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Improved Resection Rates in Locally Advanced Pancreatic Cancer (LAPC) Following EUS-FNI of Large Surface Area Microparticle Paclitaxel (LSAM Pac)

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ACCEPTED: BILIARY

S1

Machine Learning for Classification of Indeterminate Biliary Strictures During Cholangioscopy

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Introduction: Indeterminate biliary strictures remain a diagnostic challenge despite advancements in radiologic, endoscopic, and laboratory testing. More than 25% of patients presumed to have malignant strictures during cholangioscopy show benign pathology after major surgical intervention. Interpretation of the visual findings during cholangioscopy remains challenging even for experienced endoscopists. We therefore aimed to develop a software tool that classifies indeterminate biliary strictures as benign or malignant using both cholangioscopy images and clinical data.
Methods: Our dataset included cholangioscopy images and clinical data from a retrospective cohort of patients undergoing cholangioscopy for evaluation of indeterminate biliary strictures. We annotated images for abnormal features suggestive of malignancy, including papillary mass, dilated and tortuous vessels and ulceration. We trained a convolutional neural network (CNN) based on ResNet-18 to detect presence of abnormal image features and tested it in patients of independent centers (external validation). We used multiple outputation to analyze the patient as the unit of analysis and estimated accuracy, sensitivity, specificity, positive and negative predictive values (PPV and NPV), and area under the receiver operating characteristic curve (AUC).
Results: A total of 1,371,605 cholangioscopy images were obtained from 528 patients at 25 centers (13 North America, 7 Asia, 2 Europe, 2 Australia, 1 South America). Our training set included data from 254 patients at 14 centers, and the test set included data from 95 patients at 8 other independent centers. Table 1 shows the proportion of patients with abnormal cholangioscopy image features according to their final diagnosis. For detection of abnormal image features, the CNN showed a sensitivity of 0.81 (95% confidence interval: 0.72 to 0.91); specificity 0.91 (0.86 to 0.97); PPV 0.93 (0.88 to 0.98); NPV 0.77 (0.66 to 0.88); and AUC 0.86 (0.80 to 0.92).
Conclusion: Using data from a large cohort of patients across the world, we trained and externally validated a CNN that can detect key cholangioscopy image features suggestive of malignancy and thus support intra-procedural decision-making. Our next step is to enhance the CNN with clinical data and evaluate it for diagnosing and predicting malignancy in indeterminate biliary strictures. This can improve clinical outcomes through accurate diagnosis of disease and prevention of unwarranted surgical intervention.

[0001] **Table 1. Proportion of patients with cholangioscopy images showing abnormal features (suggestive of malignancy) according to their final diagnosis.**

	Malignant Biliary Stricture (N=217)	Benign Biliary Stricture (N=132)
Abnormal Cholangioscopy Image Features		
Papillary Mass; n (%)	144 (66.3)	31 (23.5)
Dilated and Tortuous Vessels; n (%)	79 (36.4)	10 (7.6)
Ulceration; n (%)	51 (23.5)	10 (7.6)

S2

Improved Resection Rates in Locally Advanced Pancreatic Cancer (LAPC) Following EUS-FNI of Large Surface Area Microparticle Paclitaxel (LSAM Pac)

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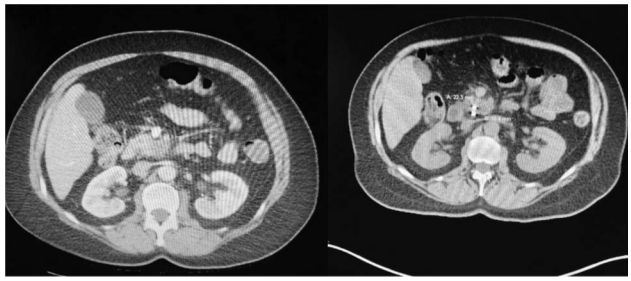
Introduction: LAPC is generally defined as unresectable disease without evidence of metastatic spread, and reports suggest between 8-25% of these patients may become resectable following current standard of care (SOC) therapy. EUS-FNI allows for the delivery of drug therapies directly into the tumor, which led to the development of LSAM pac currently being evaluated in LAPC and other solid tumors by means of direct injection, where the particles of pure drug act as a depot releasing paclitaxel over several weeks.
Methods: Clinical study [NCT # 03077685] enrolled patients with LAPC, confirmed non-surgical despite SOC therapy, to additionally receive LSAM pac (NanOlogy, Inc) via EUS-FNI into the tumor during a dose-escalation phase followed by a second phase where 2 doses of 15 mg/mL LSAM pac



