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Case report

MODIFIED APPLEBY WITH LAPAROSCOPIC AORTO-HEPATIC BYPASS FOR PANCREATIC ADENOCARCINOMA: EXPANDING THE LIMITS

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Abstract

Celiac axis involvement has long defined unresectability in pancreatic ductal adenocarcinoma (PDAC) due to its association with adverse tumor biology and the risk of hepatic ischemia after arterial sacrifice. Contemporary neoadjuvant regimens and refined vascular techniques have challenged this paradigm. We report a 65-year-old woman with locally advanced PDAC of the pancreatic body encasing the celiac trunk, splenic artery, and proximal common hepatic artery. Following FOLFIRINOX-based neoadjuvant therapy, restaging demonstrated a marked biochemical and radiologic response, with no evidence of systemic disease. Given this favorable tumor biology, the patient underwent distal pancreatectomy with en bloc celiac axis resection (modified Appleby procedure) combined with a totally laparoscopic aorto-hepatic bypass to ensure reliable antegrade hepatic inflow. R0 resection was achieved without intraoperative morbidity. Final pathology revealed a moderately differentiated adenocarcinoma (ypT2N0) with perineural invasion. Postoperative recovery was uneventful, with preserved hepatic function and no ischemic or vascular complications. At 11 months, the patient remains recurrence-free, with sustained graft patency. This report demonstrates that, in highly selected responders to neoadjuvant therapy, radical arterial resection supplemented by minimally invasive vascular reconstruction is feasible, oncologically sound, and may extend the boundaries of curative-intent surgery in locally advanced PDAC within experienced multidisciplinary programs.

Key words: pancreatectomy, celiac artery, modified appleby procedure, neoadjuvant therapy

Resumen

Appleby modificado con bypass aorto-hepático laparoscópico para el adenocarcinoma pancreático: ampliando los límites

El compromiso del eje celíaco ha definido históricamente la irresecabilidad en el adenocarcinoma ductal de páncreas (ADP), debido a su asociación con biología tumoral adversa y al riesgo de isquemia hepática tras la resección arterial. Sin embargo, los esquemas neoadyuvantes contemporáneos y los avances en reconstrucción vascular han desafiado este paradigma. Presentamos una paciente de 65 años con ADP localmente avanzado del cuerpo pancreático, con compromiso del tronco celíaco, la arteria esplénica y el segmento proximal de la arteria hepática común. Tras quimioterapia neoadyuvante basada en FOLFIRINOX, la reestadificación evidenció una respuesta radiológica y bioquímica significativa, sin enfermedad sistémica. En este contexto de biología tumoral favorable, se realizó una pancreatectomía distal con resección en bloque del eje celíaco (procedimiento

de Appleby modificado) asociada a un bypass aorto-hepático totalmente laparoscópico para asegurar flujo arterial hepático anterógrado. Se logró resección R0 sin morbilidad intraoperatoria. La anatomía patológica confirmó adenocarcinoma moderadamente diferenciado (ypT2N0) con invasión perineural. La evolución posoperatoria fue favorable, con función hepática preservada y sin complicaciones isquémicas o vasculares. A los 11 meses, la paciente permanece libre de enfermedad, con permeabilidad sostenida del injerto. Este caso demuestra que, en pacientes altamente seleccionados con adecuada respuesta neoadyuvante, la resección arterial radical asociada a reconstrucción vascular mínimamente invasiva es factible, segura y potencialmente amplía los límites de resección con intención curativa en el ADP localmente avanzado.

Palabras clave: pancreatectomía; arteria celíaca, procedimiento de Appleby modificado, terapia neoadyuvante

Appleby described the first celiac axis (CA) resection in locally advanced gastric cancers in 1953[1]. The procedure included in bloc gastrectomy, distal pancreatectomy, and splenectomy associated with the resection of the CA and the hepatic artery (HA) proximal to the gastroduodenal artery (GDA). Liver vascularization is then based on the retrograde arterial blood flow through the GDA and also on the possibility of an aberrant HA emerging from the superior mesenteric artery (SMA) or a preserved left gastric artery[1,2].

To date, the most effective treatment for pancreatic cancer remains early radical resection (R0 resection), with the specific surgical method depending on the location and depth of invasion of the tumor[3]. Resectability of pancreatic carcinoma (PC) is directly linked to vascular extension[4,5]. Involvement of the (CA) is typically a contraindication to surgery.

