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CONFERENCE REPORT

The Imaging of Pancreatic Exocrine Solid Tumors: The Role of Computed Tomography and Positron Emission Tomography

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Summary

The only potentially radical treatment for pancreatic cancer is the removal of the tumor which can be performed by total or subtotal surgical resection of the pancreas; this is possible in the early stages of the disease when the tumor is confined to the pancreatic gland without metastasis to the liver, lymph nodes and/or the peritoneum, or involvement of the vascular system such as the celiac trunk and its branches and the superior mesenteric artery. In this paper, we describe the accuracy of computed tomography and positron emission tomography in the diagnosis of exocrine pancreatic cancer.

The only potentially radical treatment for pancreatic cancer is the removal of the tumor which can be performed by total or subtotal surgical resection of the pancreas; this is possible in the early stages of the disease when the tumor is confined to the pancreatic gland without metastasis to the liver, lymph nodes and/or the peritoneum, or involvement of the vascular system such as the celiac trunk and its branches and the superior mesenteric artery. Limited involvement of the portal mesenteric vein permits surgical intervention; on the other hand, surgery is not indicated in the case of extensive invasion of the trunk or in the presence of neoplastic thrombosis. Thus, it is important to evaluate the encasement of the portal mesenteric trunk in order to plan adequate treatment.

It is well-established that multidetector computed tomography (MDCT) is the gold standard option for diagnosing and staging exocrine pancreatic cancer [1, 2]. In the last few years, a new diagnostic imaging technique, positron emission tomography with CT (CT-PET) has been introduced in the clinical setting to better evaluate the presence of distal metastases, especially since it has the possibility of evaluating the entire human body [1, 2].

The aim of the present paper is to determine the clinical role of MDCT, CT-PET, in the diagnosis and staging of exocrine pancreatic solid tumors.

We would like to emphasize that, in our Institution, MDCT is the preferred imaging technique for studying the pancreatic gland and for confirming the clinical suspicion of pancreatic cancer. MDCT is carried out using a Siemens Somatom Sensation Cardiac (Siemens AG, Berlin, Germany) which uses SOMATOM Sensation Images (Siemens Medical Solutions, Siemens AG, Berlin, Germany) as software for acquisition imaging reconstruction in which ultrafast detector rotation and thin collimation can be combined to yield high-resolution, three-dimensional reconstructions of the pancreas and nearby structures.

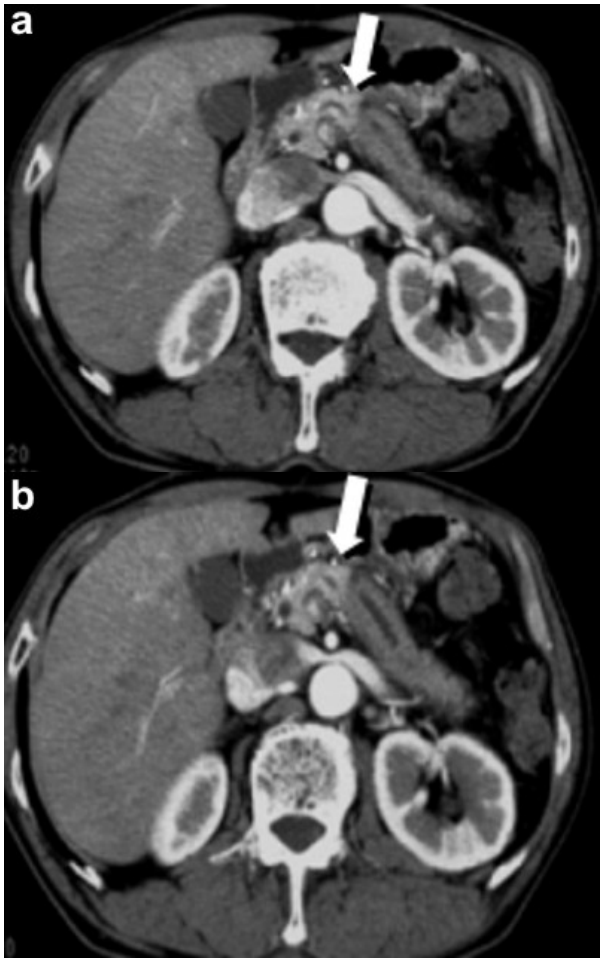

Figure 1. Multidetector computed tomography: the black and white sign visible during the arterial phase: normal appearance of the head of the pancreas and hypodense appearance of the body and tail of the gland (**a-b.**). The arrows indicate the part of the gland which was found at surgery to be involved by the tumor.

