

Hepatic artery reconstruction after extended resection for borderline resectable pancreatic head cancer: A case report

VLADISLAV BRASOVEANU^{1,2}, DRAGOS ROMANESCU³, CAMELIA DIACONU^{4,5}, LAURA ILIESCU^{4,6}, OVIDIU STIRU^{7,8}, IULIAN BREZEAN^{9,10}, EMIL BELU¹¹, CARMEN SAVU¹², CORNEL SAVU^{13,14}, OVIDIU BRATU^{15,16}, GABRIEL GORECKI¹⁷, LUCIAN POP¹⁸, IRINA BALESCU¹⁹ and NICOLAE BACALBASA²⁰⁻²²

¹Department of Surgery, 'Dan Setlacec' Center of Gastrointestinal Diseases and Liver Transplantation, 'Fundeni' Clinical Institute, 022328 Bucharest; ²Department of Surgery, 'Titu Maiorescu' University of Medicine and Pharmacy, 040441 Bucharest; ³Department of Surgery, 'Sanador' Medical Center, 011038 Bucharest; ⁴Department of Internal Medicine, 'Carol Davila' University of Medicine and Pharmacy, 020021 Bucharest; ⁵Department of Internal Medicine, Clinical Emergency Hospital of Bucharest, 105402 Bucharest; ⁶Department of Internal Medicine, 'Fundeni' Clinical Institute, 022328 Bucharest; ⁷Department of Cardiovascular Surgery, 'Carol Davila' University of Medicine and Pharmacy, 020021 Bucharest; ⁸Department of Cardiovascular Surgery, 'Prof. Dr. C.C. Iliescu' Emergency Institute for Cardiovascular Diseases, 022322 Bucharest; ⁹Department of Surgery, 'Carol Davila' University of Medicine and Pharmacy, 020021 Bucharest; ¹⁰Department of Surgery, 'Dr. I. Cantacuzino' Clinical Hospital, 030167 Bucharest; ¹¹Department of Oncology, 'Prof. Dr. Al. Trestioreanu' Institute of Oncology; ¹²Department of Anesthesiology, 'Fundeni' Clinical Institute, 022328 Bucharest; ¹³Department of Thoracic Surgery, 'Carol Davila' University of Medicine and Pharmacy, 020021 Bucharest; ¹⁴Department of Thoracic Surgery, 'Marius Nasta' Institute of Pneumology, 050159 Bucharest; ¹⁵Department of Urology, 'Carol Davila' University of Medicine and Pharmacy, 020021 Bucharest; ¹⁶Department of Urology, Emergency Central Military Hospital, Academy of Romanian Scientists, 010825 Bucharest; ¹⁷Department of Anaesthesia and Intensive Care, 'Ilfov' County Emergency Hospital, 022104 Bucharest; ¹⁸Department of Obstetrics and Gynecology, 'Alessandrescu-Rusescu' National Institute of Mother and Child Health, Fetal Medicine Excellence Research Center, 020395 Bucharest; ¹⁹Department of Surgery, 'Ponderas' Academic Hospital, 021188 Bucharest; ²⁰Department of Obstetrics and Gynecology, 'Carol Davila' University of Medicine and Pharmacy, 020021 Bucharest; ²¹Department of Visceral Surgery, Center of Excellence in Translational Medicine, 'Fundeni' Clinical Institute, 022328 Bucharest; ²²Department of Obstetrics and Gynecology, 'Dr. I. Cantacuzino' Clinical Hospital, 030167 Bucharest, Romania

Received August 31, 2020; Accepted September 30, 2020

DOI: 10.3892/etm.2020.9518

Abstract. Pancreatic head cancer is frequently associated with invasion of the surrounding vascular structures, such cases being considered for a long period of time as unresectable. Improvement of the vascular surgery techniques allowed association of extended vascular resections and reconstructions, increasing in this way the percentage of patients benefiting from radical surgery. We present the case

of a 47-year-old male patient with no significant medical history diagnosed with a large pancreatic head tumor invading the common and proper hepatic artery as well as the portal vein. The venous reconstruction was performed using a synthetic prosthesis while the left hepatic artery was sutured to the left gastric artery; meanwhile the right hepatic artery was reconstructed using the splenic artery. In conclusion, extended hepatic artery resection followed by arterial reconstruction in association with portal vein resection and prosthetic replacement might be needed in cases presenting large pancreatic head tumors with vascular invasion.

Correspondence to: Dr Nicolae Bacalbasa, Department of Obstetrics and Gynecology, 'Dr. I. Cantacuzino' Clinical Hospital, 5-7 Ion Movilă Street, 030167 Bucharest, Romania
E-mail: nicolae_bacalbasa@yahoo.ro

Key words: hepatic artery reconstruction, portal vein reconstruction, pancreatoduodenectomy, pancreatic cancer, local invasion, arterial reconstruction, venous reconstruction

Introduction

In the absence of a treatment with curative intent the long-term survival of patients diagnosed with pancreatic cancer is lower than 5% due to the high biological aggressiveness of these lesions and due to the fact that most often these cases are diagnosed in advanced stages of the disease when radical

treatment is no longer feasible (1). However, it is estimated that up to 20% of cases diagnosed with locally extended pancreatic lesions will undergo potentially radical surgery and will experience long-term survival rates of up to 25% (2,3). These improvements are most commonly related to the advances in the field of surgical techniques and of the perioperative management of these patients as well as due to the centralization of these cases in tertiary hospitals with high volumes of pancreatic surgery (3-9). In this respect the rates of resectability as well as the long-term outcomes have significantly increased leading to an overall improvement of the five year survival rates (3-7). In the meantime, standardized definitions of resectability as well as of the postoperative complications have been proposed in order to obtain the above uniform data and to provide a more adequate comparison of the outcomes (10,11). Regarding the resectability of these lesions, while cases presenting portal vein invasion have been considered in the last decades as perfectly resectable, significant benefits of survival being achieved, when it comes to cases presenting arterial invasion there is no clear consensus, a permanent debate being still present (3-5,12,13). The aim of this report is to present a case in which extended arterial and venous resections were performed in association with pancreatoduodenectomy with good postoperative results.

