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## International Journal of Surgery Case Reports

journal homepage: [www.casereports.com](http://www.casereports.com)

# Distal pancreatectomy with celiac axis resection (DP-CAR): Optimal perioperative outcome in a patient with locally advanced pancreas adenocarcinoma

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## ARTICLE INFO

## Article history:

Received 19 July 2020

Received in revised form

28 September 2020

Accepted 29 September 2020

Available online 2 October 2020

## Keywords:

Borderline pancreatic cancer  
Locally advanced pancreatic cancer  
Celiac axis resection  
Distal pancreatectomy  
DP-CAR  
Hepatic artery resection  
Appleby operation  
Pancreatectomy

## ABSTRACT

**INTRODUCTION:** Distal pancreatectomy with en bloc celiac axis resection (DP-CAR) is an operation technically demanding, uncommonly performed, even in high-volume pancreatic centers, which may offer a curative resection in patients with locally advanced cancer of the body of the pancreas, otherwise considered unresectable.

**PRESENTATION OF CASE:** We present, in clinical and technical detail, a patient with DP-CAR with a very good intraoperative and postoperative course, no complications, short hospital stay, and histology consistent with a curative resection.

**DISCUSSION:** Because of the scarcity of DP-CAR, even high-volume individual centers have been able to gather relatively limited experience, and only in a time frame of more than a decade each.

**CONCLUSION:** DP-CAR can be curative for a minority of patients with pancreatic adenocarcinoma and is performed only in centers with a long, dedicated interest in advanced pancreatic surgery with a well-known track record in resection of borderline and locally advanced pancreatic cancer involving major peripancreatic veins.

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## 1. Introduction

Distal pancreatectomy associated with celiac axis resection (DP-CAR) for locally advanced pancreatic cancer (PC), according to the NCCN criteria (Version 1.2020, 11/26/19), is a very uncommon operation, even in well-established, high-volume pancreatic centers. In a recent multi-institutional study, the cumulative experience of 23 hospitals (2000–2017), added up to 191 patients [1]. A meta-analysis, involving mostly Japanese centers, provided data on 283 patients from 18 studies over 38 years [2]. In either of these two large studies the annual number of DP-CAR per hospital is calculated at 0.4 or 0.5. Of course, in very high-volume centers, the

annual number is certainly higher and varies between 2.5 and 3.8 [1,3].

DP-CAR is generally associated with significant mortality and morbidity, much higher than “straightforward” pancreatoduodenectomy, or DP, even in experienced hands. Mortality is reported around 10% [1,2,4,5] and varies between 3.5% and 18% [3,6–9], although nil mortality has also been documented [10–12]. Median survival after DP-CAR is generally less than 20 months [1,2,4,6], but this may reflect older experience before neoadjuvant chemotherapy (NAC) was the rule for locally advanced PC. When NAC is administered, median survival may increase to 2–3 years [3,7,9]. Because DP-CAR is only sporadically performed and individual experience is limited, an orchestrated international effort by highly respected pancreatic surgeons [13] was made, so that safe and evidence-based guidelines for the indications, contraindications, management algorithms, and technicalities for this operation can be formed for wider application.

We hereby present a case of DP-CAR with excellent perioperative outcome. To the best of our knowledge this is the first DP-CAR in our country. Written informed consent was obtained from the patient for publication of this case report and accompanying images. A copy of the written consent is available for review by the Editor-in-Chief of this journal on request. This work is exempt

**Abbreviations:** CA, celiac axis; CHA, common hepatic artery; CT, computed tomography; DP-CAR, distal pancreatectomy with celiac axis resection; EBL, estimated blood loss; GDA, gastroduodenal artery; ICU, intensive care unit; LFTs, liver function tests; NAC, neoadjuvant chemotherapy; PC, pancreatic cancer; PHA, proper hepatic artery; PV, portal vein; SMA, superior mesenteric artery; SMV, superior mesenteric vein.

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<https://doi.org/10.1016/j.ijscr.2020.09.194>

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from approval from our institution's ethics committee and has been reported in line with the SCARE criteria [14].