We routinely use the following examination protocol. Before the examination, the patient drinks about 800 mL of water so that the stomach and the duodenum can be better visualized and the first acquisition is carried-out. Then a contrast medium (Iomeron, Bracco S.p.A, Milan, Italy) is intravenously infused and three consecutive image acquisitions are carried out; the arterial phase is carried out after about 25 seconds of contrast medium infusion, the pancreatic phase is carried out with a 45-second delay and, finally, the venous phase is carried out with a 65-second delay.
The images acquired undergo post-processing via multiplanar reconstruction (MPR), angio-maximum intensity projection (MIP), InSpace, and volume rendering (VRT).

Using this image acquisition, we are able to diagnose a small pancreatic cancer less than 2 cm in diameter. An indirect sign seen during the arterial phase of MDCT called “black and white” which is characterized by a difference of enhancement between the normal pancreatic gland free of tumor involvement (white) and the edematous gland above the tumor (black) together with a dilated pancreatic duct, can be found when the pancreatic mass is not visualized (Figure 1).
From a practical point of view, we also need to establish peripancreatic vascular involvement. The level of involvement of the

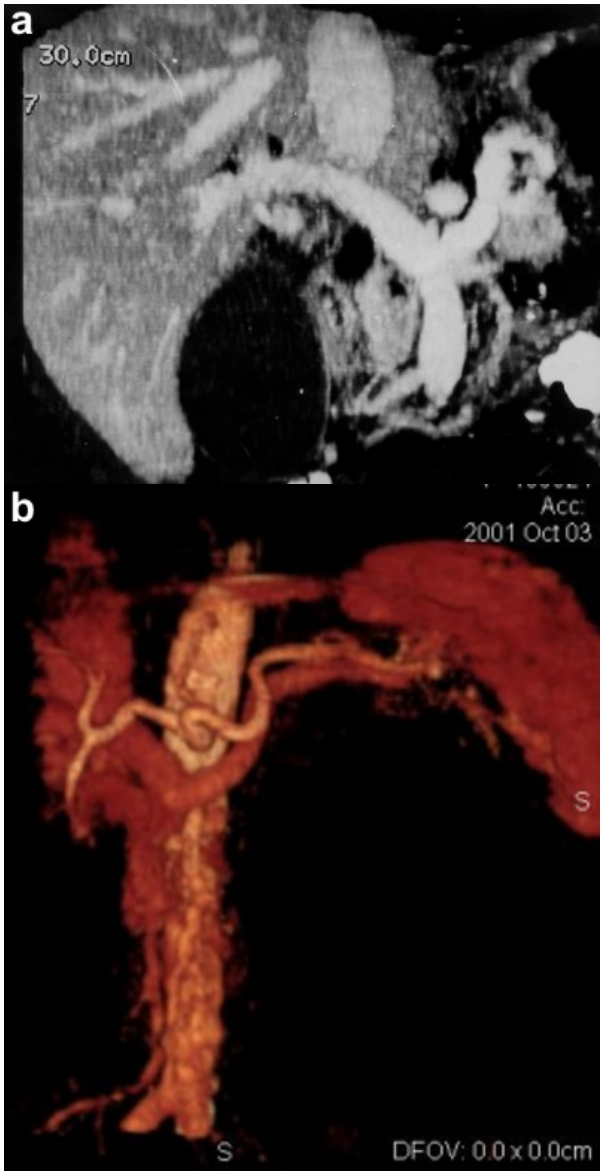

Figure 2. Stage 0. Multidetector computed tomography: normal appearance of the pancreatic gland (**a.**) and normal peripancreatic vessels (**a-b.**)

