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Real-world staging computed tomography scanning technique and important reporting discrepancies in pancreatic ductal adenocarcinoma

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Abstract

Background: Computed tomography (CT) is the first-line staging imaging modality for pancreatic ductal adenocarcinoma (PDAC) which determines resectability and treatment pathways.

Methods: Between January 2016 and December 2019, prospectively collated data from two Australian cancer centres was extracted from the PURPLE Pancreatic Cancer registry. Real-world staging CTs and corresponding reports were blindly reviewed by a sub-specialist radiologist and compared to initial reports.

Results: Of 131 patients assessed, 117 (89.3%) presented with symptoms, 74 (56.5%) CTs included slices ≤3 mm thickness and CT pancreas protocol was applied in 69 (52.7%) patients. Initial reports lacked synoptic reporting in 131 (100%), tumour identification in 2 (1.6%) and tumour measurement in 13 (9.9%) cases. Tumour-vascular relationship reporting was missing in 69–109 (52.7–83.2%) for regarding the key arterial and venous structures that is required to assess resectability. Initial reports had no comment on venous thrombus or venous collaterals in 80 (61.1%) and 109 (83.2%) and lacked locoregional lymphadenopathy interpretation in 13 (9.9%) cases. Complete initial staging report was present in 72 (55.0%) patients. Sub-specialist radiological review resulted in down-staging in 16 (22.2%) and up-staging in 1 (1.4%) patient. Staging discrepancies were mainly regarding metastatic disease (12, 70.6%) and tumour-vascular relationship (5, 29.4%).

Conclusion: Real-world staging imaging in PDAC patients show low proportion of dedicated CT pancreas protocol, high proportion of incomplete staging reports and no synoptic reporting. The most common discrepancy between initial and sub-specialist reporting was regarding metastases and tumour-vascular relationship assessment resulting in sub-specialist down-staging in almost every fifth case.

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Introduction

Pancreatic ductal adenocarcinoma (PDAC) is an aggressive malignancy that is predicted to become the second leading cause of cancer death in the western world by 2030.[1] Prognosis with this disease remains poor with an estimated 5-year survival rate of 11% only minimally improved from 5.2% in 2010 despite advances in therapy.[2,3]

Surgical resection with a clear R_0 margin remains the only potentially curative therapy for newly diagnosed PDAC patients.[4] However, due to the absence of cardinal symptoms, patient often present late with unresectable disease.[5] Prompt and accurate radiological staging is paramount for all patients with potentially resectable disease in order to minimize the time from diagnosis to surgery.

CT is the first-line imaging modality used in the staging of PDAC given its cost-effectiveness, widespread availability and reader familiarity. MRI and PET are considered second-line imaging modalities used as adjuncts to assist in the staging of difficult cases.[6]

The National Comprehensive Cancer Networks (NCCN) staging guideline is commonly used when assessing the PDAC resectability.[7] It divides patients into resectable, borderline resectable and unresectable categories (8,9 Table S1). Key features include CT imaging findings (based on international association of pancreatology consensus guidelines) and additional considerations around patient fitness and serum biomarkers.[10,11] Given the importance of accurate staging, guidelines recommend multi-disciplinary team meetings (MDTM) review of all cases to ensure comprehensive assessment that will guide further clinical management. Whilst beneficial, this environment does not guarantee a thorough evaluation of initial imaging scans.[12–14]

Discrepancies in radiological reporting are common which has the potential to impact treatment decision-making and patient outcomes. These differences in the interpretation and reporting of imaging between radiologists can occur due to technical or reader-related errors.[15] Reader-related errors are commonly categorized into major or minor, with major discrepancies being those that could adversely affect patient care due to a change in diagnosis or treatment. CT imaging in general has a low rate of discordance with reported rates between 2.7% and 7.7% across all scans.[16,17] However, abdominopelvic imaging has higher rates of discordance than other regions of the body due to its anatomical complexity and range of pathologies possible. Second reader reviews have been shown to reduce unnecessary referrals.[17–19] Early studies examining discrepancies in PDAC found reporting discrepancies in 31–32% of cases and concluded that second interpretation was a cost-effective method of determining resectability in patients.[20–22] More targeted studies have found that sub-specialist reporting of PDAC resulted in greater clarity regarding resection attempts.[21,23] Sub-specialist review often upstages patients and thus prevents unsuccessful resection attempts.[17,19]