## 2. Case report

A 74-year-old man presented with a two-month history of mild-to-moderate upper abdominal pain and a five-month history of new onset non-insulin dependent diabetes mellitus. He denied back pain, weight loss, decreased appetite, or other symptoms. He was a younger-looking, nonsmoker, active, busy professional with excellent performance status and a body mass index of 27.1 kg/m<sup>2</sup>. His past medical history included only hypertension, easily controlled with one medication. He had no family history of cancer. Physical exam and routine blood work including liver function tests (LFTs) and bilirubin were normal. Ultrasonography showed an "abnormality" in the body of the pancreas. CA 19-9 was <1.2 u/mL and CEA was 22 u/mL. Computed tomography (CT) demonstrated a 4 cm low-density tumor in the body of the pancreas with retropancreatic extension engulfing the common hepatic artery (CHA) for 360° from its origin for a length of 3 cm, as well as the celiac axis (CA) for 360° sparing 0.5 cm of its origin from the aorta. The superior mesenteric artery (SMA), superior mesenteric vein (SMV), portal vein (PV), and the splenomesenteric vein junction were free of tumor. There was no evidence of liver or peritoneal metastases. Endoscopic ultrasonography with fine needle aspiration documented ductal adenocarcinoma. NAC was initiated with FOLFIRINOX, but he was unable to tolerate more than four cycles (twice a month for four months), due to excessive degree of thrombocytopenia resistant to the appropriate and standard treatment, as well as significant decrease of his performance status. Neoadjuvant radiation was suggested, but the patient declined. Three weeks after NAC was discontinued, CT documented only slight decrease in the tumor size, but the pattern and degree of both CA and CHA involvement was unchanged (Figs. 1 and 2). Magnetic resonance imaging ruled out liver involvement and all imaging was negative for any distant metastatic disease. CEA level had decreased to 9 u/mL and CA 19-9 remained undetectable.

Given the overall good condition of the patient, his inability to complete NAC, the absence of metastatic disease, and the pattern of peripancreatic arterial involvement, a DP-CAR was planned (by the first author). To verify the patency of the SMA-PHA collateral, an angiography was performed with bilateral femoral access, test occlusion of the CHA and contrast injection through the SMA. After a satisfactory collateral network was documented, the CHA was embolized with coils until stasis. Special attention was paid in order to leave at least 1 cm of distal CHA free of coils for surgical manipulations. LFTs doubled initially, but came back to normal four days post-embolization.

Two weeks later, the patient was laparoscopically explored and absence of peritoneal, or omental seeding was secured. Intraoperative ultrasound ruled out intraparenchymal liver lesions. A bilateral subcostal incision was made. Interestingly, the GDA was unusually larger in diameter and had a very full and strong pulse. Normal flow in the PHA and minuscule flow in the CHA were recorded with doppler ultrasound. The anterior aspect of the SMA was dissected taking special care not to compromise its right aspect, where the pancreaticoduodenal artery(ies) takes off to eventually form the inflow of the GDA. The CHA was ligated and transected 1 cm proximal to the take-off of the GDA, the neck of the pancreas was dissected free from the SMV-PV and then transected, the inferior and posterior aspects of the body and tail of the pancreas were mobilized, as well as the spleen, so eventually the whole specimen was dependent upon only the CA. The left gastric artery was ligated 1 cm after its take-off from the CA. The gastroepiploic vascular arcade had been carefully preserved and dissection around the gas-

troesophageal junction had been kept at a minimum, so that blood supply to the stomach would be sufficient. The anterior, left and right aspects of the aorta were identified, the origin of the CA was dissected circumferentially and was found to be macroscopically free of tumor for 8 mm (Fig. 3). The CA was suture-ligated at 3 mm from its take-off and the specimen removed. Estimated blood loss (EBL) was 1200 ml and total operative time (including anesthesia time) was 510 min. The patient tolerated the operation very well, was intraoperatively transfused with one unit of packed red blood cells, was extubated in the operating room, did not require ICU stay and was transferred to his room. Next day's hemoglobin was 9.5 g/dL and remained stable throughout his hospitalization. His postoperative course was uneventful, he tolerated full liquids from the first postoperative day, bowel function resumed in the second day, and progressed to general diet in the fourth day. His abdominal drain was removed and was discharged in the sixth postoperative day in good condition. LFTs and bilirubin were normal at discharge. Pathology documented R0 resection (margin>1 mm), ypT1cN0 ductal adenocarcinoma. One month postoperatively, the patient has no abdominal symptoms, tolerates general diet, has loose stool twice daily (requiring loperamide), his diabetes is unchanged and LFTs are normal. He is fully cognizant that he underwent a very uncommon operation, which had a very good overall outcome and is about to return to his previous level of activity and adhering to the standard follow-up protocol.