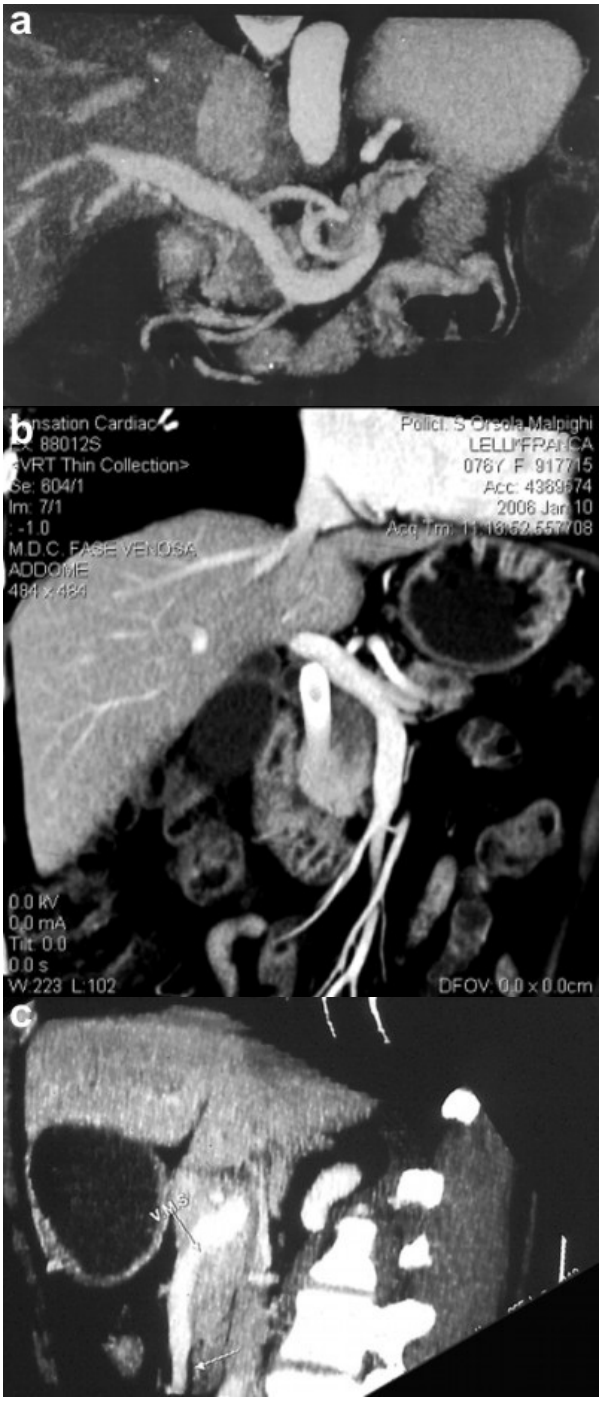

Figure 3. Stage 1. Multidetector computed tomography: disappearance of the fat plan between the pancreatic gland and the mesenteric portal vein (**a-c.**). In panel **c.**, the arrow in the upper part of the figure indicates the normal fat perivascular plan and the arrow in the low part of figure indicates the absence of this plan.

peripancreatic vascular system is of particular interest when planning adequate surgical treatment and also in order to avoid unnecessary resection.

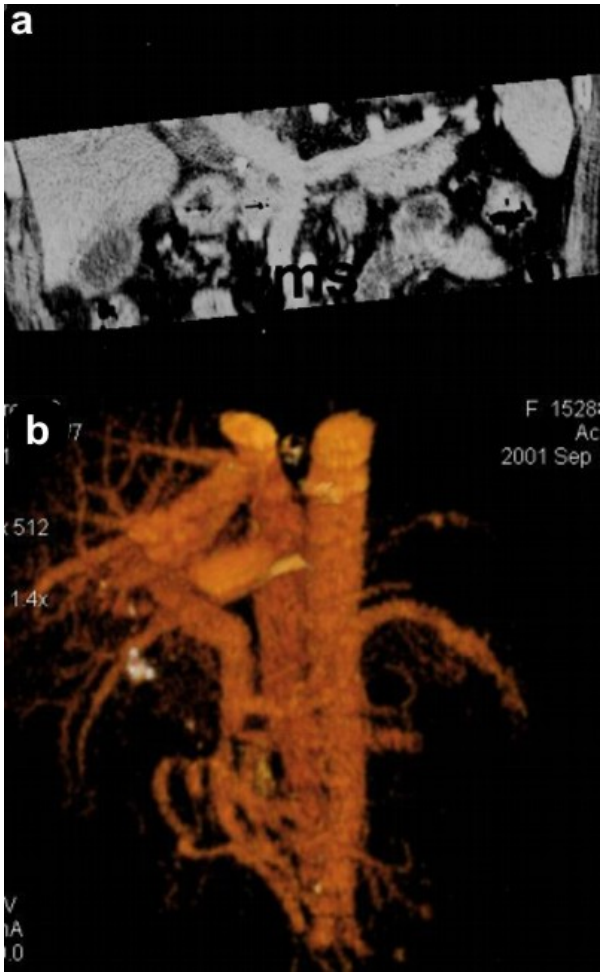

Figure 4. Stage 2. Multidetector computed tomography: involvement of the superior mesenteric vein (**a.** multiplanar reconstruction; **b.** volume rendering tomography).

Five distinct stages of peripancreatic vascular involvement have been established:

- Stage 0: absence of vascular involvement with the fat plane conserved between the tumor and the vessels (Figure 2);
- Stage 1: loss of the fat plane between the tumor and the vessels (Figure 3);
- Stage 2: tangential invasion of the vessel (Figure 4);
- Stage 3: invasion of the vascular perimeter by up to two-thirds with a ribbon-like appearance of the vascular lumen (Figures 5 and 6);
- Stage 4: neoplastic thrombosis (Figure 7).

