Impact of intraoperative ultrasound on pancreatic tumor resectability

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Background
Usually, there is no intraoperative image guidance performed during abdominal exploration of pancreatic tumor. Intraoperative ultrasound (IOUS) enhances the visualization of pancreatic tumor during resection, so it needs to be investigated in detail.
Objective
The aim of the study was to assess the impact of IOUS on preoperative surgical strategy. The authors compare IOUS findings with the operative assessment of the radicality of resection and vascular contact.
Patients and methods
The study proceeded in the Department of Surgery, Theodor Bilharz Research Institute from 2016 to 2019. This prospective cross-sectional study was to assess the impact of IOUS on preoperative surgical planning and to assess whether the radicality and vascular affection of the tumor would be correctly evaluated or not. IOUS was conducted on 38 patients by a competent surgeon during abdominal exploration of the pancreatic tumor and was then compared with intraoperative assessment.
Results
IOUS affects surgical planning in 66.6% of cases. Radical resection was achieved in 36 out of 38 malignant tumors (94.7%). By using preoperative imaging vascular contact was assessed correctly in 68.4% of the patients compared with 89.4% by using IOUS.
Conclusion
IOUS assessment in pancreatic tumors changed the surgical strategy in 21% of the patients. So, the authors can use IOUS to assess the resectability of the tumor and the possibility of vascular contact during surgical resection.

Keywords:
intraoperative ultrasound, pancreatic cancer, resectability

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Introduction

The main prognostic factor of surgery for patients with pancreatic cancer is the ability to achieve radical resection of the tumor [1]. We assess the tumor extent by preoperative computed tomography (CT) imaging [2]. Resectability depends on the extent of the tumor locally, vascular affection, and absence of metastases [3]. Neoadjuvant therapy is usually started in cases of borderline resectablitiy or advanced tumor in order to improve the outcomes [4]. But neoadjuvant chemotherapy may affect the efficacy to evaluate tumor resectability by using CT imaging, due to the difficulty to differentiate between viable tumor tissue and chemotherapy-induced fibrosis [5,6]. Surgical exploration for pancreatic cancer is based on the detection of local invasion of the tumor or presence of liver metastases which is the starting point for surgical treatment. During this exploration, the surgeon relies only on inspecting and palpating the pancreas to differentiate between normal tissue and tumor, which may be difficult, especially if there is inflammation surrounding the tumor. Adding to that, there is local tumor recurrence in up to 60% of patients who shows tumor affection to the resected borders in their histologic microscopic assessment after resection of their pancreatic tumor [7–9]. Also, 50% of the patients who have suspected tumor vascular invasion show no tumor infiltration after vascular resection based on their histologic microscopic assessment of the resected tumor [10]. Ultrasound helps to diagnose cases with a suspected pancreatic tumor in addition to its role to have cytological examination during operation [11]. Therefore, laparoscopic staging before surgical exploration can be done by laparoscopic ultrasound [12]. Intraoperative ultrasound (IOUS) can help detect vascular affection in the borderline –resectable pancreatic tumors during

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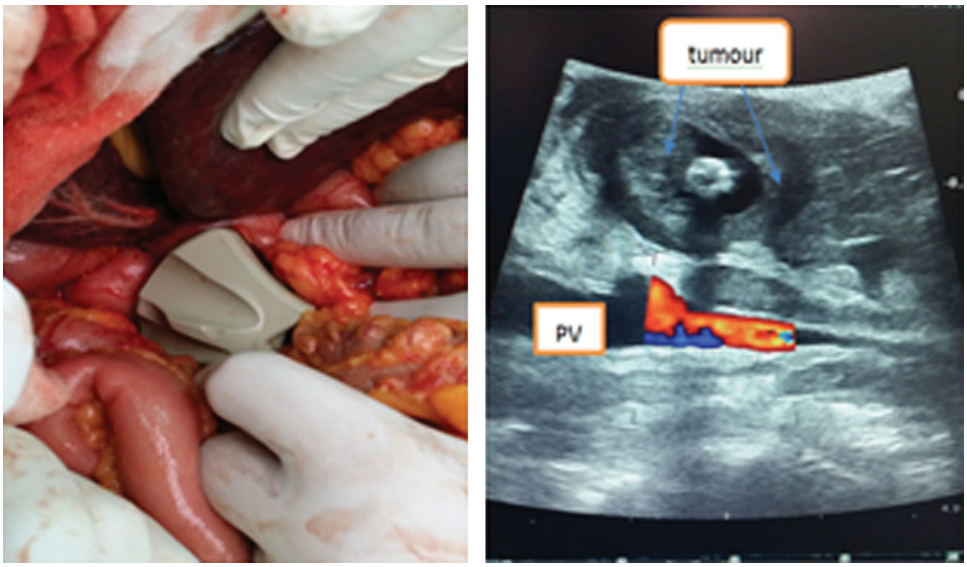
Figure 1