Given the importance of accurate initial PDAC imaging staging, this study investigated applied CT scanning technique and discrepancies between initial versus sub-specialist radiologist reporting regarding synoptic template usage, report completeness and staging in real-world setting.

Methods

Patients

This retrospective study included patients treated at two metropolitan tertiary referral centres in Australia between January 2016 to December 2019. De-identified data was extracted from the PURPLE Pancreatic Cancer Registry (ACTRN12617001474347), a large multi-centre electronic database that prospectively collates demographic, clinical, pathological, imaging, treatment and outcome data on patients with pancreatic cancer from 46 cancer centres in Australia, New Zealand and Singapore.

Patients were included if they had a histologically confirmed PDAC or if biopsy results were inconclusive but MDTM consensus resulted in presumed PDAC. Patients were excluded if initial CT imaging or staging reports were unavailable or if they were lost to follow up. Ethics approval for this study was obtained from all participating institutions.

Materials

De-identified patient CT imaging was reviewed by a sub-specialized radiologist using a Picture Archiving and Communication System (PACS, Carestream Health, Inc., Rochester, NY, USA). Initial staging reports were retrieved and stored on a secure online server. Missing external scans or reports were identified and retrieved from relevant institutions and added to the relevant databases. Patient clinical data was retrieved using the PURPLE Registry database. All data was analysed using SPSS v26 (Statistical Package for the Social Sciences) (MacIntosh, IBM, USA).

Procedure

CT protocol technique and presence of multiplanar reformatting of initial staging scans was captured. All scans were blindly reported by a radiologist with 16 years of upper gastro-intestinal sub-specialist knowledge (HSK). Image quality was assessed and categorized in 'satisfactory' versus 'poor quality study'. Key staging features based on the American Joint Committee on Cancer (AJCC) 8th Edition guidelines and current NCCN staging proforma were directly assessed by synoptic reporting. Initial and centralized sub-specialist staging reports were compared, and differences divided into minor and major discrepancies. Minor discrepancy was defined as no NCCN staging change, whereas major discrepancy was defined by means of a change of NCCN staging (resectable, borderline, locally advanced unresectable, metastatic). Comparison of staging outcomes was completed using the Wilcoxon-Signed Rank test and McNemar's analysis for paired categorical variables. Fishers exact test was used to compare unpaired categorical variables. Student's *t*-test was used for continuous variables. Findings were considered significant if *p*-values were <0.05.

Results

Patient characteristics

In total, 174 patients were identified with 131 patients fulfilling the inclusion criteria (Fig. 1). Patient demographics were captured

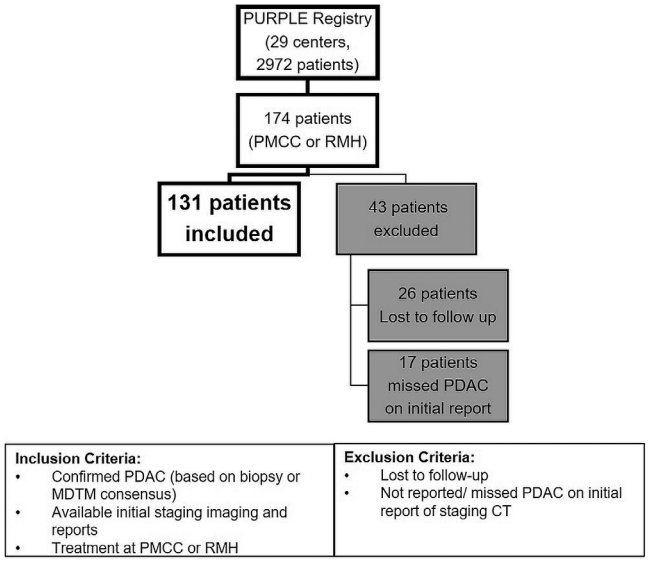

Fig. 1. Patient selection flowchart with inclusion and exclusion criteria.

which included age, gender, smoking consumption, alcohol consumption and significant family history of cancer (Table 1).

