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Current status of multi-detector row helical CT in imaging of adult acquired pancreatic diseases and assessing surgical neoplastic resectability

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KEYWORDS

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Abstract *Background:* It is usually hard to detect pancreatic lesions early as the pancreas lays retro peritoneum so it cannot be assessed during a routine physical exam. By the time a person has symptoms, the disease has already established morphological imaging CT changes.
Objective: The objective of our study was to clarify the role of multidetector computerized tomography (MDCT) in different adult acquired pancreatic diseases and assess the efficacy of surgical pancreatic tumors resectability preoperative.
Materials & methods: The study included thirty adult patients suspected to have pancreatic diseases (18 males and 12 females); their age range was 45–90 years with a mean age of 68 years. All patients underwent triple-phase multi-detector row CT using a 16-slice machine. The presence of inflammation, masses, and vascular invasion was evaluated and interpreted images were obtained during each phase. Results were compared with surgery, histopathology or follow-up.
Results: Of 30 patients, 15 had pancreatic malignancies (14 adenocarcinoma of which 6 were resectable and 8 were irresectable, 1 distant metastasis) proven at biopsy and/or surgery, 11 patients had pancreatitis (acute and chronic), three patients had cystic benign tumors (2 mucinous cystadenoma, 1 serous cystadenoma), and one patient had neuroendocrine tumor (insulinoma).
Conclusion: Contrast enhanced multiphase pancreatic imaging by MDCT with its post processing techniques represents the imaging modality of choice for the diagnosis of different adult acquired pancreatic diseases.

1. Introduction

Imaging of the pancreas is a challenging investigation because of its anatomic location in the retro peritoneum and its intricate relationship with major blood vessels and bowel. CT had been the initial imaging modality of choice for evaluation of pancreatic pathology. Improvements in CT technology during the past decade, with fast image acquisition and improved spatial resolution, had increased the accuracy of CT lesion detection and characterization. Excellent visualization of the pancreatic parenchyma in various phases of contrast enhancement facilitates

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early detection of small pancreatic lesions. Post processing techniques provide a vascular road map for the operating surgeon.[1]

Acute pancreatitis is a disease with a broad spectrum of findings that varies in severity from mild interstitial or edematous pancreas to severe form with significant local and systemic complications that are associated with a substantial degree of morbidity and mortality.[2]

Contrast enhanced computed tomography (CECT) is useful in determining the underlying cause of pancreatitis, grading the severity and detection of local complications such as necrosis, abscess, or pseudo cysts.[3]

CT outclasses all imaging modalities in detecting calcifications, any specific sign of advanced chronic pancreatitis. CT can also detect most complications such as pseudocysts, calculi in the pancreatic duct or inflammatory masses.[4]

Pancreatic cancer is one of the most lethal diseases, with a poor prognosis. Surgical resection remains the only potentially curative treatment. Therefore, accurate staging to select patients who may benefit from resection is essential. In patients with resectable tumors, accurate diagnoses of tumor extension, vessel involvement, and the presence or absence of liver metastasis are necessary before operation.[5]

The latest multi-detector computed tomography (MDCT) technology provides three-dimensional multi-planar reconstruction techniques enabling determination of tumor involvement of the common bile duct (CBD), pancreatic duct, and peripancreatic vasculature, which is expected to improve the preoperative determination of surgical resectability, particularly in relation to vascular invasion.[6]

2. Materials & methods

2.1. Subjects

This study was conducted on 30 selected patients (18 males and 12 females) suspected on clinical symptoms (Fig. 1) and laboratory findings of having different acquired pancreatic diseases listed in Table 1. The age range distribution among the examined patients is demonstrated in Table 2. The mean age of patients was 68 years.

Study was conducted in some private radiology centers and in Ain Shams Specialized Hospital starting from January 2012 to May 2015. Patients' Exclusion criteria included patients with congenital pancreatic disease, contraindication to iodinated contrast media (chronic renal impairment or previous allergy to the contrast media), and pregnant women. An informed consent was obtained from all patients after full explanation of the benefits and risks of this procedure.