Transduodenal approach showing dilated CBD with stent inside and hypoechoic periampullary tumor abutting it.

surgery [13,14]. IOUS offers real-time imaging data with direct feedback including the lesion's extent and vascular involvement. This information can help guide the surgical strategy and approach. Moreover, IOUS provides superior outcomes compared with MRI and CT because of its direct scanning to the organs [15]. However, few studies used IOUS to evaluate tumor resectability in spite of its main role in evaluating the surgical strategy for pancreatic tumors [16]. Kolesnik *et al.* [17] have reported change in their surgical planning in 30% of their cases, due to the presence of occult metastases. In our study, we evaluate the impact of IOUS to change the surgical planning in pancreatic tumors.

Aim

The primary aim of our study was to evaluate the impact of IOUS to change the plan of management of radicality of resection; thereby, their impact on the surgical strategy. The secondary aim was to assess vascular involvement.

Patients and methods

Our study was performed in the Department of Surgery, Theodor Bilharz Research Institute starting from 2016 to 2019. Preoperative imaging was done and then the surgical option was assessed by the multidisciplinary team. IOUS was performed on 38 patients by a competent surgeon during the operation of the pancreatic tumor and then compared with intraoperative assessment. This prospective cross-sectional study was to assess the impact of IOUS on our preoperative surgical planning. In our study, we compare IOUS to preoperative CT imaging and intraoperative assessment. All patients signed our consent of the Medical Ethics Committee of the Theodor Bilharz Research Institute.

Preoperative imaging: preoperative abdominal CT was performed.

As regards IOUS: we used sterile IOUS probes of different shapes (Fig. 1).

Scanning technique for malignant pancreatic operations

The diagnostic value of pancreatic and peripancreatic tumors consists mainly of detecting the local spread, liver metastases, lymph node (LN) affection, and vascular invasion:

(1) Starting on the anterior surface of the liver by detecting the intrahepatic vasculature by finding the junction of the vena cava with the three hepatic veins on the superior most portions of the liver 'rabbit ears,' by following each hepatic vein peripherally till its terminal branches and then reassessing each vein in their longitudinal plane. Then the probe is turned to the inferior surface of the liver on the hepatoduodenal ligament to scan the porta hepatis.
(2) Scanning the hepatic parenchyma in order to detect any abnormalities.
(3) In our experience, we found that LN invasion shows no morphologic criteria to differentiate between inflamed and malignant LNs.

(4) The pancreas can be scanned by opening to the lesser sac and scanning direct on the pancreas.
(5) The criteria of vascular affection included the disappearance of the interface between the external aspect of the venous wall and tumor, or tumor mass shown as a filling defect of the lumen.
(6) The superior mesenteric artery runs below and 3–5 mm lateral to the superior mesenteric vein which is adherent to the uncinate process. At this site as the pancreas is less thick, the splenic vein appears very clear on transverse scan vein as it courses the body of the pancreas to its tail.
(7) Pancreatic tumor appears as a hypoechoic heterogeneous swelling with ill-defined borders.

If starting with diagnostic laparoscopy

(1) Hepatic scanning started through the epigastric port, with the identification of the liver parenchyma and standard landmarks.
(2) Through the infraumbilical port, the porta hepatis can be visualized by placing the probe on the hepatoduodenal ligament.
(3) The pancreas can be scanned through the duodenum after complete US examination.

Statistical analysis

Statistics assume that in 38 patients the surgical planning would be changed in more than 30% because of the IOUS evaluation. The sample sizes of 38 cases have an 80% index by using the two-sided McNemar test with a significant level of 0.05.

Results

In our study, IOUS was performed in 38 surgical explorations. Patient characteristics such as age and sex distribution among the studied group are tabulated (Table 1). The research aimed to assess the impact of IOUS on surgical strategy, comparing preoperative imaging correlation (CT), IOUS, and operational findings of vascular assessments and resectability.

