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MDCT Angiography Criteria for Arteries Invasion in Patients with Pancreatic Head Carcinoma

ABSTRACT

Surgery is the first choice in treatment of malignant pancreatic head tumor. However, it is very important to determine the stage accurately. Incorrect staging leads to unnecessary and useless surgery. Multi-detector computed tomography used to rule out vascular invasion of artery and veins. This helps in taking the right surgical decision. The aim of this prospective cohort study was to determine the criteria of vascular invasion of arteries to avoid unnecessary surgery.

Patients were sent to the department of radiology to evaluate pancreatic head neoplasm with multi-detector 64 slice between 2016 and 2019. Criteria of arterial invasion with sensitivity of 86% and specificity 95% are: firstly, surrounding more than 180 degrees. Secondly, changing the diameter of the artery or irregularity of the wall, whatever the degree of surrounding. Finally, tumor longitudinal contact with artery (10 mm to 15 mm).

Keywords: MDCT; Invasion; Arteries; Pancreatic Head Neoplasm.

Abbreviations: EUS: Endoscopic Ultrasound; MDCT: Multi-Detector Computed Tomography; MIP: Maximum Intensity Projection; PDAC: Pancreatic Ductal Adenocarcinoma; R0: Negative Microscopic Residual; SMA: Superior Mesenteric Artery; VR: Volume Rendering .

INTRODUCTION

Pancreas cancer is the ninth most common cancer in women, and the tenth in men [1]. Its global incidence is 8-12 per 100,000 persons per year. 75% of pancreas cancers are in head and neck, 15% to 20% in body, and 5% to 10% in tail [2]. Ductal adenocarcinoma forms 90% of pancreas tumors [3]. Age of diagnosis is 69 years for white people and 65 for blacks. It is rare to be diagnosed before age of 45 in the absence of induced factors such as family history of pancreatic cancer and chronic pancreatitis. The pancreas cancer is a highly lethal malignancy; survival rate is 4-6 months in general; and it is 28% and 7% of patients for one and 5 years respectively [4]. Whipple surgery is the first-line treatment. Factors for long survival after surgery are: tumor largest diameter less than 3 cm with R0 pathology margins, and no metastatic lymph nodes. Only 20% of patients end with successful surgery and the expected survival for five years is 15% to 20% [4,5]. However, 80% of patients cannot have surgery at diagnosis because of the local extension or distant metastases which often be hepatic metastases or metastatic lymph nodes around

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the aorta [2]. It is easy to measure tumor size, but it is hard to determine the vascular invasion and peritoneal implants [6]. The most important question is the ability of curable surgical resection without microscopic residual of tumor in pathological margins. Tumor stage should be determined accurately, as incorrect staging leads to unnecessary surgery [6]. Non-invasive procedures (such as abdominal sonography, magnetic resonance imaging, and computed tomography) are used. Others are invasive such as preoperative and intra-operative endoscopic ultrasound (EUS) [7]. Multi-detector computed tomography (MDCT) is the best method to evaluate vascular invasion and determine the stage of tumor [8]. It is important to determine the inability of surgical removal with high specificity even if sensitivity is low. The incidence of complications after surgery might reach 40% and death rate in the best centers reaches 2.5% and in other centers 5% [9]. The superior mesenteric artery is a major artery related to pancreas head tumor then the celiac and the common hepatic artery [10]. Most of the invasion cases are easy to be detected depending on axial imaging and the importance of vascular imaging MDCT comes from using volume rendering and Maximum intensity projection (MIP) with longitudinal and coronal images to study the vascular map.

MATERIALS AND METHODS

This prospective cohort study took place in Al-Assad University Hospital Radiology Department. Patients were accepted to evaluate the malignant pancreatic head tumor between 1/9/2016 and 1/6/2019 64 MDCT (Philips) was used as follows: Patient drank 500 ml of water 20-30 minutes pre-imaging, then 250 ml immediately before imaging. The accurate time of appropriate phases is determined by the degree of enhancement measured in the reference point, which is the origin of the celiac trunk of the abdominal aorta. This point is evaluated every three seconds with low radiation dose (50-75) milliamps when Hounsfield increases to 180 unit imaging is began, the first phase with 15 seconds delay and the second with 25 second delay from the time of reference point reached the 180 Hounsfield [11].

All patients were injected with 100 ml or less of the OMINPAQUE with a concentration of 350 mg per ml at a rate of 3 ml per second with an automatic injector. All patients were suspected to have malignant pancreatic head tumor or tumor were diagnosed by other methods.

Exclusion criteria: Patients who underwent therapeutic surgery for pancreatic head tumor, patients who had investigative laparoscopic surgery, patients with renal insufficiency or allergy to contrast material, and Indoor phobia patients (inability to complete imaging). Images were obtained in 0.9 mm millimeter sections.

Work in the processing unit: Axial millimeter sections are used to obtain 2D and 3D reformatting images using Multi-Planar Reformatting (MPR) Reformation (CPR Curved Planar Reconstruction) and, VR (Volume Rendering).