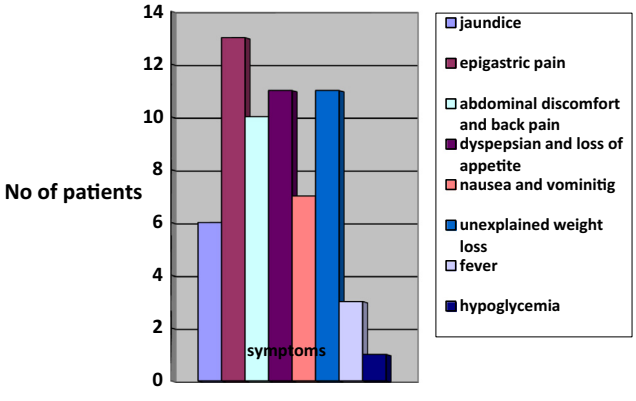


Figure 1 The clinical presentation of patients.

Table 1 MDCT diagnosis in relation to the number of patients.

MDCT diagnosis	Number of patients	Percentage (%)
Acute pancreatitis	8	26.6
Chronic pancreatitis	3	10
Adenocarcinoma	14	46.6
Neuroendocrine tumor (insulinoma)	1	3.3
Cystic pancreatic tumors	3	10
Metastasis	1	3.3

Table 2 The age range distribution in the 30 included patients.

Age range	Number of patients
45–55	13
56–65	10
66–75	6
>75	1 (90y)
	30

2.2. Methods

All patients were subjected to careful history taking, general and abdominal examination, laboratory and serological examinations, abdomino-pelvic ultrasound and multi-detector computed tomography.

This study was performed using a 16 slice multi-detector CT (Toshiba activeon). Patients fasted for about 4–6 h before examination. Reassurance and brief explanation of the procedure was done. All patients were examined in supine position, each patient was instructed to remain stable and suspend breathing during scanning time.

Opacification of the gastrointestinal tract with oral contrast material was done before CT scanning using one liter of diluted 2–4% non-ionic contrast material divided into three doses.

An initial unenhanced scan was obtained in all patients starting from the level of the diaphragm down to the iliac crest using a 5-mm slice thickness at 5-mm increments. An unenhanced scan demonstrates dense common bile duct calculi and pancreatic calcifications.

After the end of pre contrast CT examination, post contrast scan was done. IV contrast medium (Ultravist 300 mg) was injected at the rate of 4 ml per second using a power injector. The contrast enhanced scans were obtained in a late arterial phase (40s post-injection), and a portal venous phase (70s post-injection). Contrast-enhanced acquisitions were performed cranio-caudally with thin collimation (1 mm).

The pancreatic parenchymal phase provides excellent enhancement of the arterial system. The portal venous phase is ideal phase for detecting liver metastases, as well as for creating reconstructed images of the venous structures, which might be essential for surgical planning.

2.3. The scan parameters and image analysis

The scan parameters were tube current 120 kV and 400 mA, slice thickness 5 mm, collimation of 0.6 mm, pitch 0.6, 0.6-s gantry rotation time and table speed of 7.5–10 mm per rotation during a single breath-hold acquisition of 15–25 s.

Image interpretation was done on an independent workstation and included the axial source images and the reformatted (MPR, MIP, CPR and volume rendering) images which helped in the definition of the location and extent of the lesions. All TDM was interpreted by the same radiologists working in private radiology centers and in Ain Shams Specialized Hospital.

2.3.1. In cases of acute pancreatitis

The CT scan was assessed in case of non-enhancement and normal enhancement pattern of pancreas. Non-enhancement of pancreas represented pancreatic necrosis. The extent of pancreatic necrosis was estimated at $\leqslant$30%, more than 30% but less than 50% and $\geqslant$50%.

CT scans were also assessed for peripancreatic inflammation, mesenteric stranding, peripancreatic fluid collection, pseudocyst, pancreatic abscess, and inflammatory changes of the adjacent organs and vessels.

