperdensity in 43 (32%), total hyperdensity in 4 (3%), mixed density in 4 (3%). No metastases had central hyperdensity in the early phase. In the delayed phase, total hypodensity was the most common pattern, seen in 130 (97%), total isodensity in 4 (3%). No metastases showed total hyperdensity on delayed phase. Although total hypodensity in both phases was the most common appearance of metastases, hepatomas also had that pattern in both phases.

DISCUSSION

For the detection of focal hepatic lesions, the goal of intravenous contrast medium administration is to widen the difference in attenuation values between tumour and normal hepatic parenchyma. Several studies have shown the peak hepatic enhancement increases with increased volume of contrast material or rate of injection (1, 3, 4, 6, 7, 8, 10, 11). One prominent theory asserts that optimal detection of lesion depends on completion of liver scanning before "equilibrium"(1, 11). Many authors exhibit that most liver hypervascular lesions include some examples of hepatocellular (hepatoma) renal cell, thyroid, carcinoid, melanoma, some forms of sarcoma, and other less common lesions that should be examined before equilibrium phase (1, 12, 13). These metastases are detected better in the arterial phase and are usually obscured in the portal phase. On the other hand, hypovascular metastases which represent the majority of liver metastases, are detected better in the portal phase.

The ability of CT contrast technique to show hepatic tumours is enhanced by the dual blood supply of the liver. The liver is different from all other abdominal organs because of its dual blood supply. The hepatic artery delivers 20-25% of blood flow to the liver, and the portal vein delivers 75-80% (1).This and the fact that most tumours of the liver have only a hepatic arterial blood supply and receive little or no flow from the portal vein, are the key physiological parameters that make contrast-enhanced CT so successful in detecting tumours. This pattern is well seen on dynamic incremental CT and delayed-phase CT scans of hepatomas. On the early-phase images in our study, 14% of hepatomas enhanced totally and 25% enhanced partially. In the delayed phase, 94% were less dense than the surrounding hepatic parenchyma. These results are similar to a study performed by Honda et al., Ohashi et al. (6, 7, 11). Early hepatomas are also small with mean diameters shorter than 2cm and usually hypovascular – Choi (3). In encapsulated hepatomas prolonged enhancement of the capsule occurs. Attenuation is higher than that of the liver 3 min. after injection of the bolus (Fig. 4). Hepatic hemangiomas are best distinguished from other solid hepatic masses by administering contrast material and by performing dynamic CT scanning with delayed scan at 1- 4 min (4, 7, 10, 14, 15). Our results show that the peripherally hyperdense pattern was seen in the early phase in 79% of hemangiomas. The high percentage 47 % of hemangiomas were totally isodense in the delayed phase. The lower density of the tumour relative to the surrounding hepatic parenchyma in both phases strongly suggests that such a tumour is not a hemangioma.

Most secondary tumours of the liver are hypovascular. Among the primary neoplasms that tend

to give rise to hypervascular metastases are carcinoids: leiomyosarcomas, choriocarcinomas and carcinomas of renal, thyroid, adrenal and pancreatic islet cell origins (12, 13).

Some metastatic melanomas and occasional metastases from carcinomas of the colon and breast are also hypervascular. In the study, the metastases from leiomyosarcoma, renal carcinoma had totally hyperdense pattern on early phase similar to those of hepatomas. In the study 32% metastases were peripherally hyperdense in early phase images and 97% had totally hypodense pattern on delayed phase images. These results are similar to a study performed by H o n d a et al.(7).

One of the common patterns of metastases identified with CT after a bolus injection of contrast material is a rim of contrast enhancement around a less dense central zone. This reportedly occurs in 29- 35% of these lesions (6,7,13). In our study, rim enhancement was seen as peripheral hyperdensity in early phase with similar frequency (32%).

To sum up: a lesion that is totally hyperdense or totally isodense on early phase images and totally isodense and hypodense on delayed-phase images is almost always a hepatoma. Even if a lesion shows peripheral hyperdensity in the early phase, total hypodensity in the delayed-phase can be a sign that the lesion is not a hemangioma. The conclusion is that although bolus injection with incremental CT scanning is known to be useful for the quantitative diagnosis and detection of hepatic tumours, subsequent delayed-phase images are helpful in the differential diagnosis of hepatic tumours.

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SUMMARY

Dynamic sequential computed tomography (d-CT) of the liver was performed in 69 patients with histopathologic findings of hepatoma (HCC), 62 patients with hemangioma and in 78 patients with proved 134 liver metastases. Dynamic enhancement in hepatoma, hemangioma and metastases was analysed during the nonequilibrium phase (30–150s) and delayed equilibrium phase (2,5–7min) using the following classification of tumour: totally hyperdense, centrally hyperdense, mixed density, totally isodense and totally hypodense. In the early examination phase 14 (19%) HCC were totally hyperdense or peripherally hyperdense, and 40 (57%) HCC were totally hypodense. In the early phase 49 (79%) hemangiomas were peripherally hyperdense. In the early nonequilibrium examination phase 62% metastases were hypodense. In the delayed phase 94% HCC were totally hypodense. Hemangiomas in the delayed phase were totally hyperdense and totally isodense (17/29). In the equilibrium examination phase 97% metastases were hypodense. The contrast enhancement pattern of hepatomas, hemangiomas and metastases seen in dynamic CT scanning is useful in diagnosis of these tumours.

Typy i charakter wzmocnienia kontrastowego guzów wątroby (raka wątrobowo-komórkowego, naczyniaka i przerzutów) w dynamicznej tomografii komputerowej

Dynamiczną sekwencyjną tomografię komputerową (d-TK) wykonano u 69 chorych z potwierdzonym hist.-patol. rakiem wątrobowo-komórkowym, u 62 pacjentów z rozpoznanym naczyniakiem wątroby oraz u 78 pacjentów, u których stwierdzono 134 ogniska przerzutowe w wątrobie. Dynamikę wzmocnienia w tych zmianach ogniskowych analizowano w fazie wczesnej nierównowagi (30-150 s) i późnej równowagi (2,5-7 min.), posługując się następującą klasyfikacją wzmocnienia guza: całkowicie hiperdensyjny, brzeżnie hiperdensyjny, centralnie hiperdensyjny, mieszany, całkowicie izodensyjny, całkowicie hipodensyjny. We wczesnej fazie badania 14 (19%) raków było całkowicie lub brzeżnie hiperdensyjnych i 40 (57%) było całkowicie hipodensyjnych. We wczesnej fazie badania 49 (79%) naczyniaków było brzeżnie hiperdensyjnych i 62% przerzutów było całkowicie hipodensyjnych. W fazie późnej badania 94% raków wątrobowo-komórkowych było całkowicie hipodensyjne. Naczyniaki w późnej fazie badania były całkowicie hiperdensyjne i całkowicie izodensyjne (17/29). W późnej fazie badania 97% przerzutów było całkowicie hipodensyjnych. Kontrastowy wzór wzmocnienia raka wątrobowo-komórkowego, naczyniaka i przerzutów do wątroby, widoczny w d-TK, jest użyteczny w różnicowaniu tych guzów.