Recent medical advances in PC treatment such as FOLFIRINOX-based chemotherapy eventually followed by chemoradiation therapy offer the potential to select tumor for surgery and to obtain a negative-margin resection even in case of unresectable PC at diagnosis[1,6-8]. A major pathologic response has been observed in more than 20% after this treatment and is associated with an improved survival[1]. This evolution allows aggressive surgical strategies with the possibility of long-term disease control for patients showing a good response to induction treatment.

We present a case of locally advanced pancreatic adenocarcinoma successfully treated with a modified Appleby procedure combined with a laparoscopic aorto-hepatic bypass, representing a novel technical adaptation in the context of arterial resection.

Clinical case

A 65-year-old woman presented with dyspepsia and a dull, non-radiating epigastric pain. Her personal and familial history was remarkable for multiple malignancies: ductal adenocarcinoma of the breast diagnosed at age 42; a mother with colon cancer at 57; a father with pancreatic cancer at 78; a sister with breast cancer at 48 with recurrence at 52; and a maternal grandmother with a history of biliary tract neoplasia. Given this strong oncologic background, a multigene hereditary cancer panel (Color®) was performed, yielding negative results for known pathogenic germline variants.

Due to the persistence of symptoms and her significant oncologic history, a triphasic contrast-enhanced abdominal computed tomography (CT) scan was obtained (Fig. 1A, B). It revealed a 42 × 36 mm expansive lesion located in the pancreatic body, with infiltrative growth toward the celiac axis, encasing the celiac trunk, splenic artery, and proximal third of the common hepatic artery, consistent with direct vascular invasion, associated with ca 19-9 of 123 U/mL. Endoscopic ultrasonography confirmed the lesion, and fine-needle aspiration was performed for biopsy, followed by celiac plexus neurolysis. Histopathologic analysis revealed invasive adenocarcinoma.

The case was discussed at a multidisciplinary oncologic board, and neoadjuvant chemotherapy with FOLFIRINOX was initiated. During the third cycle, the patient developed marked gastrointestinal toxicity, requiring dose reduction to complete four cycles.

After completion of neoadjuvant therapy, restaging magnetic resonance imaging (MRI) (Fig. 1C) and PET-CT (Fig. 1D) demonstrated a substantial tumor response, particularly in vascular involvement, with no evidence of extrapancreatic disease. Serum CA 19-9 decreased to 50 U/mL. Considering this favorable scenario, the patient underwent radical surgical resection through a modified Appleby procedure combined with a laparoscopic aorto-hepatic bypass, aiming to achieve oncologic radicality while preserving hepatic perfusion Fig 2 (A-D).

The procedure was performed using a minimally invasive approach. After initial laparoscopic exploration to

Figure 1 | Preoperative imaging. A, B: Contrast-enhanced CT showing a pancreatic body mass with encasement of the celiac trunk, splenic artery, and proximal common hepatic artery (white arrow). C: MRI demonstrating a pancreatic lesion with restricted diffusion and poor contrast enhancement, consistent with malignancy, with involvement of the celiac axis and its branches. D: PET-CT showing a hypermetabolic lesion in the pancreatic body extending to the celiac region, without evidence of distant disease