The severity of the pancreatitis for each case was assessed using the CT severity index (CTSI) developed by Balthazar et al. (Table 3). CTSI includes grading of pancreatitis (A–E) and the extent of pancreatic necrosis. The maximum score that can be obtained is 10.[7]

2.3.2. In cases of chronic pancreatitis

CT scans were assessed for intraductal calcifications, main pancreatic duct dilatation and parenchymal atrophy. It was also assessed for any peri pancreatic collections and masses.

2.3.3. In cases of pancreatic neoplasm

Any pancreatic lesion was assessed according to tumor site, size, and invasion of adjacent organs, CBD and pancreatic ducts caliber, major vascular invasion, and lymph node metastasis. Staging of the pancreatic mass was done according to TNM system (Table 4). Classic criteria for defining non-resectability (Fig. 2) included extrapancreatic invasion of adjacent tissues and organs other than the duodenum; occlusion, stenosis, or semicircular encasement of any major peripancreatic vessel (celiac, hepatic, or superior mesenteric artery or portal or superior mesenteric vein); hepatic metastases; peritoneal carcinomatosis; and lymph node or distant metastases (Fig. 3).

Table 3 CT severity index (CTSI) for grading of acute pancreatitis by Balthazar et al.

CTSI
Grading of pancreatitis
• A: normal pancreas: 0
• B: enlargement of pancreas: 1
• C: inflammatory changes in pancreas and peripancreatic fat: 2
• D: ill-defined single fluid collection: 3
• E: two or more poorly defined fluid collections: 4
Pancreatic necrosis
• None: 0
• Less than/equal to 30%: 2
• > 30–50%: 4
• > 50%: 6

Table 4 TNM Classification for the staging of pancreatic cancer.[25]

Tumor (T)	
TX	Primary tumor not assessed
Tis	Carcinoma in situ
T1	Tumor less than or equal to 2 cm in diameter and confined to the pancreas
T2	Tumor greater than 2 cm in diameter and confined to the pancreas
T3	Tumor extends beyond the pancreas but does not involve the celiac axis or SMA
T4	Primary tumor involves either the celiac axis or the SMA
Node (N)	
NX	Regional lymph nodes not assessed
N0	No involvement of the regional lymph nodes
N1	Involvement of the regional lymph nodes
Metastases (M)	
MX	Distant metastases cannot be assessed
M0	No distant metastasis
M1	Distant metastasis

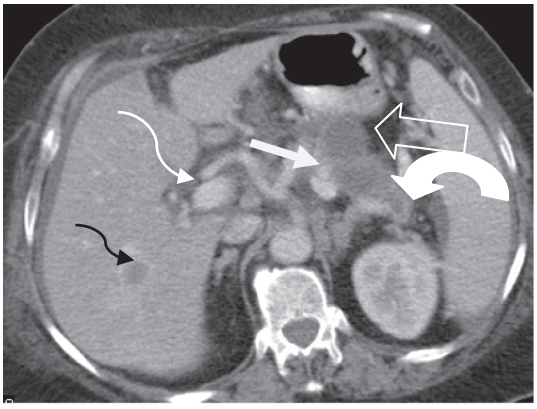


Figure 2 Irresectable pancreatic body adenocarcinoma T4N1 M1. Axial post contrast CT images (porto-venous phase) show pancreatic body hypodense mass lesion inducing focal contour bulge (white arrow) with loss of fat plane between it and the posterior wall of the stomach (thick arrow). There is also right hepatic lobe hypodense metastatic focal lesion (thin curved black arrow) and peri pancreatic nodal involvement (thin curved white arrow). The distal pancreatic duct is seen dilated (thick curved white arrow).

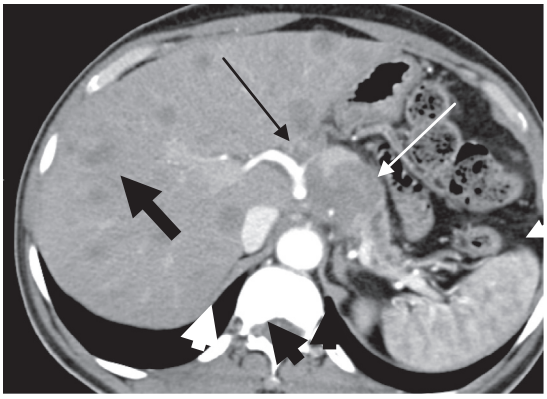


Figure 3 Irresectable pancreatic body carcinoma (T4 N0M1). Axial CT image shows hypodense heterogenous pancreatic body mass (white arrow) encasing the celiac trunk (black arrow) and atrophy of the pancreatic tail (arrowhead). Liver with multiple hypodense lesions due to metastasis (thick black arrow).