## 3. Discussion

CA resection, first performed by Appleby [15] for locally extensive gastric carcinoma, has become one of the new frontiers in modern pancreatic surgery, so that curative resections can be performed for locally advanced cancer of the body of the pancreas, as defined by the NCCN criteria (Version 1.2020, 11/26/19). DP-CAR had been anecdotally performed for several years, but only over the last decade studies with more than single-digit number of patients have been published. This is probably not only because of the scarcity of patients suitable (anatomically and oncologically) for DP-CAR, but also because this operation is technically highly demanding and associated with significant morbidity and mortality.

Our division (led by the first author) has a long-standing dedication to pancreatic surgery and performs more than 30 pancreas resections annually. We have been performing pancreatectomies with SMV-PV resection and reconstruction for several years [16] for borderline and locally advanced PC and we have moved on to major peripancreatic arterial resections. The case presented is our first DP-CAR and, to the best of our knowledge, the first in Greece. Our patient was carefully selected, in that he had excellent performance status, his tumor and peripancreatic vascular anatomy were scrutinized and had completed all possible NAC that he could tolerate. His intraoperative course was smooth, he did not require ICU monitoring and care, his postoperative course was remarkably swift with no complications, such as hemorrhage, pancreatic fistula, gastropathy, delayed gastric emptying, chylous ascites, diarrhea, or failure to thrive.

We chose to perform preoperative CHA embolization to precondition the liver in arterial blood supply solely via the GDA, as is the rule in some centers [9,13,17]. Indeed, at exploration we found that the GDA was unusually wider and the blood flow through the PHA was normal. However, preoperative CHA embolization is not performed in several other high-volume pancreatic centers [13]. In a recent comparative study [7], no advantage was documented in 23 patients with CHA embolization before DP-CAR over 8 without. These authors proved that liver ischemia after DP-CAR developed in patients with GDA/PHA stenosis usually after operative dissec-

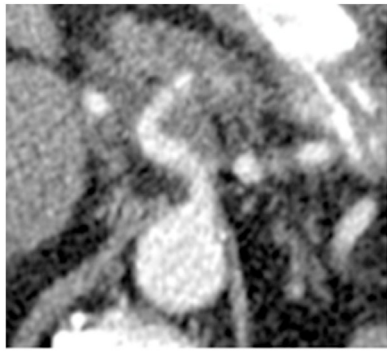


Fig. 1. CT (axial and sagittal planes): Tumor around CA.

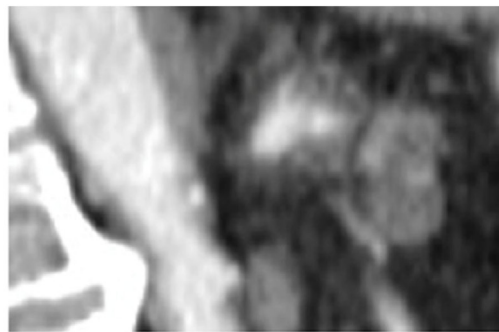
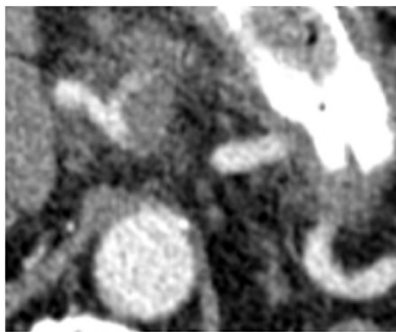


Fig. 2. CT (axial and sagittal planes): Tumor around the bifurcation CHA-splenic artery.

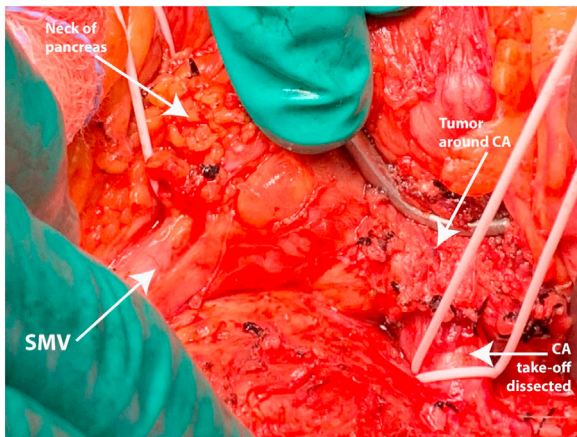


Fig. 3. CA take-off dissected free.