The most common experienced symptom prior to diagnosis was pain (61.8%), followed by obstructive jaundice (34.4%) and weight loss (22.1%). At time of diagnosis Eastern Cooperative Oncology Group (ECOG) performance status was 0 in 72 (55.0%) of patients, ECOG 1 in 41 (31.2%) of patients while 18 (13.8%) patients had poor performance status of ECOG 2 and above (Table 1).

CT scanning characteristics

CT pancreatic protocol imaging (including slice thickness ≤3 mm) was performed in 69 (52.7%) patients with 66 of these scans (95.7%) deemed adequately timed for all phases regarding contrast administration. Overall, all remaining 62 out of 131 CTs were performed in portal venous phase with adequate contrast timing to enable synoptic reporting. Five patients underwent CT non-pancreas protocol scanning with slice thickness ≤3 mm scanning. Among these 74 patients (slice thickness ≤3 mm), 21 (16.0%) patients underwent CT imaging with slice thickness ≤1 mm. CT imaging with slice thickness >3 mm was found in 57 (43.5%) patients (Table 1).

CT imaging included multiplanar reformats in 127 (96.9%) patients with 69 (52.7%) patients having had their imaging completed at public hospitals and 62 (47.3%) patients being scanned at private imaging centres (Table 1).

Initial CT reporting characteristics

No initial CT reports were performed in a synoptic reporting style (Table 1).

CT image quality was deemed 'satisfactory' in 105 (80.2%) and deemed 'poor quality' in 26 out of 131 cases (19.8%) (Table 1).

Table 1 Patient and CT scan characteristics

Characteristic	Total patients ($n = 131$)
Patient characteristics (Number, %)	
Age at diagnosis (mean ± SD) (years)	64.94 ± 11.67
Males	68 (51.9%)
Never smoker	45 (34.4%)
History of heavy alcohol use	14 (9.5%)
Significant family history of cancer	39 (29.8%)
Common bile duct stented	56 (42.7%)
Symptoms at diagnosis: (Number, %)	
Symptomatic at diagnosis	117 (89.3%)
Pain	81 (61.8%)
Loss of weight >10%	29 (22.1%)
Obstructive jaundice	45 (34.4%)
New onset diabetes	8 (6.1%)
Gastric outlet obstruction	2 (1.5%)
Other symptoms	10 (7.6%)
ECOG status at diagnosis (Number, %)	
Grade 0	72 (55.0%)
Grade 1	41 (31.2%)
Grade 2	15 (11.5%)
Grade 3	3 (2.3%)
Grade 4	0 (0.0%)
Computed tomography features (Number, %)	
Scan features	
Image quality	
Satisfactory quality	105 (80.2%)
Poor quality	26 (19.8%)
Slice thickness	
Slice thickness >3 mm	57 (43.5%)
Slice thickness ≤3 mm	**74 (56.5%)**
Slice thickness ≤1 mm	21 (16.0%)
Pancreatic protocol and slice thickness ≤3 mm	**69 (52.7%)**
Non pancreatic protocol	**62 (47.3%)**
Contrast phase adequate for synoptic reporting	131 (100.0%)
Multiplanar reformats available	127 (96.9%)
Initial staging scan location	
Public tertiary hospital	69 (52.7%)
Private imaging service	62 (47.3%)
Initial reporting style	
Synoptic	0 (0.0%)
Non-synoptic	131 (100.0%)

Note: Equal or less than 3mm slice thickness and a dedicated pancreatic protocol are the NCCN recommended criteria to be used on CT imaging in pancreatic cancer.