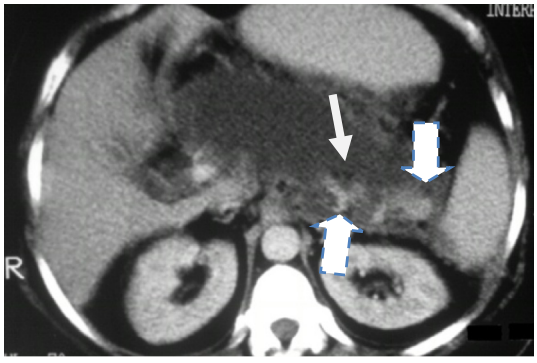


Figure 4 Acute necrotizing pancreatitis CT SI 9. Note a fluid attenuation collection in the pancreatic bed with minute islands of preserved fatty tissue (thin arrow) and well defined rim, suggestive of walled off necrosis with fat necrosis involving the pancreas and peri pancreatic tissue. Few small areas of glandular enhancement are only seen at the region of the body and tail (thick arrow).

3. Results

3.1. In case of pancreatitis

Eleven cases of pancreatitis were detected; eight patients were diagnosed as acute pancreatitis (7 males and 1 female) and three patients were diagnosed as chronic pancreatitis (2 male and one female).

All cases of acute pancreatitis in our study were diagnosed on the basis of the clinical data and elevated serum amylase.

The causes of acute pancreatitis in the 8 patients were as follows: Gall Bladder stones (6 patients), alcohol (1 patient), and idiopathic (1 patient).

Acute pancreatitis was graded by MSCT according to the currently accepted CT severity index into 3 categories: Mild (CT severity index 0–3), Moderate (CT severity index 4–6), Severe (CT severity index 7–10) (Table 5).

Six patients showed complications resulting from acute pancreatitis in the form of variable degrees of pancreatic necrosis (Fig. 4). One patient showed pancreatic abscess (Fig. 5), three patients showed pseudocysts (Fig. 6), three patients complicated with organ failures, and one patient showed sepsis. Percutaneous drainage of pancreatic pseudocysts was performed in two patients. Percutaneous drainage of an abscess was performed in one patient. Pseudocysts in two patients showed spontaneous resolution during the course of medical treatment for acute pancreatitis. The size of these cysts did not exceed 5 cm in diameter.

3.2. Chronic pancreatitis

Three cases of chronic pancreatitis were diagnosed (2 males and 1 female). Their age ranges from 45 to 60 years (mean, 52.5 years). All patients had a history of repeated attacks of pancreatitis.

Table 5 CT severity index in case of acute pancreatitis.

Category	Number of patients	Percentage (%)
Mild	2	25
Moderate	1	12.5
Severe	5	62.5

Variable degrees of irregular and beaded pattern of pancreatic duct dilatation were noted in all cases of chronic pancreatitis. Pancreatic intraductal stones were observed in two cases of the study. Pancreatic parenchymal atrophy was present in all cases of chronic pancreatitis in this study. It was graded as mild in two cases and moderate in one case.

Pancreatic calcification was detected in cases of chronic pancreatitis with variable size (tiny stippled calcifications to large coarse calcifications) and distribution from localized involving one portion of the gland to diffusely distributed (Fig. 7).