It has been reported that vascular involvement is very common in tumors involving the

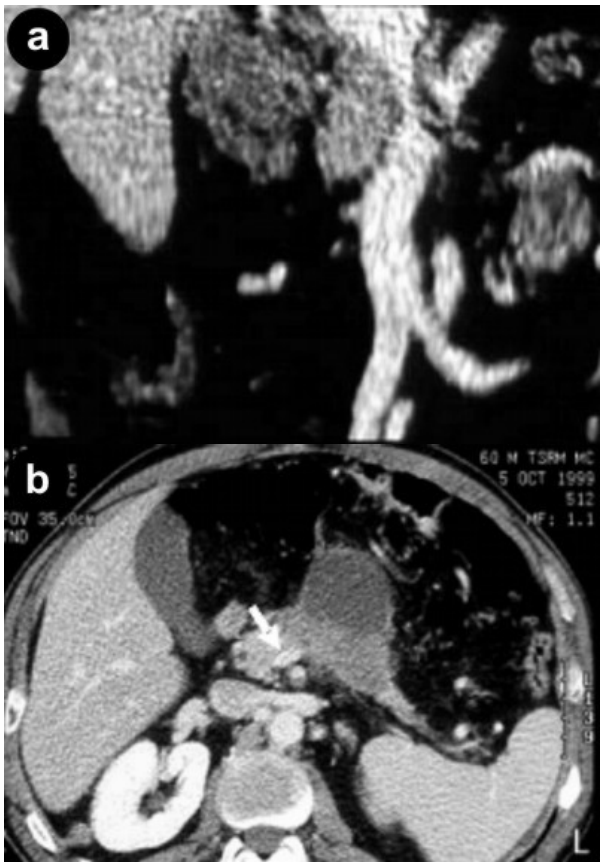

Figure 5. Stage 3. Multidetector computed tomography: circumferential involvement of the superior mesenteric vein (**a.** multiplanar reconstruction). In panel **b.**, the sign of the tear drop of the superior mesenteric vein is also visible (arrow).

pancreas head, having a frequency of 65% [3]. In the absence of lymph node and hepatic metastases and peritoneal carcinosis, the resectability of pancreatic tumors mainly depends on the level of vascular involvement [4]. Several authors [5, 6, 7, 8, 9, 10, 11] have suggested that CT is the best technique for evaluating vascular involvement and determining the viability of surgical resection of pancreatic tumors. Raptopoulos *et al*. [6] noted that CT is capable of establishing the non-resectability of tumors in 96% of cases which were demonstrated to be non-operable. Yosmini *et al*. [7] suggested that the presence and the level of portal mesenteric trunk invasion by the tumor needs to be established prior to surgery. O'Malley *et al*. [10] argued that demonstrating, with CT, the invasion of the circumference of a vascular structure by the tumor is vital for establishing which patients should undergo surgery. Howard *et*