Table 1 Age and sex distribution among the studied group (*N*=38)

	n (%)
Age	
Mean±SD	57.0±13.9
Median (range)	58.0 (18–77)
Sex	
Male	20 (52.6)
Female	18 (47.4)
Total	38 (100)

Age was distributed as 57.0±13.9, regarding sex male represents 52.6%.

Vascular involvement was suspected of 14 preoperative scans. Thirty-six malignant tumors were resected. In two explorations, resection was abandoned because of the irresectable tumors.

Among 38 patients (20 men, 18 women) with a mean age of 57 years in our study, all patients were subjected to CT scan; 38 patients have been exposed to an IOUS (open method). In 86% of cases, the average value of CEA and CA19.9 was elevated.

Among 38 patients in our study, all patients had obstructive jaundice; 28 of them suffered of typical pancreatic pain. Actually in our clinical records, after the performance of IOUS scan, complete tumor resection was done in 36 patients, there was failed resection in two patients due to vascular invasion, so 68.4% was with preoperative data.

The preoperative diagnosis performed with CT failed to detect in 15.7% (six patients) the site of the tumor, detect 34 patients with enlarged suspected locoregional LNs, and two patients with para-aortic LNs. In 94.7% (36 patients) IOUS can detect the tumor, 31 patients with enlarged suspected locoregional LNs, and two patients with para-aortic LNs (Table 2).

IOUS detects six (15.7%) patients with local or vascular invasion (with 88.9% specificity and 100.0% sensitivity) (Fig. 2), while CT detects 14 (36.8%) patients with local or vascular invasion (with 66.7% specificity and 100.0% sensitivity) (Table 3).

Average for the mean time for the IOUS procedure was 16.8421±4.77567 min. CT procedure was 25.0000 ±0.00000 min. The mean time for the whole operation was 6.7 h±54 min.

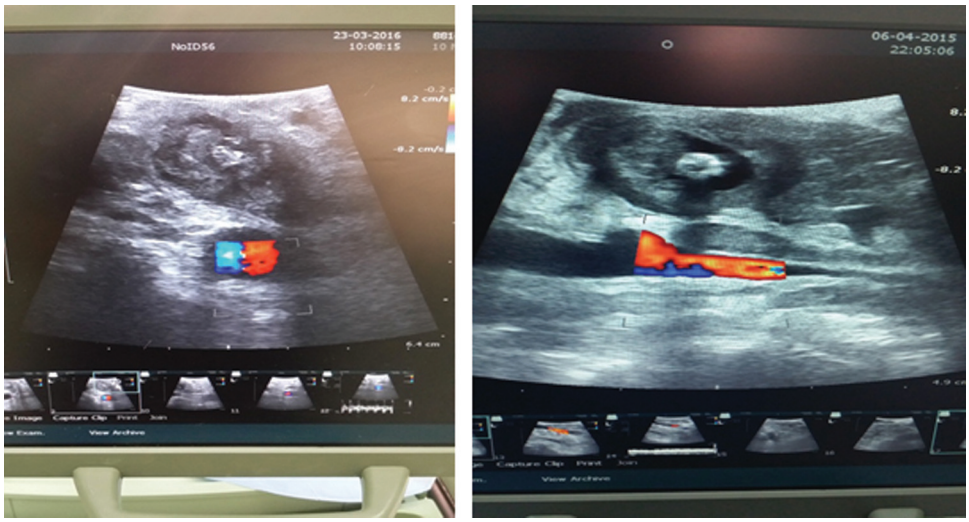
Our study shows that there was a highly statistically significant increase in the diagnostic accuracy of IOUS in the diagnosis of the distal versus proximal common bile duct (CBD) stricture with *P* value less than 0.001. There were no cases of intraoperative deaths.

Table 2 Comparative study between computed tomography and intraoperative ultrasound in the detection of locoregional and para-aortic lymph nodes

	Sensitivity (%)	Specificity (%)	Positive predictive value (%)	Negative predictive value (%)	Accuracy (%)
CT	94.4	100.0	100.0	100.0	94.7
IOUS	83.3	50.0	96.7	33.3	81.5

CT, computed tomography; IOUS, intraoperative ultrasound.