Tumour morphology on initial CT reporting

Initial staging reports listed PDAC presence and location in 129 out of 131 (98.4%) cases and 118 out of these 129 (90.1%) reports contained tumour dimensions (Table 2). Tumour attenuation was commented on in 107 out of 129 (81.7%) cases. Out of 131 patients, initial reports listed the main pancreatic duct in 98 (74.8%) and the common bile duct in 91 (69.5%) cases (Table 2).

Tumour-vascular relationship

Out of the 131 patients, tumour relationships to the superior mesenteric artery (SMA), common hepatic artery (CHA) and coeliac axis (CA) were not mentioned in 69, 96 and 102 (52.7, 73.3% and 77.8%), cases respectively. Further characterization of arterial vessels by describing perivascular haziness and vessel contour change, respectively were absent on initial CT reporting in additional 13 and 1 (9.9% and 0.6%) cases for the SMA, in 7 and 5 (5.3%

Table 2 Tumour morphology descriptions and extra-pancreatic features on initial staging reports

Key morphology	Initial report (Number, %)
Tumour location	
Head/uncinate/neck	84 (64.0%)
Body/tail	45 (34.4%)
Unreported	2 (1.6%)
Tumour measurement	
Yes	118 (90.1%)
Unreported	13 (9.9%)
Tumour attenuation	
Hypo-attenuation	105 (80.1%)
Iso-attenuation	1 (0.8%)
Hyper-attenuation	1 (0.8%)
Unreported	24 (18.3%)
Main pancreatic duct reported	
Yes	73 (55.7%)
No	25 (19.1%)
Unreported	33 (25.2%)
Common bile duct reported	
Yes	60 (45.8%)
No	31 (23.7%)
Unreported	40 (30.5%)
Extra-pancreatic staging features	
Locoregional lymphadenopathy	
Present	35 (26.7%)
Absent	83 (63.4%)
Unreported	13 (9.9%)
Local disease	77 (58.8%)
Spread of disease unreported	0 (0.0%)
Distant metastatic disease	**54 (41.2%)**
Liver	38 (29.0%)
Spleen	8 (6.1%)
Renal	6 (4.6%)
Adrenal	2 (1.5%)
Stomach	5 (3.8%)
Lung	11 (8.4%)
Peritoneal or omental nodules	
Present	10 (7.6%)
Absent	100 (76.3%)
Unreported	21 (16.1%)

Note: Distaant metastatic disease is a heading whereas the specified organs in the fields underneath (liever, spleen, etc) are subheading of distant metastatic disease.

3.8%) cases for the CHA and in 9 and 5 (6.9% and 2.9%) cases regarding the CHA (Table 3).

Tumour relationship to the superior mesenteric vein (SMV) and main portal vein (MPV) was unreported in 64 and 73 cases (48.9% and 55.7%) cases, respectively. Out of the 64 SMV and 73 MPV reported cases, perivascular haziness was unreported in an additional 20 and 15 (15.2% and 11.5%) cases and venous contour irregularity was unreported in an additional 4 and 2 (3.0% and 1.6%) cases, respectively. The presence or absence of a venous thrombus was unreported in 80 (61.1%) and venous collateral unreported in 109 (83.2%) out of 131 initial staging reports (Table 3)

Loco-regional and metastatic disease reporting

All initial 131 reports specifically mentioned the presence of absence of loco-regional and distant metastatic disease. Locoregional lymphadenopathy was present in 118 (90.1%) and distant metastatic disease in 54 (41.2%) reports. The most common metastatic sites were the liver (29.0%), lung (8.4%) and kidney (4.6%) (Table 2).

Comparison of initial and centralized sub-specialized staging

Out of the total 131 patients, sub-specialist radiological staging determined 13.7% of patients with resectable, 13.0% with borderline resectable, 30.5% with locally advanced unresectable and 42.7% of with metastatic unresectable disease (Table 4, Fig. 2).