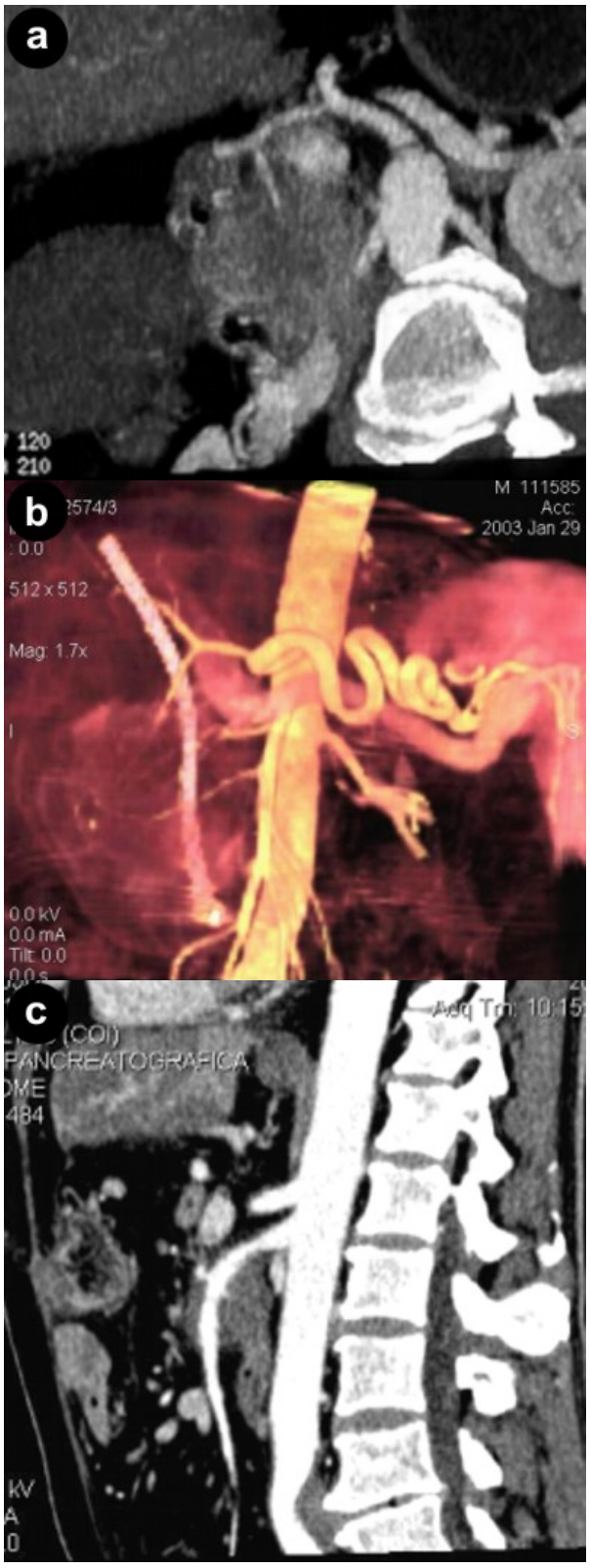

Figure 6. Stage 3. Multidetector computed tomography: circumferential involvement of the peripancreatic artery (multiplanar reconstruction). Panel **a.** shows the involvement of the pancreatic-duodenal and hepatic arteries. In panel **b.**, the involvement of the pancreatic-duodenal arteries is also visible (volume rendering tomography). In panel **c.**, the circumferential involvement of the superior mesenteric artery (multiplanar reconstruction) is seen.

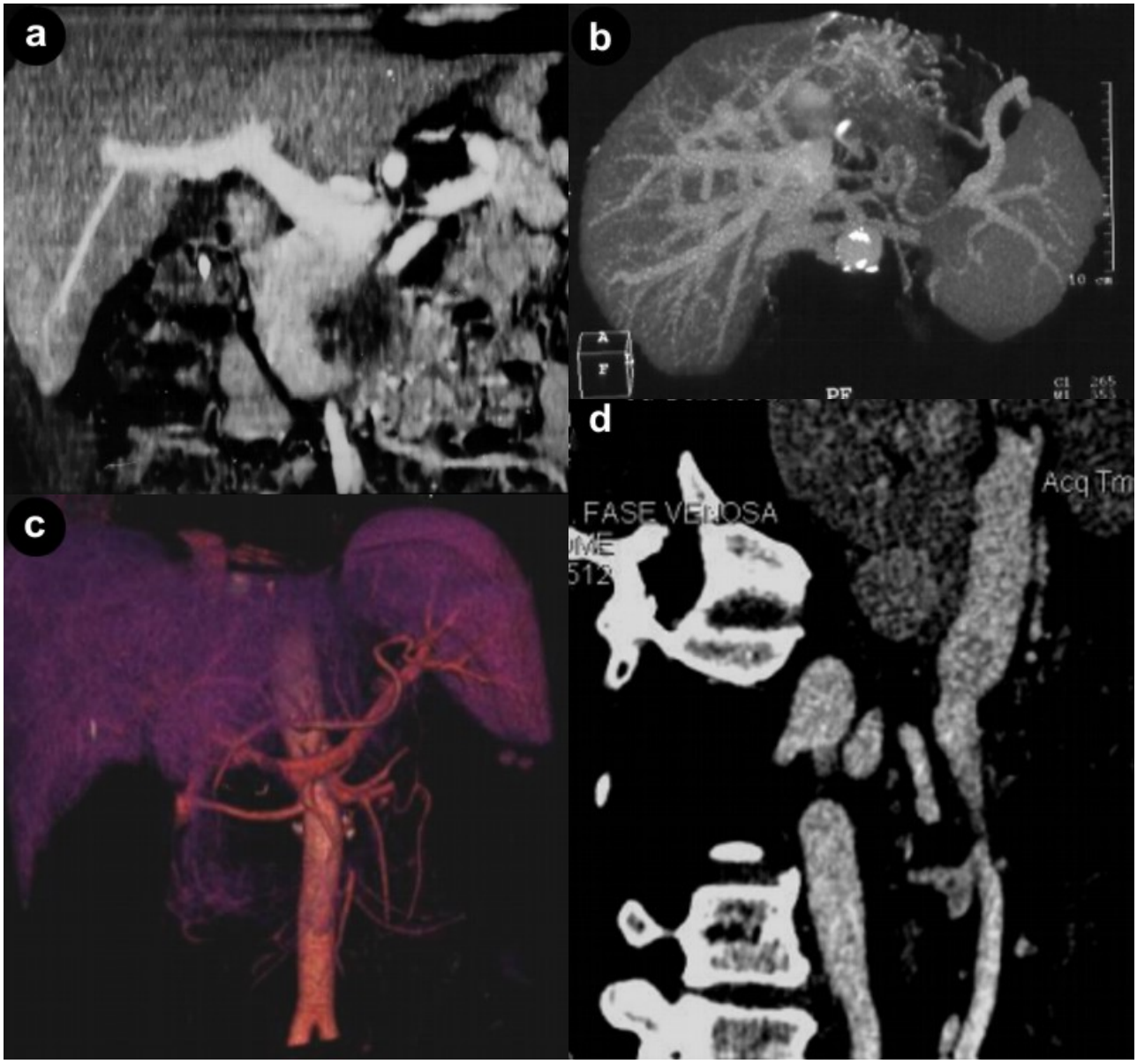

Figure 7. Stage 4. Multidetector computed tomography: thrombosis of the superior mesenteric vein (**a.** multiplanar reconstruction; **b.** angiography minimum intensity proiection; **c.** InSpace; **d.** curvilinear multiplanar reconstruction).

