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Differentiation of Malignant from Benign Portal Vein Thrombi on CT Images Using Thrombus Density

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Abstract

Background: Portal vein thrombosis described as the presence of a clot in the portal vein lumen or a permanent obliteration of the portal vein as a result of prior thrombosis with replacement by numerous tortuous venous channels (termed cavernoma). Malignant portal vein thrombus, so named for its neoplastic origin, is a common complication of HCC, and, in some cases, it may be even the initial sign of an undetected HCC. Detection of malignant PVT in a patient with liver cirrhosis heavily affects the therapeutic strategy.

Aim of Study: The purpose of this study was to investigate the role of CT thrombus density (measured in Hounsfield Units) in distinguishing between neoplastic and bland portal vein thrombosis on arterial and portal venous phases.

Material and Methods: In this study, 30 patients underwent contrast-enhanced CT of abdomen & pelvis were included for characterization of portal vein thrombosis. Assessment of portal vein thrombosis was performed by measuring of CT attenuation values of the thrombi in Hounsfield Units (HU).

ROC (Receiver Operating Characteristic) curves were used to identify accuracy and optimal cutoff values.

Results: Of the 30 CT studies, 14 neoplastic thrombi and 13 bland thrombi were identified on the images. CT thrombus density (measured in Housinfield Unit) to differentiate neoplastic from bland thrombus. The AUCs was 0.98 in arterial phase and 0.98 in portovenous phase for thrombus density.

The optimal cut off in arterial phase is 47 and in portovenous phase is 50.

Conclusion: CT attenuation values allow reliable differentiation between neoplastic and bland thrombi on arterial and portal venous phase CT examination.

Key Words: *Triphasic CT – PVT – CT density.*

Introduction

LOCAL factors that precipitate thrombosis in the portal venous system in patients who are in a state of thrombophilia can be classified into three categories. The first category includes conditions that cause PVT due to local inflammation and infection [1].

A second category of local factors includes blunt trauma and surgical procedures that cause injury to the portal venous system. Generally these do not precipitate PVT unless there is an associated prothrombotic state or portal hypertension. The last and most important group of conditions that cause PVT is neoplastic disease [2].

Neoplastic thrombus of the portal vein is found in 6.5%-44% of patients with Hepatocellular Carcinoma (HCC). Presence of neoplastic thrombus serves as an important determinant of tumor staging, as well as prognosis, and influences treatment selection. HCC invasion into the portal vein renders a patient unsuitable for aggressive treatment approaches such as surgical resection, orthotopic liver transplantation, or chemoembolization, due the unusually high incidence of tumor recurrence and dismal survival associated with this finding [3].

The findings of PVT of the dynamic CT are filling defect partially or totally occluding the vessel lumen and rim enhancement of the vessel wall, sometimes with extension into splenic or superior mesenteric veins. Unenhanced scans have been shown to be of minimal benefit in the identification of thrombus [4].

Indirect signs of PVT are the presence of portosystemic collateral vessels, cavernous transformation of the portal vein, and arterioportal shunts [5].

Malignant and benign thrombi can often be differentiated by radiologists on the basis of CT imaging characteristics [6].

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CT radiological findings of tumor thrombus suggesting malignancy are: Dilatation of portal vein, intra thrombus neovascularity arterial enhancement in CT. Thread and streak sign multiple enhancing intraluminal smaller vessels that can be seen at arterial phase imaging. Contiguity to tumor often with direct invasion [7].

CT density: Mean thrombus density values can distinguish neoplastic and bland thrombi by measuring thrombus density (in Hounsfield Unit) in arterial and portal venous phase [8].

Subjects and Methods

This study was approved by Radiology Department at Menofiya University between period from December 2016 to December 2017.

In this study, we included all patients who underwent a contrast-enhanced CT examination of the abdomen and pelvis in the arterial and portal venous phases and for whom PVT was noted on the radiology reports. We excluded patients who did not undergo a contrast-enhanced portal venous phase CT examination, those without clinical or medical data for confirmation or follow-up examination regarding the nature of the thrombus.

CT Technique:

All the patients included in the study underwent contrast-enhanced (CECT) of the abdomen and pelvis. The studies were performed in the arterial and portal venous phase and were acquired at 20 & 80 seconds after administration of IV contrast material. A total of 80-120mL of nonionic iodinated contrast material (300mgI/mL) was injected IV at 3mL/s for all patients. The scanning protocols and parameters included slice thickness of 5mm, weight-based tube potential (100-120kVp), automatic tube current modulation (75-500mA), and 0.5-second gantry rotation time. All the patients had multiplanar reformations in the coronal and sagittal plane with 3-mm thickness.