Initial staging reports provided complete information regarding NCCN resectability status in 72 out of 131 (55.0%). Out of these 72 patients, initial CT staging deemed 4.6% cases as resectable, 1.6% as borderline resectable, 3.8% as locally advanced unresectable disease and 45.0% as metastatic unresectable disease (Table 4).

Table 3 Tumour-vascular relationship descriptions on initial staging reports

Tumour-vascular relationship	Tumour-vascular contact (Number, %)					Perivascular haziness/ stranding (Number, %)				Focal vessel narrowing or irregularity (Number, %)		
	None	≤180°	>180°	Occluded	Unreported	None	≤180°	>180°	Unreported	Present	Absent	Unreported
Superior mesenteric artery (SMA)	48 (36.6%)	11 (8.4%)	3 (2.3%)	-	69 (52.7%)	41 (31.3%)	7 (5.3%)	1 (0.8%)	82 (62.6%)	1 (0.8%)	60 (45.8%)	70 (53.4%)
Celiac axis (CA)	24 (18.3%)	5 (3.8%)	4 (3.1%)	2 (1.5%)	96 (73.3%)	23 (17.6%)	2 (1.5%)	3 (2.3%)	103 (78.6%)	3 (2.3%)	27 (20.6%)	101 (77.1%)
Common hepatic artery (CHA)	17 (13.0%)	5 (3.8%)	6 (4.6%)	1 (0.8%)	102 (77.8%)	14 (10.7%)	1 (0.8%)	5 (3.8%)	111 (84.7%)	5 (3.8%)	19 (14.5%)	107 (81.7%)
Superior mesenteric vein (SMV)	34 (26.0%)	21 (16.0%)	10 (7.6%)	2 (1.5%)	64 (48.9%)	33 (25.2%)	12 (9.2%)	2 (1.5%)	84 (64.1%)	12 (9.2%)	51 (38.9%)	68 (51.9%)
Main portal vein (MPV)	38 (29.0%)	13 (9.9%)	4 (3.1%)	3 (2.3%)	73 (55.7%)	35 (26.7%)	6 (4.6%)	2 (1.5%)	88 (67.2%)	8 (6.1%)	48 (36.6%)	75 (57.3%)
Additional venous features	(Number, %) Present	Absent	Unreported									
Venous thrombus	8 (6.1%)	43 (32.8%)	80 (61.1%)									
Venous collaterals	15 (11.5%)	7 (5.3%)	109 (83.2%)									

Table 4 Initial versus sub-specialist staging discrepancies

Initial Staging (total *n* = 131)	Sub-specialist Staging (total *n* = 131)	Discrepancy category	Key Discrepancies	Cases per Initial Stage
Resectable *n* = 6 (4.6%)	**Resectable *n* = 3 (2.3%)**	NA	None	3 (50.0%)
	Locally Advanced *n* = 3 (2.3%)	Poor tumour vascular assessment	SMV - tumour abutment underestimated, extension to first jejunal branch unreported	3 (50.0%)
Borderline resectable *n* = 2 (1.6%)	**Borderline *n* = 1 (0.8%)**	NA	None	1 (50.0%)
	Locally Advanced *n* = 1 (0.8%)	Poor tumour vascular assessment	SMV - tumour abutment underestimated, extension to first jejunal branch unreported	1 (50.0%)
Locally advanced unresectable *n* = 5 (3.8%)	**Borderline *n* = 1 (0.8%)**	Poor tumour vascular assessment	CHA - tumour involvement and extension overestimated	1 (20.0%)
	Locally Advanced *n* = 4 (3.0%)	NA	None	4 (80.0%)
Metastatic unresectable *n* = 59 (45.0%)	**Resectable *n* = 2 (1.6%)**	Metastatic disease overcall	Overcall of lung nodules as metastatic disease	2 (4.4%)
	Borderline *n* = 4 (3.0%)	Metastatic disease overcall	Overcall of lung nodules as metastatic disease	1 (2.2%)
			Adrenal and renal spread overcalled	2 (4.4%)
			Peritoneal/Omental metastatic disease overcalled	1 (2.2%)
	Locally Advanced *n* = 6 (4.5%)	Metastatic disease overcall	Peritoneal/Omental metastatic disease overcalled	2 (4.4%)
			Liver metastatic disease overcalled	2 (4.4%)
			Adrenal and splenic involvement overcalled	1 (2.2%)
			Adrenal involvement overcalled	1 (2.2%)
	Metastatic *n* = 47 (35.9%)	NA	None	47 (79.7%)
Incomplete initial reporting *n* = 59 (45.0%)	**Resectable *n* = 13 (9.9%)**			
	Borderline *n* = 11 (8.4%)			
	Locally Advanced *n* = 26 (19.8%)			
	Metastatic *n* = 9 (6.9%)			