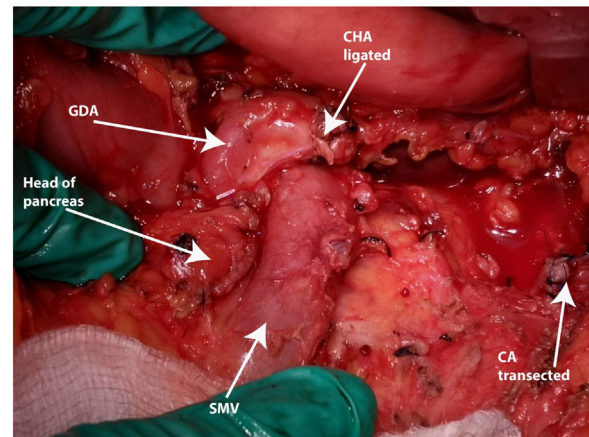


Fig. 4. CA and CHA ligated and transected. Note 1 cm CHA remnant proximal to GDA take-off.

tion of the tumor located too close to the GDA, which needed to be dissected off of it, but was not related to lack of preoperative CHA embolization. In our case, we took special care to stay away from the GDA, which was ligated 1 cm proximal to its take-off from the CHA (Fig. 4) and indeed, there was no liver compromise, as reflected in the normal LFTs and bilirubin postoperatively. In the literature, liver ischemic complications vary a lot: 0–62% [1,2,4,7,11,17,18], but seem to be around 20% in the larger studies [1,4,7]. Ischemic gastropathy is also not infrequent, ranging from nil [11,18] to 29% [9], but generally occurs in around 10% of patients [1,2,12,17]. Few authors emphasize the need for preservation, or reconstruction of the left gastric artery [17–19], whereas most others have not found the need for it. Our patient never complained postoperatively of any symptom that might allude to gastric pathology and upper endoscopy was not performed.

Postoperative pancreatic fistula (grade B/C) is a rather frequent complication after DP-CAR ranging from 10% [5] to 55–58% [7,9], but most commonly around 20–30% [1–4,11]. In general, Clavien-Dindo  $\geq 3$  complications are common: 25–41% [3,6,7,9,17] and certainly more frequent compared to DP alone [5]. Postoperative 30-day mortality is significant in all studies: 3.5–10% [4–6,9,17] and 90-day mortality even higher: 7–16% [1,3–5,7]. Either is very much higher than the respective mortality after DP alone, or pancreatoduodenectomy without vascular resection/reconstruction in centers of excellence. The reported median LOS is rather long around 20 days [2,4,11,17], not uncommonly over 30 days [7,9,18], and only rarely around 10 [3,5]. EBL for DP-CAR has been documented between 1000 and 1550 ml [1–3,11] and 29–67% of patients receive at least one blood transfusion perioperatively [1,3–5,11]. Our patient had uneventful recovery, had EBL of 1200 ml, received only one unit of blood, had stable hemoglobin postoperatively, did

not suffer any postoperative complication, and was discharged in good condition on the sixth postoperative day, all of which compare favorably to the published experience. R0 resection rate is much lower after DP-CAR compared to usual pancreatoduodenectomy or DP in centers of excellence and varies between 42% and 75% [1–3,6,7,17], which may in part reflect the absence of NAC in such studies covering a period of over two decades. Indeed, when NAC is the rule, R0 resection may increase to 80% [3], as in our case.

In summary, we presented a patient with locally advanced PC of the body of the pancreas involving the CHA and CA, who underwent DP-CAR, an operation rarely performed because of its unique oncologic, anatomic and technical features. Our patient had a curative resection, excellent postoperative course and recovery, reflecting the optimal possible outcome in published experience.

### Declaration of Competing Interest

The authors report no declarations of interest.

### Sources of funding

No funding was received for this work.

### Ethical approval

This work is exempt from approval from our institution's ethics committee.

### Consent

The patient's written and signed consent was obtained for publication of the case, as well as of all relevant imaging and operative photographs.

Written informed consent was obtained from the patient for publication of this case report and accompanying images. A copy of the written consent is available for review by the Editor-in-Chief of this journal on request.

### Author contribution

Gregory G. Tsiotos: Performed the operation, study concept, wrote the paper.

Nikiforos Ballian: Assisted in the operation, data collection, reviewed and edited paper.

Fotios Milas and Panoraia Ziogou: Assisted in the operation.

Ilias Athanasiadis: Administered neoadjuvant chemotherapy, reviewed and edited paper.

### Registration of research studies

1. Name of the registry: Research Registry.
2. Unique identifying number or registration ID: researchregistry5824.
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### Guarantor

Gregory G. Tsiotos, M.D.

### Provenance and peer review

Not commissioned, externally peer-reviewed.

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