3.3. Neoplastic pancreatic lesions

This included 19 cases that were classified into two main groups according to their pathological findings (Table 6):

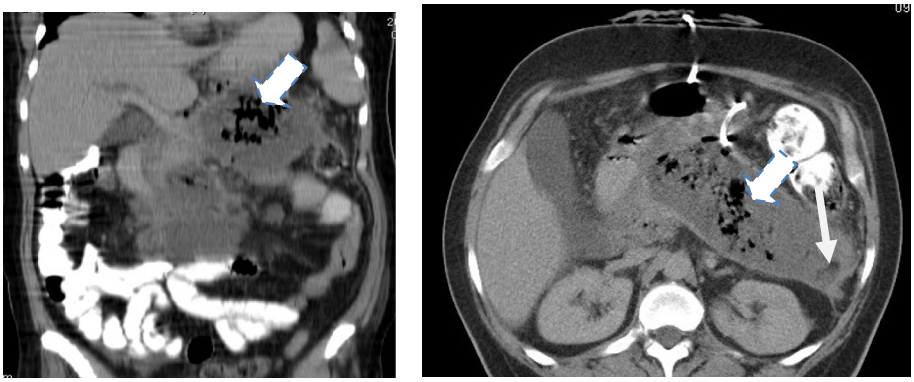
1. *Group I:* Pancreatic adenocarcinoma.
2. *Group II:* Miscellaneous.

3.3.1. Group I (pancreatic adenocarcinoma)

This group included 14 patients, their age ranged from 50 to 72 years with a mean age of 62 years. Variable degrees of MDCT findings are listed in Table 7.

Three patients showed ill-defined heterogeneous focal lesion in the pancreas, and one had peri pancreatic lymphadenopathy. Three patients showed focal lesion of heterogeneous echogenicity at the head of the pancreas (Fig. 8), with dilatation of CBD, and/or intrahepatic biliary radicles. Three patients showed only dilatation of CBD and intrahepatic biliary radicles and the pancreatic area were obscured by gases. Two patients showed focal lesion of heterogeneous echogenicity at the pancreas, with dilatation of intrahepatic biliary radicles, and hypoechoic focal lesions of the liver. Two patients showed focal lesion of the pancreas with hypoechoic areas of the liver (mostly metastatic).

Percutaneous CT guided biopsy was done in 4 patients, intra-operative true-cut biopsy was done in 2 patients, percutaneous ultrasound guided biopsy was done in 2 patients and



(a) (b)

Figure 5 (a and b) Acute necrotizing pancreatitis with pancreatic necrosis and abscess formation. **CTSI 10** Axial and coronal MDCT images showed Fluid attenuation collection at the pancreatic body, tail and part of the head with well-defined wall. It shows small fat density (thin arrow) and air (thick arrow) loculi, suggestive of infected pancreatic walled off necrosis and abscess formation. Percutaneous catheter is seen inside the collection for drainage.

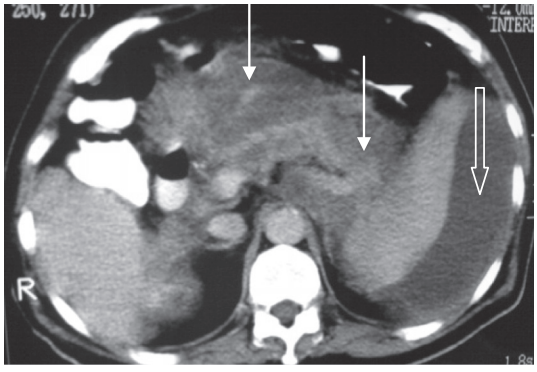


Figure 6 Axial MDCT image showed Enlarged/swollen pancreas with patchy ill-defined non enhancing areas of necrosis (thin arrows) are seen at the pancreatic head, body and tail. There is also stranding of the peri pancreatic fat and peri splenic fluid collection (thick arrow).