[0002] **Figure 1.** Before and after EUS FNI-reduction of SMA involvement and size

[0002] **Table 1. Treatment Details**

Subject ID	Stage at Diagnosis	Treatments pre	LSAM pac INJ Dates	Treatments post	Surgery Date	Margins	Regional Lymph
4001	T2N0M0 SMA involvement	FOLFIRINOX Sep 2018 SBRT Nov 2018	8JAN2019 4FEB2019	22JAN2019 GEM/Abrax (tox)	1JUN2019	All Negative	0/14
4005	T2N1M0 Portal Vein and SMV abutment	Gem/Abrax Apr 2019 FOLFIRINOX Jun 2019	12JUN2019 11JUL2019	IMRT Mar2020	18JUN2020	All Negative	0/10
4006	T4N0M0 encased GDA, 180° involved SV at entry portal confluence. 5-8mm length of abut/encase SMA < 180°	FOLFIRINOX Mar 2019 (nephrotox)	24JUN2019 24JUL2019	SBRT OCT2019	30JAN2020	All Negative	1/15
4007	T2N0M0 encasement of GDA; abuts Portal Vein for 1.9cm	Gemzar Feb 2019 (nephrotox) SBRT Jul 2019	7OCT2019 4NOV2019		13MAR2020	No evidence of residual tumor	0/41
4013	T4N1M0 encases entire Celiac Axis, Splenic Artery. Left Gastric Artery, involvement of Hepatic Artery	FOLFIRINOX Jun2019 Gem/Abrax Sep2019	2JAN2020 29JAN2020	IMRT (Xeloda) JUL2020	24SEP 2020	Uninvolved margins	0/32
4012	T2N1M0 There is less than 180° of involvement of the Hepatic Artery & involvement of the SMA	FOLFIRINOX Sep 2019	16DEC2019 13JAN2020		6APR2020	SMV and SMA margins Positive, Uncinate margin 0.5mm, Pancreatic neck margin extranodal extension identified	8/13

were administered 1 month apart. The aim was to determine safety and tolerability of LSAM pac when injected directly into the lesion and assess the impact on the lesion by means of imaging assessments every 3 months following first injection. Parkview Cancer Institute (Ft Wayne, IN) enrolled 13 of the 22 subjects in the second phase of the trial.

Results: There were no safety concerns identified. Of the 13 subjects from Parkview, seven (54%) were restaged becoming eligible for surgery following LSAM pac injections. Of the seven, 6 proceeded to surgery, 1 opted to receive alternate treatment. Five resulted in successful R0 resections, the 6th resulted in R1 resection (Table 1). Multiplex immunofluorescence analysis of biopsy samples from pre-LSAM pac and surgical specimens in 5 subjects (one pending analysis) demonstrated an increase in the density of adaptive and innate immune cells and an increase in NK cells in the tumor microenvironment, and a decrease in the myeloid/MDSC populations.

Conclusion: Approximately 30% of pancreatic cancer patients are considered non-surgical due to involvement of local arterial or venous structures. Existing treatment options are relatively ineffective in producing changes in the tumor to allow for conversion, and surgery still provides the best outcome. We present early findings in a series of 13 subjects with a conversion rate of 54%. LSAM pac increased the rate of conversion to resectable in these subjects without increasing toxicities associated with systemic chemotherapy. Due to theses promising results, the clinical trial is ongoing, enrolling subjects to receive up to 4 injections one month apart.