Note: Pancreatic cancer international staging has 4 clinical categories that determine treatment and are indicative of prognosis. We chose a colour scheme that is similar to a colour scheme used with traffic lights or often used in project management (green, yellow, orange, red). resectable= green means that the patient can undergo surgery (= best prognosis) borderline resectable= yellow means the patient should receive neo-adjuvant therapy that would downstage the disease and the patient would be resectable locally advanced and metastatic categories are both unresectable status and the differentiation is the extent of disease which also correlates with overall survival.

Where complete initial staging reports were available ($n = 72$) initial versus sub-specialist reporting showed a discrepancy in 17 (23.6%) patients. The most common cause of discrepancy (12 out of 17 (70.6%) patients) was classifying locoregional spread or lung or liver lesions as metastatic disease on initial staging reports. The most common cause of up-staging on sub-specialist imaging review was due to undercalled SMV vascular involvement in 4 out of 17 (23.5%) patients (Table 4).

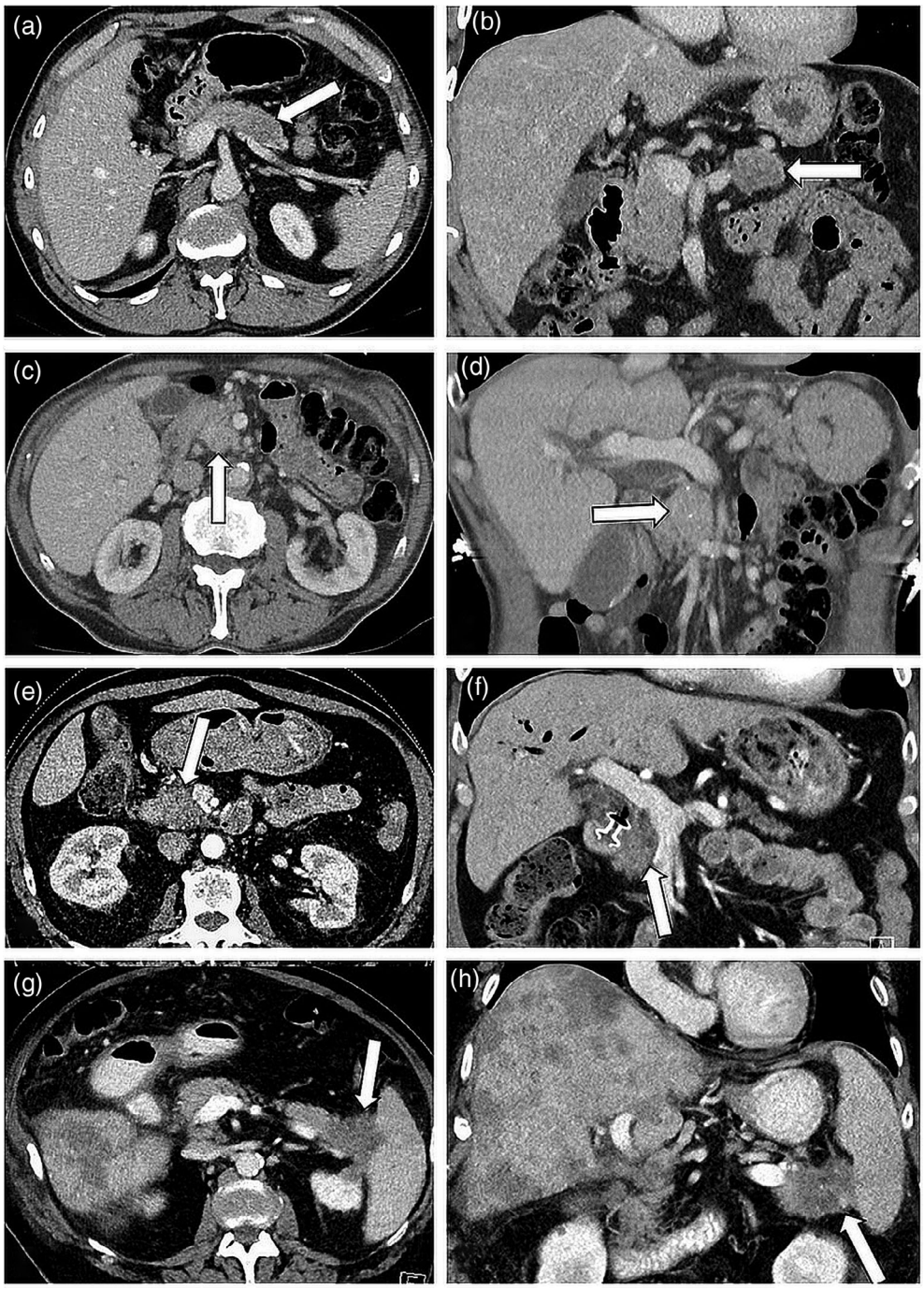

Fig. 2. a/b: Resectable 36 mm PDAC in the body and tail in a 64-year-old man in axial (a) and coronal (b) reformats showing mildly hypodense and heterogenous PDAC (white arrow). c/d: borderline resectable 26 mm PDAC in a 76-year old man in axial (c) and coronal (d) reformats showing heterogeneous PDAC (white arrow). e/f: locally advanced 36 mm PDAC in a 71-year old male with at the head/ uncinate process in coronal (a) and axial (b) reformats showing mildly heterogeneous PDAC (white arrow) with SMV involvement. g/h: metastatic 53 mm PDAC in a 79-year old man at the pancreatic tail with coronal (a) and axial (b) reformats showing ill-defined hypodense PDAC (white arrow) with splenic and left renal involvement.