al. [9] found that the specificity, sensitivity and accuracy in determining the resectability of pancreatic tumors were 100%, 63% and 86%, respectively; the low level of sensitivity is due to the fact that CT is not always able to identify small peritoneal metastases and/or small hepatic metastases below the Glisson capsule (Figure 8). According to Lu *et al*. [5], the sensitivity, specificity, and the positive and negative predictive values for the non-resectability of pancreatic tumors are 84%, 98%, 95% and 93%, respectively. Bluemke *et al*. [11] found that the accuracy of CT was 70% in evaluating resectability. However, to evaluate the necessity of possible curative surgery, we need to know the possible local or distant malignant invasion (Figures 8 and 9). At present, three techniques capable of reaching this objective are available: CT-PET, magnetic resonance imaging (MRI), and echoendoscopy (EUS). The exact role of these techniques in the evaluation of local and distant metastatic disease is currently under investigation. A recent meta-analysis carried out by Orlando *et al*. [12], which evaluated 17 studies, found that CT-PET has a sensitivity of 71-100% and specificity of 53-100% in the detection of pancreatic cancer, and claimed

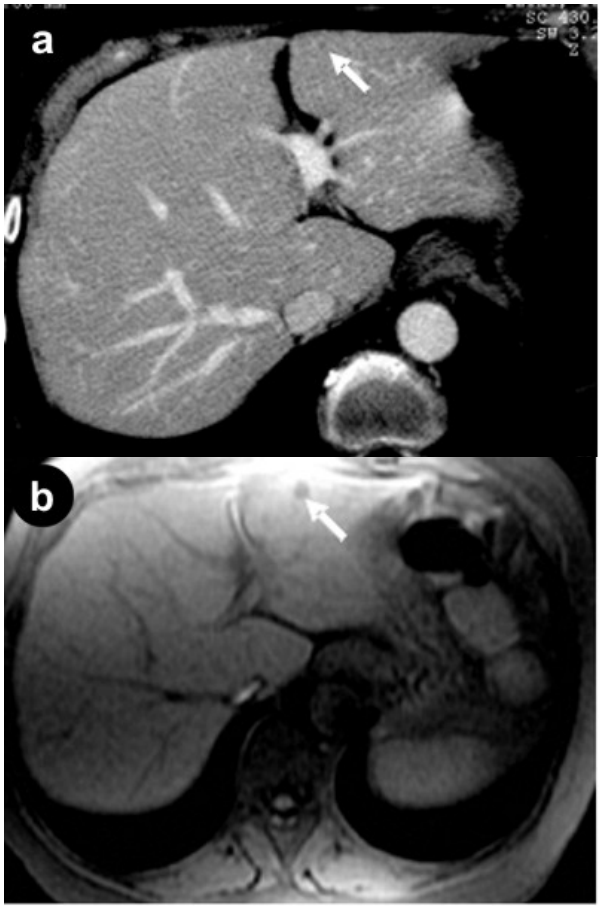

Figure 8. Multidetector computed tomography (MDCT): small liver lesion (**a.** arrow). MRI: presence of the same liver lesion found at MDCT; the lesion appears to be larger than that seen at CT and Glisson's capsule involvement (**b.**).

that CT-PET might be an ideal method of distinguishing between benign and malignant lesions of the pancreatic gland [13]. However, another conclusion of this study was that the specificity of this imaging technique is of limited value because the hypermetabolic cell found in chronic pancreatitis or other inflammatory conditions may lead to false positive diagnoses [14]. Finally, CT-PET may be useful in monitoring disease recurrence or response to neoadjuvant therapy [15] (Figure 9).

Table 1. Sensitivity, accuracy and positive predictive value (PPV) of magnetic resonance imaging (MRI) and positron emission tomography with computed tomography (CT-PET) in evaluating metastatic disease in patients with exocrine pancreatic cancer.