S3

Identification of Patients at Risk for Pancreatic Cancer in a 3-Year Timeframe Based on Machine Learning Algorithms in the Electronic Health Record

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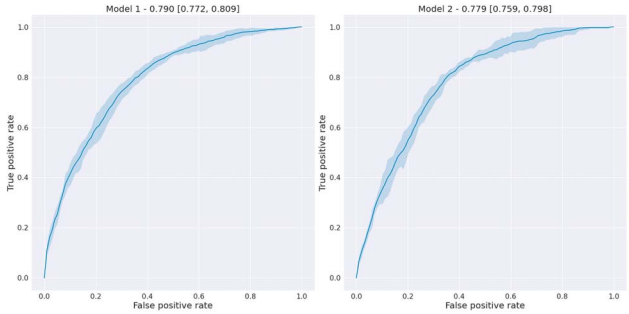
Introduction: Early detection of pancreatic cancer (PC) remains challenging largely due to the low population incidence and few known risk factors. However, screening in at-risk populations and detection of early cancer has the potential to significantly alter survival. We used an Electronic Health Records (EHR) based large-scale machine learning algorithm to identify disease codes that are associated with the development of PC at least 3 years before diagnosis and developed a predictive model to identify patients at risk for PC 27-33 months later.

Methods: EHR data was analyzed between 2000 and 2021 and individuals with at least 3 years of continuous presence in the database were included. A 1:4 case-control matching based on age, sex, length of medical history to all diagnosed with PC was performed. In one model, all patients meeting database presence were included, whereas in a second model only those without known prior pancreatic disease were evaluated. Among demographic and 19,304 disease variables 27-33 months prior to PC diagnosis, we used the *P*-value of associations to select significant variables (cut-off *P*-value $<$ 0.01), and trained a logistic regression model. Final predictive performance was tested on a held-out validation cohort.

Results: 544,000 patients were analyzed. 2091 patients with PC were matched to 8364 cancer-free patients. We identified 73 variables with significant association of development of PC, including pancreatic cysts, diabetes, family or personal history of breast cancer, and chronic pancreatitis (ranked results and statistical analysis are shown in Table 1). These variables were selected for the regression model, which we trained in over 541,602 patients. In our second model, in patients without prior pancreatic diseases, 541,377 patients were included. The area under the receiver operating characteristic curve (AUROC) were 0.790 [0.772, 0.809] and 0.779 [0.759, 0.789] in the two models respectively.

Conclusion: In a robust EHR-based analysis, we identified a list of diagnostic variables associated with pancreatic cancer development in a 3-year time frame and developed a model to identify patients at risk. Although the inclusion of additional variables such as laboratory results and radiomics will likely improve the accuracy of the model, the current algorithm will allow us to develop an EHR-based identification of patients at risk for PC.



[0003] **Figure 1.** The ROC curves of models 1 and 2 on the held-out validation set from the overall patient cohort.

[0003] **Table 1. The top 10 variables with significant positive association to PC**

ICD10 Codes	Description	*P*-value	Unadjusted Odds Ratio	*P*-value (Model 1)	Adjusted odds Ratio	*P*-value (Model 2)	Adjusted odds Ratio
			[95% Confidence Interval]		(Model 1) [95% Confidence Interval]		(Model 2) [95% Confidence Interval]
K86.89	Other specified diseases of pancreas	1.50E-06 **	5.49 [2.52, 11.96]	0.00E+00 ***	4.357 [3.629, 5.084]	NA	NA
D49.0	Neoplasm of unspecified behavior of digestive system	1.05E-08 **	8.05 [3.44, 18.84]	0.00E+00 ***	4.064 [3.414, 4.715]	0.00E+00 ***	5.220 [4.468, 5.972]
Z15.09	Genetic susceptibility to other malignant neoplasm	1.17E-05 **	5.23 [2.29, 11.94]	0.00E+00 ***	3.232 [2.498, 3.966]	1.30E-13 ***	3.246 [2.330, 4.162]
C64.9	Malignant neoplasm of unspecified kidney, except renal pelvis	7.89E-03	2.87 [1.27, 6.46]	1.60E-09 ***	2.689 [1.856, 3.522]	6.01E-08 ***	1.979 [1.484, 2.474]
K86.2	Cyst of pancreas	6.21E-29 **	14.45 [7.79, 26.80]	2.44E-15 ***	2.617 [1.978, 3.255]	NA	NA
K85.90	Acute pancreatitis without necrosis or infection, unspecified	4.98E-03	4.01 [1.41, 11.45]	8.44E-14 ***	2.579 [1.950, 3.207]	NA	NA
Z15.01	Genetic susceptibility to malignant neoplasm of breast	8.97E-05	4.91 [2.03, 11.86]	1.40E-05 **	2.500 [1.602, 3.399]	5.39E-04 **	2.181 [1.251, 3.110]
E11.9	Type 2 diabetes mellitus without complications	4.71E-05 *	1.47 [1.22, 1.76]	0.00E+00 ***	1.967 [1.868, 2.067]	0.00E+00 ***	1.770 [1.627, 1.913]
Z80.9	Family history of malignant neoplasm, unspecified	2.51E-04	3.35 [1.69, 6.66]	0.00E+00 ***	1.765 [1.560, 1.969]	3.57E-05 **	1.665 [1.277, 2.053]
M19.049	Primary osteoarthritis, unspecified hand	9.46E-03	3.21 [1.26, 8.14]	3.11E-07 ***	1.715 [1.359, 2.070]	2.54E-03	1.527 [1.134, 1.920]