Results

This study was carried out on 30 patients presented to the Radiology Department at Menofiya University diagnosed to have portal vein thrombosis by triphasic CT.

All patients with malignant PVT showed enhancement of the thrombus in arterial phase, while all patients with benign PVT and cavernous transformation showed no enhancement (Table 1).

15% of patients with benign PVT had collaterals, 28.5% of patients with malignant PVT had collaterals and 100% of patients with chronic thrombus with cavernous transformation were found to have collaterals (Table 1).

There is 50% of patients with malignant PVT were found to have an AP shunt. Non of patients with benign thrombi had an AP shunt (Table 1).

Table (1): Comparison between benign, malignant PVT & cavernous transformation.

	Benign (13)		Malignant (14)		Cavernous transformation (3)		*p*-value
	No.	%	No.	%	No.	%	
Cirrhosis:							
Yes	11	84	14	100	3	100	0.41
No	3	16	0	0.0	0	0.0	
HCC:							
Yes	6	46.0	14	100	1	33	0.04
No	7	54.0	0	0.0	2	67	
Embolization:							
Yes	4	30	2	14	0	0	0.54
No	9	70	12	86	3	100.0	
Ablation:							
Yes	2	15	1	7	1	33	0.46
No	11	85	13	93	2	67	
High AFP:							
Yes	6	46	14	100	0	0	0.015
No	7	54	0	0.0	3	100	
Dilated caliber	5	38	6	42	0	0	0.94
	8	62	8	58	3	100	
Enhancement	0	0	14	100	0	0	
Collaterals:							
Yes	2	15	4	28	3	100	0.65
No	11	85	10	72	0	0.0	
AP shunt:							
Yes	0	0	7	50	0	0	0.04
No	13	100	7	50	3	100	
Ascitis:							
Yes	2	15	6	42	1	33	0.29
No	11	85	8	58	2	67	
Tumor invasion	0	0	14	100	0	0	

Out of 30 patients, 27 (13 cases) with benign portal vein thrombus, (14 cases) with malignant thrombus and the following study is detected:

Sensitivity of thrombus density in the pre-contrast phase is 53%, specificity 50% and accuracy 50%, sensitivity of thrombus density in arterial phase is 100%, specificity 93% and accuracy 100%, sensitivity of thrombus density in the porto-venous phase is 100%, specificity 93% and accuracy 100%. The best cut off in pre-contrast phase is 25.5, in arterial phase is 47 and in porto-venous phase is 50 (Table 2).

Table (2): Sensitivity and specificity of HU in detection nature of thrombus.

	AUC	Best cut off (HU)	Sensitivity	Specificity	PPV	NPV	Accuracy
Density thrombus pre-contrast	0.552	25.5	53%	50%	65%	54%	50%
Density thrombus arterial	0.981	47	100%	93%	100%	100%	100%
Density thrombus porto-venous	0.981	50	100%	93%	100%	100%	100%

*: AUC (Area Under Curve) is significant if more than 0.7.