The following factors have been studied to assess arterial infiltration:

1. Dirty fat plan between artery and tumor.
2. Clear fat plan between artery and tumor.
3. Abutment (<180° circumference contact) of the artery by tumor.
4. Encasement (>180° circumference contact) of the artery by tumor
5. Deformity of the artery or change of artery diameter
6. Tumor Longitudinal contact more than 10 mm to 15 mm **(Figure 1)**.

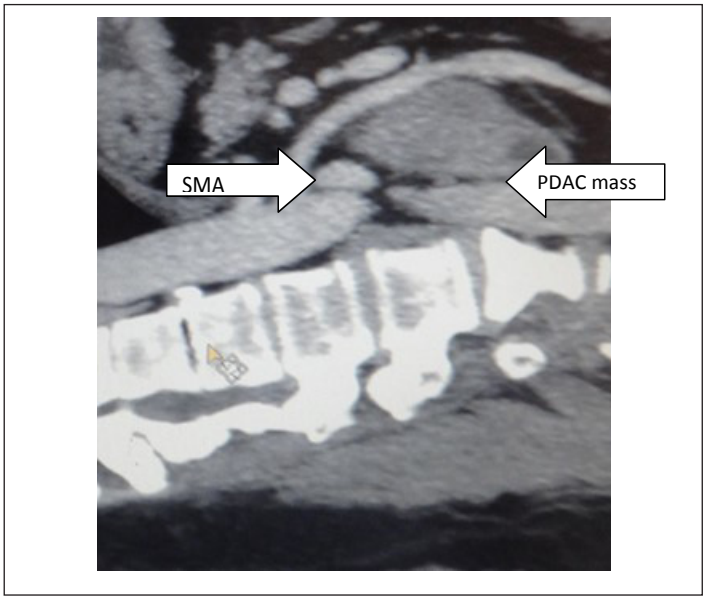

Figure 1: MIP and CRP reconstruction of SMA shows abutment of PDAC with longitudinal. Contact more than 15 mm.

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RESULTS

MDCT was performed with contrast for 85 patients. 40 patients not had surgery due to: distant metastases (liver ovarian, lungs, and peritoneal implants seen with MDCT and abdominal ascites). Inflammatory findings consistent with acute pancreatitis in three patients, two patients refused surgery, four patients cannot be followed 45 patients underwent Whipple, but three of them did not have Whipple due to:

1. Inflammatory lesions infiltrating the head of the pancreas from a pseudo cyst with old inflammation
2. Infiltration from a nearby kidney tumor
3. Patient with hepatic metastases

However, 29 patients did not have Whipple because of vascular infiltration and 20 for arterial invasion. Whipple operation was performed for 16 patients, 14 patients of them had negative surgical margins R0, and two patients had positive surgical margins uncinate process medial aspect.

Tables 1-3 summarize results of the arterial study compared to the results of pathological anatomy:

Table 1: Arteries invasion with MDCT criteria.

MDCT Criteria	NO INVASION (43) artery	INVASION (22) artery
Patient number	N	N
Clear fat plan	18	0
Dirty fat plan	8	1
Abutment of artery	14	4
Encasement of artery	3	17
Irregularity the artery or change the diameter of the artery.	3	18
Tumor Longitudinal contact more than 10 mm to 15 mm.	17	20

Table 2: Statistical analysis of MDCT criteria of cohort study.

MDCT Criteria	Sensitivity	Specificity	Accuracy	NPV	PPV
Clear fat plan	0%	58.1%	38.5%	53.2%	0%
Dirty fat plan	4.5%	81.4%	55.4%	62.5%	11.1%
Abutment of artery	18.2%	67.4%	50.8%	61.7%	22.2%
Encasement of artery	77.3%	93%	87.7%	88.9%	85%
Irregularity of artery or change the diameter of the artery.	81.8%	93%	89.2%	90.9%	85.7%
Tumor Longitudinal contact more than 10 mm to 15 mm.	90.9%	60.5%	70.8%	92.9%	54.1%
Abutment of artery with Tumor Longitudinal contact more than 10 mm to 15 mm.	18.2%	86%	63.1%	67.3%	40%
Encasement of artery with Tumor Longitudinal contact more than 10 mm to 15 mm.	68.2%	93%	84.6%	85.1%	83.3%

Table 3: Multivariate analyses of criteria for histological arterial invasion in the training cohort.

MDCT Criteria	INVASION 22		NO INVASION 43		*P* VALUE
Clear fat plan	**0**	**0%**	**18**	**41.9%**	**<0.001**
Dirty fat plan	1	4.5%	8	18.6%	0.12
Abutment of artery	4	18.2%	14	32.6%	0.22
Encasement of artery	17	77.3%	3	7%	<0.001
Irregularity of artery or change the diameter of the artery.	18	81.8%	3	7%	<0.001
Tumor Longitudinal contact more than 10 mm to 15 mm.	20	90.9%	17	39.5%	<0.001
Abutment of artery with Tumor Longitudinal contact more than 10 mm to 15 mm.	4	18.2%	6	14%	0.65
Encasement of artery with Tumor Longitudinal contact more than 10 mm to 15 mm.	15	68.2%	3	7%	<0.001

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DISCUSSION

Clear fat plan

Of the 18 arteries with clear fat plan around the artery: no invasive was seen during surgery the positive predictive value of vascular invasion is zero. All vessels surrounded by clear fat plan are 100% free of tumor.