	MRI	CT-PET
Sensitivity	96.6%	93.3%
PPV	100%	90.3%
Accuracy	97.1%	85.3%

In a recent interesting study, Sahani *et al*. [16] evaluated the comparative accuracy of MRI and CT-PET in assessing metastatic disease. The results are reported in Table 1. The authors found that the two techniques are equally useful in obtaining information on metastatic disease because there was no significant difference between MRI and 2-[F-18]-fluoro-2-deoxy-D-glucose (FDG) CT-PET in the detection of liver metastases on a patient-by-patient basis. However, for liver lesion detection, MRI detected significantly more and smaller metastases than FDG CT-PET and this observation was most significant for lesions which measured less than 1 cm. Finally, it has been reported [17] that, using MCDT and EUS, the sensitivity in assessing

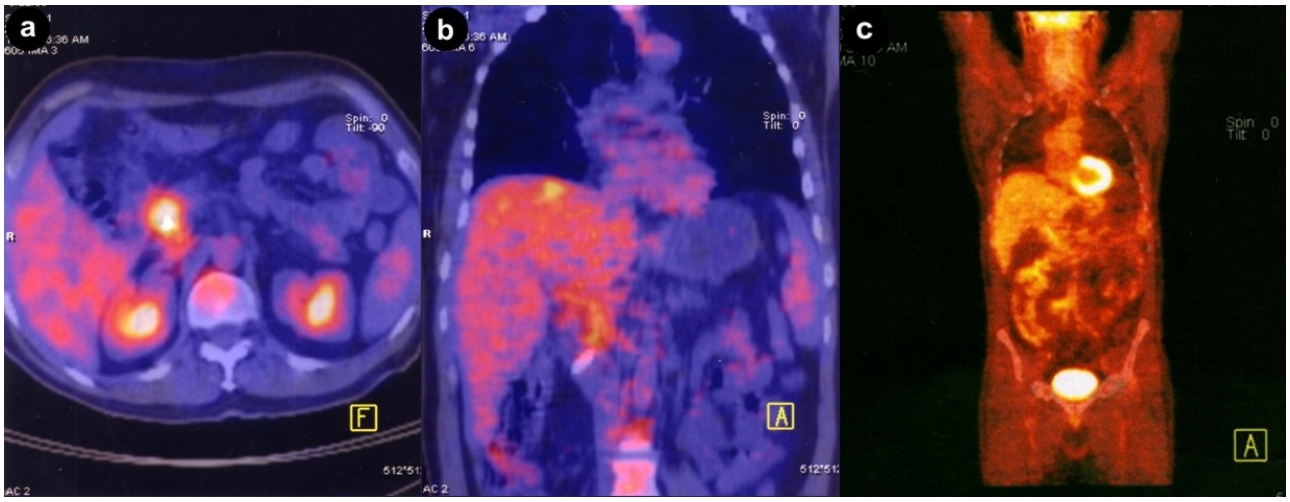

Figure 9. Positron emission tomography with computed tomography: pancreatic lesions (**a.**) and liver metastases (**b.**) at diagnosis. Disappearance of the liver lesion after neo-adjuvant therapy (**c.**).

the presence of a pancreatic neoplasm and local invasion was similar. The only superiority EUS has with respect to MDCT is in the detection and the biopsy of pancreatic lesions less than 2-3 mm in diameter, having a diagnostic sensitivity greater than 90% [2, 3, 4, 5, 6, 7, 8, 9, 10, 11, 16, 17, 18, 19, 20].
Finally, we would point out that the presence of lymph node metastases is high, ranging from 33 to 77% in patients with pancreatic cancer [18]; however no imaging techniques are capable of identifying metastatic lymph node involvement with a satisfactory degree of sensitivity. This is a drawback of the imaging assessment because Japanese authors have claimed that small metastases of lymph nodes and the extrapancreatic nerve plexus near the mesenteric superior artery are always present and this phenomenon is probably the cause of local and distant recurrence of the disease [19].
In conclusion, MDCT is the gold standard for diagnosing and staging more than 90% of pancreatic cancers; in the percentage remaining, MRI, CT-PET and EUS may play a role.

Keywords Diagnostic Imaging; Lymphatic Metastasis; Magnetic Resonance Imaging; Neoplasm Metastasis; Pancreatic Neoplasms; Positron Emission Tomography; Tomography; Ultrasonography

Abbreviations CT-PET: positron emission tomography with computed tomography; FDG: 2-[F-18]-fluoro-2-deoxy-D-glucose; MDCT: multidetector computed tomography; MIP: maximum intensity projection; MPR: multiplanar reconstruction; VRT: volume rendering

Conflict of interest The authors have no potential conflicts of interest

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References

1. Borbath I, Van Beers BE, Lonneux M, Schoonbroodt D, Geubel A, Gigot JF, Deprez PH. Preoperative assessment of pancreatic tumors using magnetic resonance imaging, endoscopic ultrasonography, positron emission tomography and laparoscopy. Pancreatology 2005; 5:553-61. [PMID 16113592]

2. Michl P, Pauls S, Gress TM. Evidence-based diagnosis and staging of pancreatic cancer. Best Pract Res Clin Gastroenterol 2006; 20:227-51. [PMID 16549326]

3. Garber SJ, Lees WR. The characterization of pancreatic and bile duct tumours by duplex Doppler. Clin Radiol 1992; 45:181-4. [PMID 1555370]

4. Ishikawa O, Ohigashi H, Imaoka S, Furukawa H, Sasaki Y, Fujita M, et al. Preoperative indications for extended pancreatectomy for locally advanced pancreas cancer involving the portal vein. Ann Surg 1992; 215:231-6. [PMID 1543394]