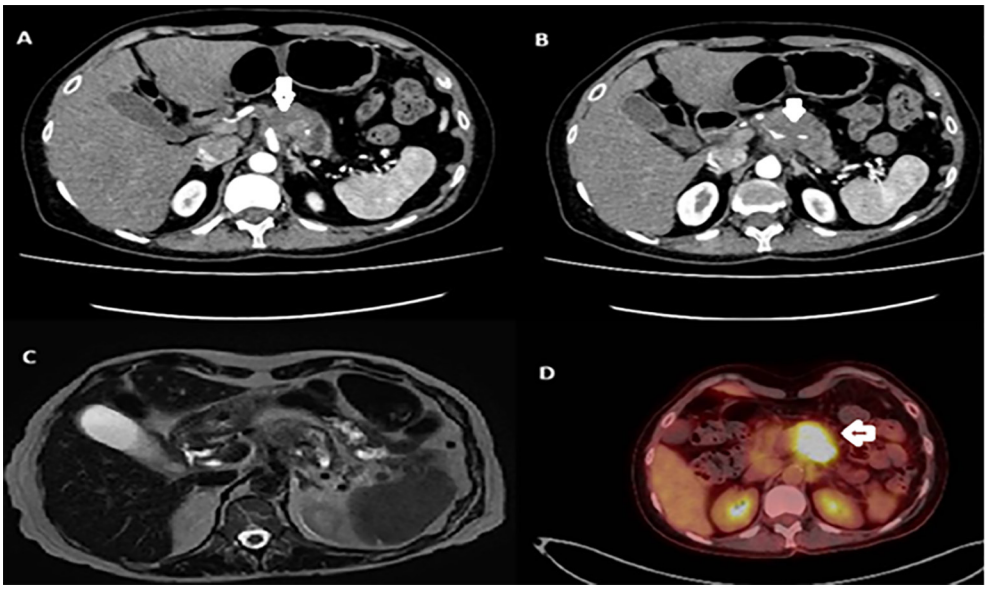
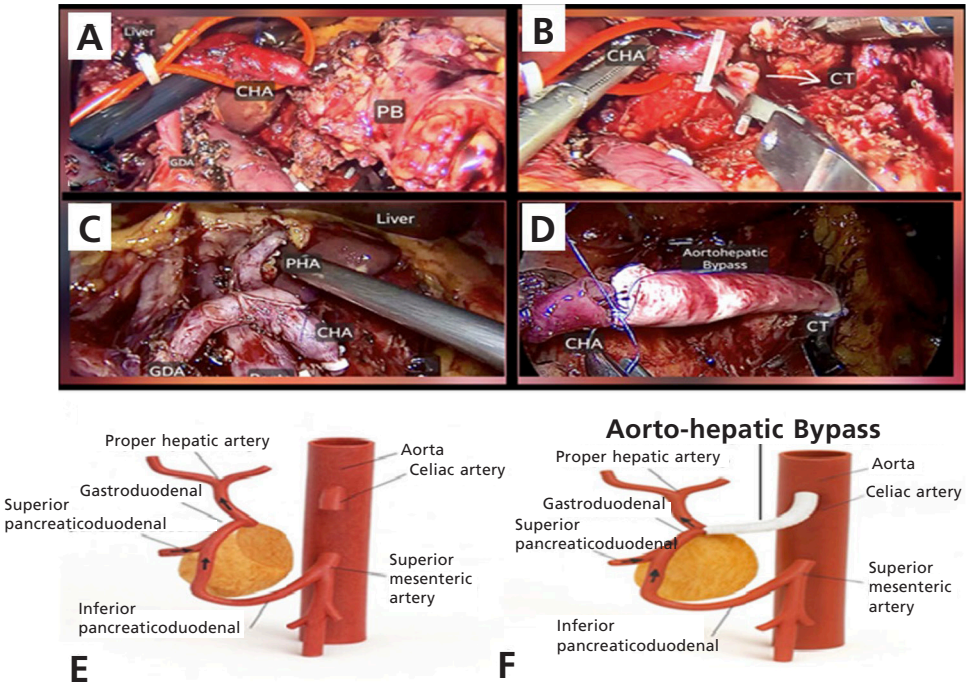


Figura 2 | Surgical technique and arterial reconstruction. Resective phase. A: Exposure of the common hepatic artery (CHA) and pancreatic body (PB). B: Transection of the celiac trunk (CT) and common hepatic artery (CHA). C: Preservation of the gastroduodenal artery (GDA) and proper hepatic artery (PHA). D: Construction of a laparoscopic aorto-hepatic bypass using a polytetrafluoroethylene (PTFE) graft. E: Final arterial configuration after resection of the celiac trunk and common hepatic artery. F: Reconstruction through an aorto-hepatic bypass using a prosthetic graft
Figure 2 was generated with artificial intelligence software



rule out occult metastatic disease and confirm resectability, proximal vascular control was established.

The celiac axis and its branches were carefully dissected, confirming tumor involvement of the celiac trunk, splenic artery, and proximal common hepatic artery. A modified Appleby procedure was then carried out, including distal pancreatectomy and en bloc resection of the celiac axis.

Following celiac axis ligation, intraoperative assessment of hepatic arterial flow was performed. Due to insufficient collateral perfusion through the pancreaticoduodenal arcade, arterial reconstruction was deemed necessary.

A laparoscopic aorto-hepatic bypass was constructed using a vascular graft, establishing antegrade arterial inflow from the abdominal aorta to the hepatic artery. Adequate hepatic perfusion was confirmed intraoperatively.