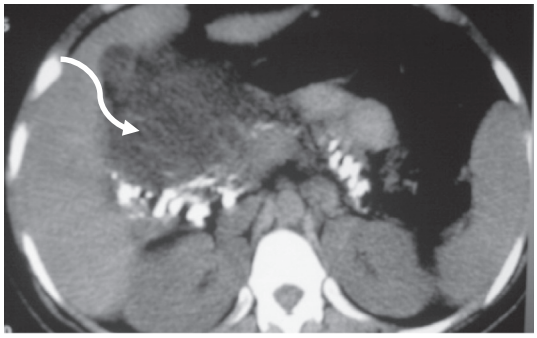


Figure 7 Chronic calcific pancreatitis with intra ductal stone and pseudopancreatic cyst. Axial CT images demonstrate atrophic pancreas with innumerable diffuse calcification. A well-defined homogenous fully encapsulated collection, representing pseudopancreatic cyst is seen related to the pancreatic head region (curved arrow).

Table 6 Distribution of neoplastic pancreatic lesions according to pathological findings.

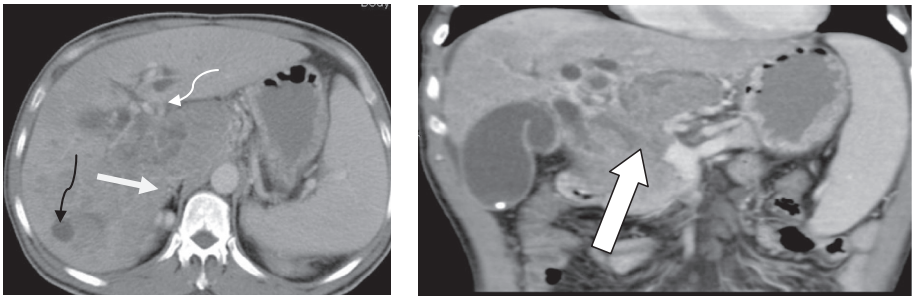
Pathological diagnosis	No. of cases	Group
Pancreatic adenocarcinoma	14	I
Miscellaneous	5	II
	19	Total

Table 7 The MDCT findings in pancreatic adenocarcinoma.

CT findings	Number of patients	Percentage (%)
Intrahepatic biliary dilatation	6	42
Dilated pancreatic duct	6	42
Dilated CBD	6	42
Hepatic metastasis	7	50
Duodenal invasion	3	21
Enlarged lymph nodes	3	21
Ascites	2	14
Peri-pancreatic vascular invasion	3	21
Chest lesions		
Pulmonary		
Deposits	4	28.5
Atelectatic bands	3	21
Pneumonic patches	2	14
Pleural effusion	2	14
Osteolytic bone lesions	1	7

ERCP biopsy was done in 6 patients. All fourteen patients were proved to be adenocarcinoma by histopathological examination.

Six cases that were suggested to be resectable by MDCT criteria in our study proved to be surgically resectable intra operative. However, surgical resection was aborted in only one case out of 6 cases due to unsuspected peritoneal deposits.



(a) (b)

Figure 8 (a and b) Irresectable pancreatic head adenocarcinoma T4 N0M1. (a) Axial post contrast CT images (porto-venous phase) pancreatic head heterogeneously enhancing irregular mass lesion inducing contour bulge (white arrow) invading the CBD with consequent intra hepatic biliary dilatation (thin curved white arrow). There is also right hepatic lobe hypodense metastatic focal lesion (thin curved black arrow). (b) Coronal MIP reconstruction clearly shows the vascular invasion of the portal vein.

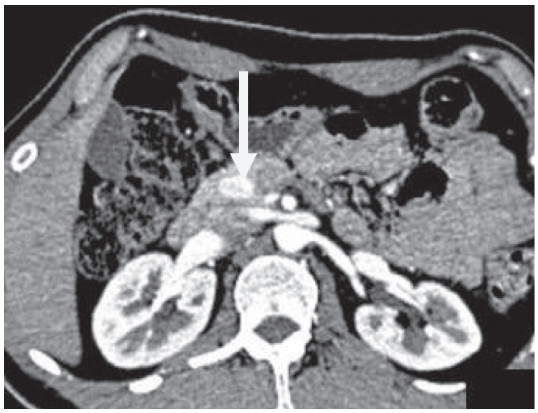


Figure 9 Benign pancreatic head insulinoma. Axial CT cut pancreatic-phase shows a 1 cm small, typically hyperenhancing nodule in the pancreatic head (arrow).