P value is <0.001 and the results of this study are consistent with the study of Springett [11], Lu [12], and Loyer [13].

Dirty fat plan

Out of 9 arteries with dirty fat plan around the artery only 1 had tumor invasion and 8 without tumor invasion. This was nearly like Baker et al., study [14]. This sign is seen with acute or chronic pancreatitis or caused by a biopsy of the pancreas head directed via EUS or ERCP [15].

Tumor abutment of the artery

Means not to exceed more than 50% of the circumference of the artery wall:

- Sensitivity and specificity for vascular invasion were 18% and 67% respectively.
- *P* value is higher than 0.05.

There is no statistical significance for this criterion.

Positive predictive value was 22% for this criterion less than the positive predictive value 57% in the study LU, and less than 40% in Springett [11]. Combination of arteries and veins is the reason why positive predictive values of the previous studies are little higher.

Tumor encasement of the artery

Exceed more than 50% of the circumference of the artery wall: Arterial encasement more than 180º has 77% sensitivity and 93% specificity for invasion, out of 20 arteries with arterial encasement, only three cases underwent Whipple. Sensitivity, specificity, positive predictive value and negative predictive value were respectively 77 %, 93%, 85% and 88%.

Statistical results of the Nakayama study, where the same (sensitivity of artery encasement is 78% and specificity is 79%). This study had the same sample numbers and arteries were studied separately from the veins [15].

According to İşcanlı, in Kaneko study, there were 8 patients with a peripheral arterial encasement mentioned as degree C according to the Li criteria. All of the vessels were infiltered with tumor [16] Compared with the Li, which studied 54 patients with pancreatic head tumor, we note the same sensitivity, which measures in our study 77% and in Li study 97% and same specificity in this study 93% and in Le study 100% [17].

In the Lu, study, which examined vascular infiltration with MDCT, sensitivity was 84% and specificity was 98% when the degree of tumor surrounding artery was more than 180 degrees without changing the shape of the vessel [12].

It is consistent with the results of our study.

Changing the diameter of the artery or irregularity of the artery wall

Of the 21 arteries with transverse diameter change or irregularity of the artery wall, only 3 arteries were surgically clear of tumor invasion. The sensitivity, specificity and positive and negative predictive value were 81%, 93%, 85.7%, 90.9%.

Compared to study of Li, the specificity of the previous criteria was consistent with our study in terms but different from it by separating narrowed arteries from irregular ones in return to the study of Li and bring the two criteria together we have 23 arteries out of 29 showed irregular edges or change in the diameter of the artery or both, the positive predictive value (79%), and specificity (100%), were in consistent with our study [18,19].

Li et al., study studied the change of vessel diameter (artery and vein) regarding the surrounding incidence. Clearly, these changes may not appear in the cross sectional study [20] so we used MIP, VR, by calculating the specifically and sensitivity of the previous study we find that the specifically was 97% and positive predictive value measures was 86% and they consistent with the results of our study [17].

Longitudinal contact between the artery and tumor more than 10 mm to 15 mm

This standard is new to the best of our knowledge, and according to the Shen, et al. [19].

We have 22 infiltrated arteries, 18 of them have longitudinal contact for a distance over 10 mm to 15 mm, sensitivity was 90%, specificity 60%, negative predictive value 92%, and accuracy 70% (*P* value <0.001).

Finally, our study, merged criteria of longitudinal contact to

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abutment and encasement. The sensitivity, specificity and positive and negative predictive value respectively when tumor encasement the artery and the longitudinal contact more than 10 mm to 15 mm were 84.6% 85.1% 83.3% 93% (*P* value <0.001). In our study out of 22 arteries with vascular invasion MDCT predicted infiltration in 20 arteries by the following criteria: encasement and longitudinal contact more than 10 mm to 15 mm or and (irregularity of the artery wall and diameter changing). Of the 43 arteries that did not have vascular invasion, 40 arteries with a clean fat plan, dirty fat plan, or abutment of artery. The sensitivity, specificity, positive predictive value, negative predictive value and accuracy of angiography of the MDCT in the evaluation of arterial invasion when considering pathology report is the gold standard as follows: 86%, 95%, 90%, 93%, 92% and thus we have obtained high positive predictive value and high specifically.

This was consistent with the Squillaci, study where a DMCT was used with three-dimensional recombination that showed a sensitivity of 97%, specificity up to 100%, positive predictive value of 100%, and negative predictive value of 95% in the assessment of vascular invasion [20] and our results are compatible with Somers, study where the positive predictive value is 87% and we have 90% [21]. This study did not include all arteries in all patients, surgical work in many cases turns to palliative surgery when atrial invasion detected. The remaining vessels are not assessed because of deep placement or inability to separate them from the adjacent organs [22].

CONCLUSIONS

Tumor longitudinal contact with artery for 10 mm to 15 mm is a new criterion for arterial invasion head pancreatic carcinoma. It is important to pay attention to this result in order to improve the accuracy of diagnosing vascular invasion.

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