5. Lu DS, Reber HA, Krasny RM, Kadell BM, Sayre J. Local staging of pancreatic cancer: criteria for unresectability of major vessels as revealed by pancreatic-phase, thin-section helical CT. AJR Am J Roentgenol 1997; 168:1439-43. [PMID 9168704]

6. Raptopoulos V, Steer ML, Sheiman RG, Vrachliotis TG, Gougoutas CA, Movson JS. The use of helical CT and CT angiography to predict vascular involvement from pancreatic cancer:correlation with findings at surgery. AJR Am J Roentgenol 1997; 168:971-7. [PMID 9124153]

7. Yoshimi F, Hasegawa H, Koizumi S, Amemiya R, Ono H, Kobayashi H, et al. Application of three-dimensional spiral computed tomographic angiography to pancreatoduodenectomy for cancer. Br J Surg 1995; 82:116-7. [PMID 7881927]

8. Calculli L, Casadei R, Diacono D, Caputo M, Cavina M, Minguzzi MT, Marrano D, Gavelli G. Role of spiral computerized tomography in the staging of pancreatic carcinoma. Radiol Med (Torino) 1998; 95:344-8. [PMID 9676213]

9. Howard TJ, Chin AC, Streib EW, Kopecky KK, Wiebke EA. Value of helical computed tomography,

angiography, and endoscopic ultrasound in determining resectability of periampullary carcinoma. Am J Surg 1997; 174:237-41. [PMID 9324129]

10. O'Malley ME, Boland GW, Wood BJ, Fernandez-del Castillo C, Warshaw AL, Mueller PR. Adenocarcinoma of the head of the pancreas: determination of surgical unresectability with thin-section pancreatic-phase helical CT. AJR Am J Roentgenol 1999; 173:1513-8. [PMID 10584794]

11. Bluemke DA, Cameron JL, Hruban RH, Pitt HA, Siegelman SS, Soyer P, Fishman EK. Potentially resectable pancreatic adenocarcinoma: spiral CT assessment with surgical and pathologic correlation. Radiology 1995; 197:381-5. [PMID 7480681]

12. Orlando LA, Kulasingam Si, Matchar DB. Meta-analysis: the detection of pancreatic malignancy with positron emission tomography. Aliment Pharmacol Ther 2004; 20:1063-70. [PMID 15569108]

13. Imdahl A, Nitzsche E, Krautmann F, Hogerle S, Boos S, Einert A, et al. Evalutation of positron emission tomography with 2-[18F] fluoro-2-deoxy-D-glucose for the differentation of chronic pancreatitis and pancreatic cancer. Br J Surg 1999; 86:194-9. [PMID 10100786]

14. Sendler A, Avril N, Helmberger H, Stollfuss J, Weber W, Bengel F, et al. Preoperative evaluation of pancreatic masses with positron emission tomography using 18-F-fluorodeoxyglucose: diagnostic limitations. World J Surg 2000; 24:1121-9. [PMID 11036292]

15. Rose DM, Delbeke D, Beauchamp RD, Chapman WC, Sandler MP, Sharp KW, et al. 18Fluorodeoxy-glucose-positron emission tomography in the management of patients with suspected pancreatic cancer. Ann Surg 1999; 229:729-37. [PMID 10235532]

16. Sahani DV, Kalva SP, Fischman AJ, Kadavigere R, Blake M, Hahn PF, Saini S. Detection of liver metastases from adenocarcinoma of the colon and pancreas: comparison of mangafodipir trisodium-enhanced liver MRI and whole-body FDG PET. AJR Am J Roentgenol 2005; 185:239-47. [PMID 15972430]

17. Hunt GC, Faigel DO. Assessment of EUS for diagnosing, staging, and determining respectability of pancreatic cancer: a review. Gastrointest Endosc 2002; 55:232-7. [PMID 11818928]

18. Roche CJ, Hughes ML, Garvey CJ, Campbell F, White DA, Jones L, Neoptolemos JP. CT and Pathologic Assessment of Prospective Nodal Staging in Patients with Ductal Adenocarcinoma of the Head of the Pancreas. AJR Am J Roentgenol 2003; 180:475-80. [PMID 12540455]

19. Noto M, Miwa K, Kitagawa H, Kayahara M, Takamura H, Shimizu K, Ohta T. Pancreas Head Carcinoma. Frequency of Invasion to Soft Tissue Adherent to the Superior Mesenteric Artery. Am J Surg Pathol 2005; 29:1056-61. [PMID 16006800]

20. Katz M.H, Savides T.J, Moossa A.R., Bouvet M. An Evidence-Based Approach to the Diagnosis and Staging of Pancreatic Cancer. Pancreatology 2005; 5:576-90. [PMID 16110256]