Discussion

PDAC mortality has largely remained unchanged over the last decades which is caused by multiple factors including the lack of cardinal symptoms at presentation, delayed detection, rapid spread of disease and limited efficacy of current therapeutic options.[24] However, the incidence and death rate of pancreatic cancer is rising globally. It is predicted to become the second leading cause of cancer related deaths within the next 10 years.[1,3] These statistics flag the importance of earlier detection, and accurate staging of pancreatic cancer to ensure optimal management and outcomes. Patient undergoing R_0 resection and adjuvant chemotherapy have the highest overall survival with median survival times reported between 20.1 and 29.2 months versus to the reported 8 and 15.2 months median survival for patients with margin positive (R_1) resection.[25–27]

This study highlights multiple issues regarding current real-world practice:

First, the need to increase the proportion of gold standard CT pancreatic protocol including thin slice (≤3 mm) imaging and secondly, to improve reporting standards for patients with suspected PDAC.

In our study, just slightly more than half of patients (n = 74, 56.5%) had CT imaging including ≤3 mm thin slice reformats and in even less patients (n = 69, 52.7%) a CT pancreas protocol was

performed. The low proportion of gold-standard CT scanning technique might be explained by lack of cardinal symptoms and CT indication being rather nonspecific and not including PDAC. In addition, CT scanning with thicker slice reformats >3 mm is likely a reflection of the difference between a CT scan performed at a private imaging clinic versus at a tertiary referral centre. Nearly half of our cohort (62 patients, 47.3%) had their CT performed at a private radiology practice, which is similar to the number of scans that only had thick slice reformats.