Figure 2



By intraoperative ultrasound, ampillary mass infiltrating the duodenal wall, abutting SMV, PV, and PV confluence and encroached onto the distal CBD. CBD, common bile duct; PV, portal vein; SMV, superior mesenteric vein.

Table 3 Comparative study between computed tomography, intraoperative ultrasound, and operative finding in the detection of vascular invasion

	Sensitivity (%)	Specificity (%)	Positive predictive value (%)	Negative predictive value (%)	Accuracy (%)
CT	100.0	66.7	14.2	100.0	68.4
IOUS	100.0	88.9	33.3	100.0	89.4

CT, computed tomography; IOUS, intraoperative ultrasound.

Discussion

Our study aimed to assess the role of IOUS compared with other imaging modalities in the diagnosis of radicality of the resection.

This study is a cross-sectional study conducted on 38 patients who had malignant OJ.

In this study, most patients were in their third to sixth decades of life with the mean age of all patients being (57.0±13.9) years with male predominance (52.6%); among malignancy, the single most common cause is carcinoma head of the pancreas in 26 (68.4%) cases.

These results are in agreement with Heinzow *et al.* [18], who comparatively analyzed the role of endoscopic retrograde cholangiopancreatography (ERCP), endoscopic ultrasound (EUS), intraductal ultrasound (IDUS), and CT in predicting malignant bile duct strictures, with a median age of 64 years, range of 20–90 years with male predominance of 54%; in our study the male predominance was 52.6%.

In our study, there was statistical significance in clinical presentation as regards jaundice, itching, and weight loss. All patients were complaining of jaundice with no history of previous biliary surgery (100%). Itching was seen in 31.5% and abdominal pain was in 73.6 and 24%.

These results were consistent with the study conducted by Weilert *et al.* [19], who select patients presented with jaundice (100%). However, there was no abdominal pain in all patients.

Mahaboobkhan *et al.* [20] reported that 53% had complaints of obstructive jaundice and 40% had abdominal pain.

In our study, IOUS and CT determine the site of cause of malignant CBD stricture with a sensitivity and accuracy of 94.7 and 84.2%, respectively.

This results in agreement with Ćwik *et al.* [21] who reported that the sensitivity and specificity of IOUS were determined in the range of 90–96% and sometimes even close to 100% for detection of the site of pancreatic tumor. Also, in agreement with Sun *et al.* [15], who reported that IOUS had a sensitivity of 92–93%, an average of 95% for detection of the site of pancreatic tumor.

Also, in agreement with DeWitt *et al.* [22], in 25 patients recommended for surgery reported that the sensitivity of CT for detecting a pancreatic mass was

86% (confidence interval: 77–93%).This results in agreement with Kolesnik *et al.* [17], who reported that the IOUS assessment changed the surgical strategy in 30%.

The current study found that the specificity and sensitivity of IOUS in the diagnosis of malignant vascular invasion (88.9%) had a sensitivity of 100% which is more precise and accurate than CT (68.4%).

This results are in agreement with the Grzegorz *et al.* [23] study, which reported a significant advantage of IOUS tolerance, precision, and accuracy in the diagnosis of malignant invasion of portal vein flow compared with CT; IOUS accuracy was 89.7% compared with an average of 64.1% for CT.

This study showed that the sensitivity, specificity, positive predictive value, negative predictive value, and accuracy of CT in nodal staging (94.4, 100, 100, 100, and 94.7%) are higher than IOUS with specificity, positive predictive value, negative predictive value, and accuracy (50, 96.7, 33.3, and 81.5%) .

This results agree with DeWitt *et al.* [22], who reported that CT results for tumor staging had an accuracy of 67% and were comparable with nodal staging accuracy (94%).

Conclusion

In this study, the diagnostic value of IOUS showed that the correct diagnostic identification, reached by IOUS, has allowed to select patients with resectable cancer as IOUS changed the surgical strategy in 21%. IOUS plays a golden role in our institute in evaluating the extent and vascular affection. In our institute, the same surgeon who performs IOUS undergoes surgery therefore providing ideal decision during surgery.

Recommendations

IOUS can be a valid imaging modality in the diagnosis of malignant lesions in a noninvasive and accurate way. Multiple institutions and further studies are required to evaluate on wide scales of patients the role of IOUS in the diagnosis of common bile duct stricture.

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Nil.

Conflicts of interest

There are no conflicts of interest.

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