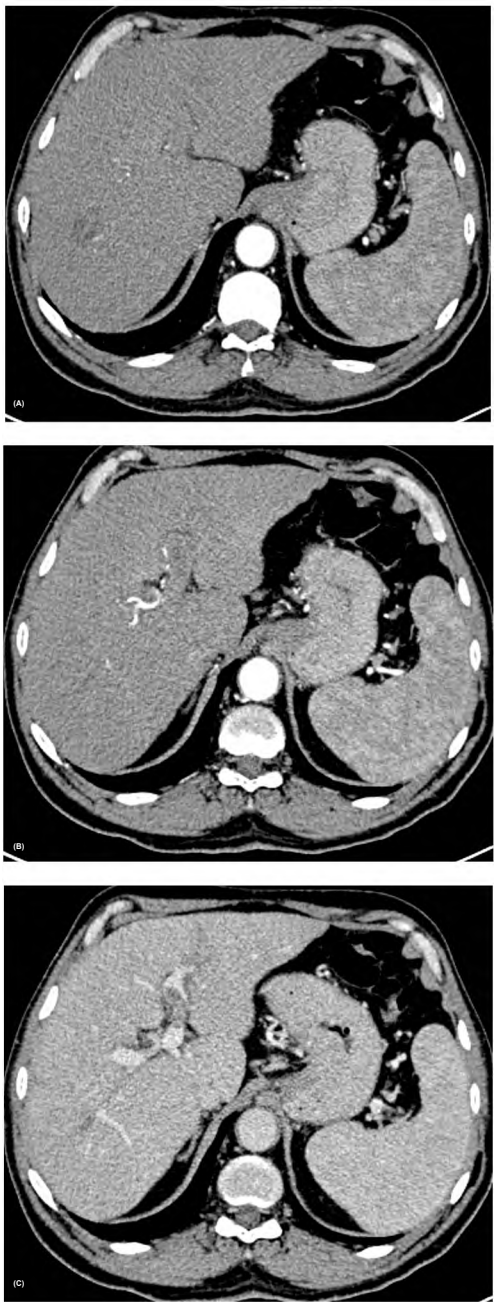

Fig. (1): Male patient 64 years old presented with disturbed liver functions, hypodense lesion in segement VII in precontrast phase shows no arterial enhancement or washout in delayed phases. Adequately ablated HCC Fig. (1A). Hypodense non enhanced thrombus (30HU) in left main portal vein in arterial (33HU) Fig. (1B) and portovenous phases (39HU) Fig. (1C).

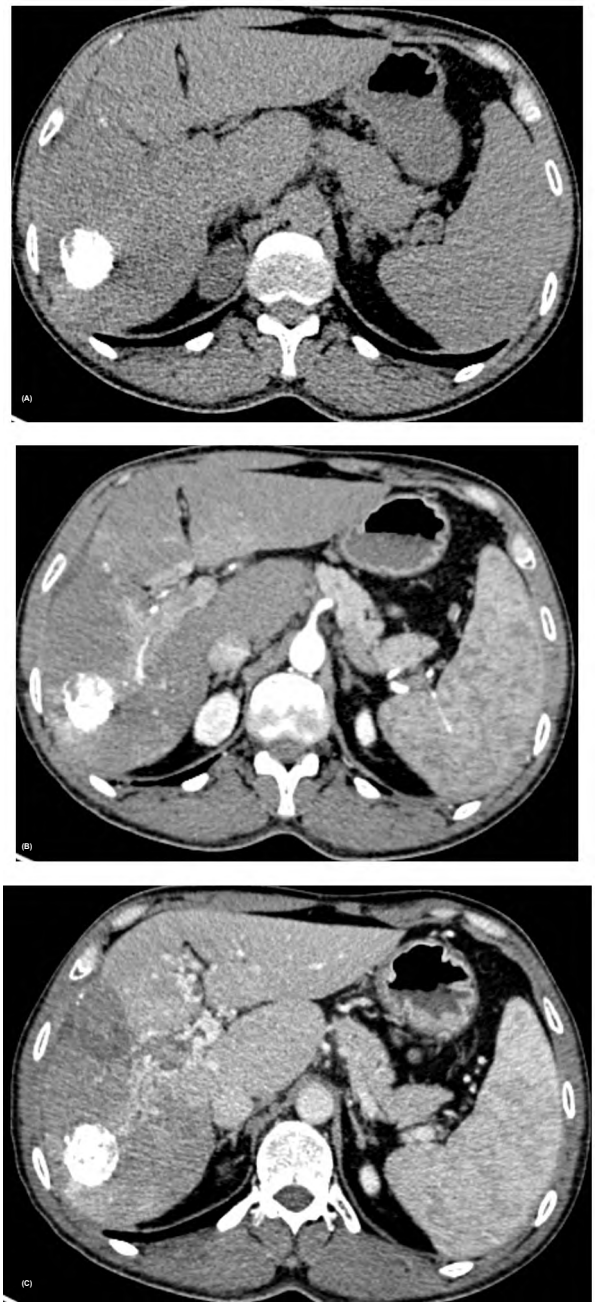

Fig. (2): Male patient 65 years old had history of HCC and he underwent symptoms, right lobe arterially enhancing hepatic focal lesion inadequately managed by TACE (transarterial chemoembolization) with lipidol uptake Fig. (2A). Right main portal vein is distended by a thrombus which is isodense in precontrast phase (33HU) and shows arterial enhancement (74HU) Fig. (2B) and washout in portovenous phase (84) Fig. (2C).

Discussion

Dynamic contrast enhanced CT is the best means of diagnosis of PVT and evaluation of various causative diseases **[9]**.