All 131 initial staging reports in our study lacked a synoptic reporting style. This likely is closely linked to the observed high proportion of missing key imaging findings (59 cases, 45.0%) that are required to determine the patient's resectability status.

Though recommended by diverse guidelines and preferred by clinicians,[28–32] the uptake and use of synoptic reporting—in particular regarding PDAC staging—is highly variable among radiologists given the extra time and effort required.[32–35]

In contrast, very few have examined the accuracy and completeness rates of CT reporting in free form style. A review by Marcal *et al.* in 2015 showed that in 20.3% of reports resectability status could not be determined on reporting alone, which was lower than the 45.0% found within our study.[36] Similarly, the reporting of vascular involvement was highly variable and often absent with unreported tumour-arterial and tumour-venous relationships in 77.8% and 55.7%, respectively leading to additional imaging request and treatment delays.

Our study showed only 72 of 131 initial CT staging reports to be complete and able to determine NCCN resectability criteria. Seventeen (23.6%) out of these 72 patients with complete initial staging reports showed a major discrepancy between initial reporting and sub-specialist resulting in a change of NCCN staging.

There was a trend towards overcalling of metastatic disease with adrenal, renal and splenic involvement and liver, peritoneal or lung lesions being false positives, which contrasts with a retrospective study by Lauritzen *et al.* which evaluated 1071 double-read abdominal CTs from five different hospitals. Their study showed a trend towards under-calling of significant findings by initial reporting radiologists compared to sub-specialist review, however, their study included all CT abdominal reports which contained a high proportion of emergency cases and therefore was not selective regarding PDAC staging CTs.[37] Furthermore, as recently described by Chong *et al.* non-sub-specialized reporting has higher risk in erroneous interpretation of key imaging features[38] This might result in suboptimal patient care.

Overall, this study is not without limitations given its retrospective nature. Our data was collected at two major tertiary metropolitan hospitals and consequently the results might not be applicable in a rural or remote setting. Finally, additional restaging by more than one sub-specialty radiologist would have further strengthened this study's evidence.

In summary, this study highlights ways that radiological reporting can be improved to ensure that PDAC patients will receive best practice treatment.[7] Measures like synoptic and sub-specialized radiological reporting are particularly important in determining resectability and are the foundation of any subsequent treatment decision such as neoadjuvant therapy or surgical exploration. Inaccurate or incomplete imaging staging may require additional imaging, further radiological and MDTM reviews and poses risk treatment delay and poorer outcomes.

Ultimately, despite novel therapeutic options and more personalized medicine, these staging difficulties and inaccuracies could lead to skewness of outcome measures and potential misinterpretation of treatment efficacy. This might be one of the reasons why PDAC prognosis has not been lifted significantly over the last decades.

Further prospective studies are needed to measure the true impact on patient outcomes of CT scanning techniques in public versus private setting, metropolitan versus rural/ remote areas and synoptic and sub-specialist reporting in patients with suspected or newly diagnosed PDAC. This will hopefully lead to an increased uptake on optimal CT scanning technique, increased staging accuracy and better prognosis of PDAC patients.

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Author contributions

Alexander Grogan: Data curation; formal analysis; validation; writing – original draft. **Benjamin Loveday:** Writing – review and editing. **Michael Michael:** Writing – review and editing. **Hui-Li Wong:** Writing – review and editing. **Peter Gibbs:** Funding acquisition. **Benjamin Thomson:** Data curation. **Belinda Lee:** Funding acquisition; project administration; resources; supervision; writing – review and editing. **Hyun Soo Ko:** Conceptualization; data curation; formal analysis; investigation; methodology; project administration; resources; software; supervision; validation; visualization; writing – original draft; writing – review and editing.

Conflict of interest

None declared.

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Supporting information

Additional Supporting Information may be found in the online version of this article at the publisher's web-site:

Table S1: Summary of NCCN Guidelines regarding resectability