3.3.2. Group II (miscellaneous)

This group included 5 patients with two patients were diagnosed as mucinous cystadenoma at the tail of the pancreas by MSCT criteria. The two cases were females. The diagnosis was confirmed in one case by ultrasound guided aspiration cytology and proved to be mucinous cystadenoma. Follow-up was done in the other case and showed stationary course.

One male patient showed pancreatic head irregular small cystic lesion and MSCT diagnosis was pancreatic serous cystadenoma. Follow-up was done after 6 months and showed stationary course.

One female patient 45 years old presented with episodes of hypoglycemia. MSCT showed hyper vascular well defined small lesion which enhanced more intensely than the normal pancreatic parenchyma in all phases, and the final diagnosis was established as benign insulinoma (Fig. 9).

One female patient was diagnosed by MSCT as pancreatic metastasis at the neck of the pancreas as well as at the operative bed that showed the same pattern of enhancement. She had a known history of right nephrectomy for renal cell carcinoma. Biopsy from the operative bed revealed recurrent renal cell carcinoma (see Table 8).

Table 8 Classification of patients according to resectability.

Resectability of the pancreatic adenocarcinoma according to MSCT findings	Number of the patients
Resectable group	6
Irresectable group	8
Total	14

4. Discussion

Imaging with CT had become a frontline technique for initial diagnosis, evaluation of complications, and long-term follow-up of a variety of diseases of the pancreas.[8]

Almost all life-threatening complications occur with necrotizing pancreatitis, including secondary bacterial contamination and multi-organ failure.[9] In our study 2 patients showed mild form of pancreatitis. In one patient (50%) fluid collections were detected and resolved within one week. This agrees with a study done by Lenhart and Balthazar[10], in which fluid collections were detected in 73 patients (43.2%) and almost totally resolved within 7–10 days in most patients.

No complications were detected in our study in the mild form of acute pancreatitis. This is in contrary to the study done by Lenhart and Balthazar[10] who found Complications developed in nine patients with acute non necrotizing pancreatitis with incidence of 5.3%.

The internationally accepted CT severity index, which is based on scoring the presence and degree of pancreatic inflammation and pancreatic necrosis, not only allows accurate differentiation of mild from severe pancreatitis but also numerically correlates with the patient's prognosis.[11]

Our results confirmed that the currently accepted CT severity index is indeed a powerful tool with which we can predict morbidity in patients with acute pancreatitis. When comparing patients with mild pancreatitis and those with severe pancreatitis, we documented a statistically significant correlation between the numeric score obtained with the currently accepted index and the presence of infection, the need for surgery and percutaneous interventions, and the length of the hospital stay.

The reported mortality rate for patients with acute pancreatitis varies greatly. A study by Casas[12] demonstrated

that CTSI $\geqslant$ 5 is the index for patients under the danger of death. In Bradley's study[13], the CTSI > 8 is the index for death. According to Simchuk et al.[14], the CTSI < 3 had a 3% mortality rate, whereas patients with a CTSI > 7 had a mortality rate of 17%. In our study, one patient out of the eight patients died (12.5%) and had a CTSI = 10 and no mortality was detected in mild and moderate form of acute pancreatitis.

In our study we found that main pancreatic duct dilatation, intra ductal calcification and variable degrees of pancreatic atrophy were detected in all cases of chronic pancreatitis. Pancreatic pseudocyst was found in 33% of cases. This agreed with Remer and Baker[15] who found dilatation of the main pancreatic duct in 68% of patients, parenchymal atrophy in 54% of patients, pancreatic calcifications in 50% of patients, and fluid collections in 30% of patients.

In our work we used the pancreatic parenchymal phase and the portal venous phase. Also Sahani et al.[16] recommended the same biphasic technique. 14 patients out of 19 had pancreatic adenocarcinoma i.e. (75%) this comes in agreement with this of Carbognin et al.[17] who decided that ductal adenocarcinoma accounts from 80% to 90% of all tumors of the pancreas.