In the current study, all patients with malignant PVT (100%) showed enhancement of the thrombus in arterial phase and washout in portovenous phase while all patients with benign PVT and cavernous transformation showed no enhancement, our results in agreement with the study of Osman **[10]** they found that on tri-phasic CT of the 33 patients with malignant PVT, 28 (84.8%) patients showed neovascularity of PVT, early arterial enhancement and rapid washout of the thrombus (29/33) (87.8%) and none of the 17 patients with benign PVT showed intrathrombus neovascularity or enhancement.

In our study, sensitivity of thrombus density in pre-contrast phase 53%, specificity 50% and accuracy 50%, sensitivity of thrombus density in arterial phase 100%, specificity 93% and accuracy 100%, sensitivity of thrombus density in porto-venous phase 100%, specificity 93% and accuracy 100%. The best cut off value to diagnose malignant thrombus in arterial phase is 47HU and in porto-venous phase is 50HU. AUC is more than 0.7 in arterial and poto-venous phases (significant) but in pre-contrast phase is less than 0.7 so this phase is non-significant in differentiating between benign and malignant and this match with the study of Canellas **[11]** mean thrombus density values could also reliably distinguish neoplastic (81 .39HU) and bland (32.88HU) thrombi. The optimal cutoffs values were 54HU for thrombus density in porto venous phase. This match with our study to diagnose malignant thrombus as optimal cut offs value by HU in porto-venous phase similar.

Conclusion:

CT attenuation values allow reliable differentiation between neoplastic and bland thrombi on arterial and portal venous phase CT examination.

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التفريق بين خثرة الوريد البا بى الحميدة والخبيثة عن طريق الآشعة المقطعية بإستخدام كثافة الخثرة

تخثر الوريد البابى دل على وجود جلطة فى تجويف الوريد البابى آو إستبدال تجويف الوريد بالعديد من الآوردة المتعرجة نتيجة لتجلط الدم المسبق (وهو ما يسمى ورم كهفى). يمكن آن يكون موجودا فى داخل الكبد و/آو المساحات الوريدية خارج الكبد.

تشكيل خثرة الوريد البابى غالبا ما يكون متعدد العوامل، وفى ٧٠٪ من الحالات يتم العثور على سبب التخثر العام آو مزيج من الإضطرابات المؤيدة الجلطة (مرض الدم الخبيث، آهبة التخثر). فى ٣٠٪ من الحالات يتم العثور على سبب العلاج الموضعى (تليف الكبد، وإلتهاب العلاج الموضعى والعدوى، والجراحة الموضعية). فى بعض الآحيان لا يتم التعرف على السبب، ويعتبر تجلط الدم نتيجة مجهول السبب.

تخثر الوريد البابى الخبيث هو عرض شائع من سرطان الكبد، وفى بعض الحالات، قد يكون حتى العلامة الآولى لسرطان الخلايا الكبدية التى لم يتم كشفها. الكشف عن تخثر الوريد البابى الخبيث فى مرضى يعانون من تليف الكبد يؤثر بشكل كبير على إستراتيجية العلاج.

الموجات فوق الصوتية التقليدية بشكل عام، هى آول تقنية تستخدم فى المرضى الذين يعانون من آمراض الكبد للكشف عن الخثار الوريدى. ومع ذلك، قدرتها على تميز بين الخثرة الخبيثة آو الحميدة محدود. التصوير المقطعى والتصوير بالرنين المغناطيسى هى الخطوات القادمة المعتادة وتكون فعالة فى الكشف عن وجود تخثر وريدى.

تبقى الآشعة المقطعية الوسيلة الرئيسية لتوصيف تخثر الوريد البابى، ويرسخ المعايير الواضحة للتمييز بين الجلطة الدموية الخبيثة والحميدة بإستخدام التصوير المقطعى.

تم العثور على الآورام متخثرة فى الوريد البابى فى ٦.٥٪–٤٤٪ من المرضى الذين يعانون من سرطان الكبد. فإنة يجعل المريض غيير صالح للنهج العلاجية العدوانية، مثل الإستئصال الجراحى آو الحقن الشريانى، ويرجع ذلك إلى إرتفاع معدل الورم. تحدث الجلطة الحميدة فى المرضى الذين يعانون من آمراض الكبد المزمنة والمرضى الذين يعانون من سرطان الكبد. يمكن حلها بمضادات التخثر. التمييز بين الخثرة الحميدة والخبيثة ذو آهمية كبيرة لتحديد الطريقة العلاجية، وتوقع البقاء على قيد الحياة، وتقييم المرشحين لزرع الكبد.