The unadjusted odds ratios of PheWAS on the case-control cohort and adjusted odds ratios of two models on the overall cohort are listed. Note that "NA" exists in model 2 because patients with known prior pancreatic diseases were not included in this study. *The statistically significant features under Bonferroni correction are marked (*** means corrected *P*-value $<$ 0.001; ** means corrected *P*-value $<$ 0.05; * means corrected *P*-value $<$ 0.1).

S4

Time-Trends, Outcomes and Risk Factors of Portal Vein Thrombosis in Acute Pancreatitis Patients: A Propensity-Matched National Study

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Introduction: Portal vein thrombosis (PVT) is a rare complication of acute pancreatitis (AP) and might be associated with worse outcomes. We aimed to study trends, outcomes, and risk factors of PVT in AP patients.

Methods: The National Inpatient Sample database was utilized to identify the adult patients (>18 years) with primary diagnosis of AP from 2004 and 2013 using International Classification of Disease, Ninth Revision. Patients with and without PVT were entered into a nearest neighbor 1:1 variable ratio propensity-matching model on baseline variables. Outcomes assessed included need for percutaneous drainage, surgery, in-hospital mortality, acute kidney injury (AKI), shock, need for mechanical ventilation, total cost, and length of stay (LOS). A multivariate logistic regression analysis was done to identify risk factors of PVT in AP.

Results: Amongst the total of 2,389,337 AP cases, 7,385 (0.3%) had associated PVT. The overall mortality of AP decreased throughout the study period whereas mortality of AP with PVT remained stable (1-5.7%, *P*-trend = 0.3) (Figure 1). After propensity matching, 7,385 and 7,400 patients with and without PVT were assessed. Compared to non-PVT patients, AP with PVT patients had significantly higher in hospital mortality (3.3% vs 1.3%), AKI (13.5% vs 0.7%, shock (2.2% vs 0.6%) and need for mechanical ventilation (0.7% vs 0.2%) ($P < 0.001$ for all). AP with PVT also had significantly higher cost of hospitalization (84881±140425 vs 34,185 ± 75427, $P < 0.001$) and length of stay (12.3± 15.4 vs 5.7± 7.1, $P < 0.001$) as compared to patient without PVT. Lower age (Odd ratio [OR], 95% CI, 0.99-0.99, Female (OR 0.75), African Americans (OR 0.57), Hispanics (OR 0.62), gallstone pancreatitis (OR 0.71, 95% CI, 0.65 - 0.76), obesity (OR 0.75, 95% CI, 0.68 - 0.82), antiplatelet (OR 0.51, 95% CI 0.41 – 0.61) had significantly lower risk of PVT whereas alcoholic pancreatitis (OR 1.45, 95% CI, 1.38 - 1.54) cirrhosis (OR 1.73, 95% CI 1.5 – 1.92), Charlson Comorbidity Index >2 (OR 1.85, 95% CI 1.73 – 1.97) and coagulopathy (OR 1.86) were associated with significantly higher rates of PVT ($P < 0.001$ for all).

Conclusion: PVT in AP is associated with a significantly higher risk of death, AKI, shock, and need for mechanical ventilation. Male gender, older age, whites, and alcoholic pancreatitis is associated with higher risk of PVT in AP patient. Further research is needed to determine the influence of disease activity and risk mitigation strategies in this patient population.