8 male patients and 6 female patients had pancreatic carcinoma and this was as the same as David's et al. study[18] which stated that higher rates of pancreatic carcinoma are seen in men than in women and this is in contrast to John's et al.[19] who found that recently more women are developing pancreatic malignancy.

Scaglione et al.[20] reported that 60% of pancreatic tumors occupied the head of pancreas, 10% the body, about 5% the tail and the remaining 25% were diffusely involved. In our study 57% of tumors occupied the head of the pancreas, 29% the body, and 14% the tail. That explains why 42% of patients had a clinical history of jaundice because 57% of the masses occupied pancreatic head.

The size of the pancreatic head tumors in our study was between 2 and 4 cm and that was similar to Scaglione et al.[20] who reported that at the level of the pancreatic head, the average size was 2–3 cm.

Scaglione et al.[20] stated that pancreatic carcinoma tended to be hypo dense masses distorting pancreatic contour. In our study 11 patients showed hypo dense lesions, while 3 cases showed heterogeneous focal lesions.

In this study, the most common reported associated extra pancreatic finding was dilated CBD and intra hepatic biliary radical, which was seen in 6 patients (42%); this is seen in 75% of patients with head masses. John et al.[19] stated that ductal dilatation occurs in 58% of patients with pancreatic neoplasm and ductal dilatation proximal to the obstructing tumors was detected in approximately 88% of pancreatic head tumors.

Liver metastases were detected by multi slice CT in 7 patients (50%). This comes in agreement with Murfitt[21] who stated that metastasis to the liver occurred in approximately 17–55% of the patients.

Chest distant metastatic finding was a common association with pancreatic neoplasm in the current study. This was reported in 28.5% of the patients. Osteolytic bony lesion was found in 7%. This comes in agreement with the statement of Kloppel[22] who stated that metastasis to lung, pleura and bone is only seen in advanced tumor stages.

In our study, 5 cases were resectable out of 14 cases (35%). Near to this is the study of Grenacher and KlauB[23] which stated that only 20% of all patients believed to have a surgically resectable disease.

Resection is aborted in one case out of 6 cases (about 16% of the suspected resectable cases) due to unsuspected peritoneal deposits, whereas Zamboni et al.[24] decided that resection was aborted in 11% of their suspected resectable cases.

Darren et al.[25] stated that False-negative results almost often occur because of the unsuspected liver surface metastases, peritoneal deposits, or unsuspected vascular invasion.

Frate et al.[26] stated that MSCT has an accuracy rate for staging of pancreatic adenocarcinoma of virtually 100%. In our study the overall accuracy of tumor staging by MSCT was 84%. Whereas Zamboni et al.[24] stated that the accuracies ranged from 85% to 95%, Scaglione et al.[20] decided that the accuracy of MSCT in staging of pancreatic cancer is as high as 93%.

In our study insulinoma appeared as well defined small lesion which enhanced more intensely than the normal pancreatic parenchyma in all phases. This coincides with McLean[27] study which stated that insulinomas are typically hyper attenuating on at least one phase of contrast enhancement typically on the late arterial [25 s] or pancreatic phase [35–40 s] of imaging but occasionally in the portal venous phase.

In our study there were two cases of pathologically confirmed pancreatic mucinous cystadenoma. Both patients were female and in relatively younger age group (53 and 57 years). Aslam and Yee[28] stated that a mucinous cystic neoplasm occurs predominantly in women.

One case was diagnosed by MDCT as serous cystadenoma. This was a 54 year old male. This is in contrast to Dewhurst et al.[29] who stated that about 80% occur in women who are more than 60 years old. This is possibly attributed to small number of cases enrolled in our study.

One case of pancreatic metastasis was from renal cell carcinoma. Paspulati[1] stated that the common primary tumors that metastasize to the pancreas are from lung, breast, kidney, and melanoma. Mechó et al.[30] stated that pancreatic metastases are uncommon, representing 4.5% of pancreatic tumors.

5. Conclusion

Contrast enhanced multiphase pancreatic imaging by MDCT with its post processing techniques represents the imaging modality of choice for diagnosis of different adult acquired pancreatic disease.

Conflict of interest

The authors declare that there are no conflict of interests.

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