The procedure was completed with standard lymphadenectomy. Hemostasis was secured, and no intraoperative complications were observed.

As a subsequent study following resection, the deferred biopsy report confirmed the diagnosis of moderately differentiated pancreatic adenocarcinoma, with lymphadenectomy negative for malignancy, evidence of perineural invasion and negative surgical margins. Tumor staging according to the AJCC 2018 TNM classification was ypT2 pN0.

In the postoperative follow-up, the patient demonstrated a favorable clinical course. At the time of this report, with 11 months of follow-up after surgery, she remains under regular outpatient surveillance, with no evidence of local recurrence or distant metastatic disease on imaging studies. The vascular graft shows *sustained patency*, with no evidence of thrombosis or ischemic complications. Hepatic function has been preserved throughout the follow-up period, without clinically significant abnormalities. The patient has resumed her usual daily activities and maintains an adequate quality of life.

Written informed consent was obtained from the patient for publication of this case and accompanying images.

Discussion

Pancreatic ductal adenocarcinoma remains one of the most lethal malignancies in digestive oncology, with most patients presenting with locally advanced or metastatic disease, limiting the possibility of curative-intent resection to a minority of cases[9]. Within this spectrum, vascular involvement, particularly of the celiac trunk, common hepatic artery, and splenoportal axis has historically been considered a criterion of unresectability. However, the development of neoadjuvant strategies based on FOLFIRINOX and advances in vascular reconstructive techniques have allowed reconsideration of surgical indications in selected patients with significant tumor response[1,3].

The Appleby procedure, originally described in 1953 for locally advanced gastric cancer, introduced the concept of celiac trunk resection with preservation of hepatic perfusion through retrograde flow via the pancreaticoduodenal arcade[2]. Its subsequent adaptation to pancreatic tumors, known as distal pancreatectomy with celiac axis resection (DP-CAR) or modified Appleby procedure, has become an accepted alternative in high-volume centers with vascular expertise[9,10]. In this context, preoperative planning, intraoperative hemodynamic assessment, and selective arterial reconstruction are essential components of surgical strategy[11,12].

In the present case, a modified Appleby procedure combined with a laparoscopic aorto-hepatic bypass was performed to ensure adequate hepatic perfusion in the setting of insufficient collateral flow. Similar reconstructive strategies have been described in selected cases, including iliac-hepatic bypass or direct prosthetic anastomosis between the hepatic artery and the aorta, supporting the feasibility of vascular reconstruction when required[11,12].

The tumor response observed after neoadjuvant FOLFIRINOX was a key factor in surgical decision-making, consistent with evidence supporting induction chemotherapy to improve resectability and facilitate R0 resection in initially unresectable disease[1,3]. The reduction in CA 19-9 levels and decreased vascular involvement on imaging are recognized indicators of favorable tumor biology and have been associated with improved oncologic outcomes[9].

From a technical perspective, celiac trunk resection requires careful evaluation of collateral circulation through the pancreaticoduodenal arcade and gastroduodenal artery, as hepatic perfusion depends on their integrity (Fig. 2C). When retrograde flow is insufficient, arterial reconstruction becomes necessary to prevent

ischemic complications[11,12]. In our patient, the aorto-hepatic bypass provided stable antegrade hepatic inflow, allowing preservation of hepatic function. The laparoscopic approach, increasingly adopted in specialized centers, has been associated with reduced blood loss and faster recovery without compromising oncologic principles[3,10].

Multidisciplinary management plays a central role in patient selection and treatment planning. Careful assessment after neoadjuvant therapy, including radiologic and biochemical response, is essential to identify candidates for extended resection. Previous series have reported median survival up to 26 months following modified Appleby procedures, and longer survival in selected cases undergoing arterial reconstruction[9,11].

In the present case, postoperative follow-up at 11 months demonstrated sustained graft patency, preserved hepatic function, and no evidence of local recurrence or distant metastatic disease. Although these findings are encouraging, particularly given that most recurrences occur within the first 6–12 months, but they should be interpreted with caution.

This case suggests that, in highly selected patients with favorable tumor biology treated in experienced multidisciplinary centers, aggressive arterial resection combined with laparoscopic vascular reconstruction may be feasible and allow achievement of oncologic radicality while preserving hepatic perfusion. However, these results remain preliminary and require confirmation in larger series with longer follow-up.

Conflict of interest: None to declare

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