Case report

A 47-year-old previously healthy man was investigated for diffuse epigastric pain and weight loss and was diagnosed with a pancreatic head tumor measuring 4.4x4.8x3.4 cm which induced a semi-circumferential abutment of the hepatic artery and infiltration of the portal vein wall.

The patient was submitted to endoscopic ultrasound which confirmed the presence of a large pancreatic head tumor invading the common and proper hepatic artery and the portal vein; biopsy was retrieved and demonstrated the presence of a well differentiated pancreatic adenocarcinoma. However, the lesion seemed to induce a semi-circumferential abutment of the arterial axis, being therefore considered as borderline resectable. In this respect the patient was submitted to 6 cycles of neoadjuvant chemotherapy-FOLFIRINOX regimen which induced tumoral shrinkage to 4.1x4x3 cm; however, the local abutment of the hepatic artery as well as the infiltration of the wall of the portal vein was still present. Due to the good clinical and biological status of the patient surgery with curative intent was proposed. Therefore, pancreatoduodenectomy en bloc with common and hepatic artery and portal vein resection was performed. The arterial blood supply of the liver was provided by the anastomosis of the left hepatic artery to the left gastric artery and of the right hepatic artery to the splenic artery, respectively; meanwhile the portal vein was reconstructed by using a synthetic prosthesis (Figs. 1-4). Due to the low caliber of the arterial branches, microscope reconstructive surgery was needed. The intraoperative and 48 h postoperative ultrasound demonstrated an adequate liver inflow. The biological tests revealed a transient increase of the transaminases which normalized in the first five days postoperatively. The patient was discharged in the seventh postoperative day with a good clinical and biological status.

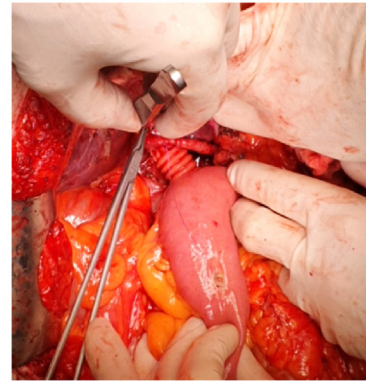


Figure 1. Anastomosis between the right hepatic artery and splenic artery. The continuity of the portal vein had already been established by prosthesis placement.



Figure 2. The final aspect after vascular reconstruction: The right hepatic artery was anastomosed to the splenic artery while the left hepatic artery was anastomosed to the left gastric artery.



Figure 3. Creation of the bilio-enteric anastomosis.

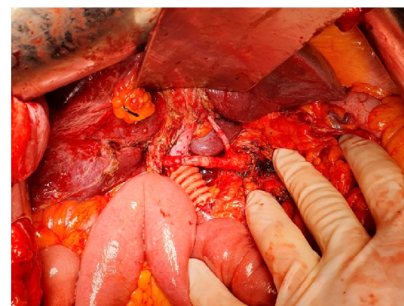


Figure 4. The final aspect after pancreatoduodenectomy en bloc with hepatic artery and portal vein resection and reconstruction.

Discussion

According to the International Study Group for Pancreatic Surgery, pancreatic head tumors can be classified in three categories based on the preoperative imagistic studies: Resectable, borderline resectable and unresectable. While resectable lesions refer to the tumors which have no vascular involvement, borderline resectable lesions refer to lesions presenting portal vein involvement alone or in association with semicircumferential arterial involvement; meanwhile unresectable lesions refer to cases presenting a more extended (>180°) area of arterial invasion (10,11).

When it comes to borderline resectable lesions, particular attention should be focused on the type of vascular invasion (arterial versus venous invasion). Therefore, if in cases in which venous invasion is present large studies have demonstrated that the long-term outcomes are similar to cases with no venous invasion if radical surgery is achieved, in cases where arterial invasion is present the rationale of radical surgery is still being submitted to permanent debate (3,4,14-16). In cases presenting both arterial and venous invasion most often neoadjuvant chemotherapy alone, or in association with radiation therapy, is recommended; in cases in which a good local control of the disease is achievable, surgery with curative intent might be taken in consideration in order to maximize the chances of long-term survival. Therefore, it is estimated that this is achievable in 33-50% of cases initially diagnosed with locally advanced or borderline resectable lesions (17,18). In the study conducted by Sgroi *et al* (19) on a 10 year period there were 183 patients diagnosed with pancreatic head adenocarcinoma, 60 of them requiring vascular resections; among these cases 11 patients associated arterial resections and reconstructions, the most frequently involved structure being represented by the hepatic artery, in seven cases; the Kaplan-Meier survival curves at one and three years failed to demonstrate any significant difference in terms of survival between cases submitted to standard pancreatoduodenectomy and those necessitating vascular resections and reconstruction; meanwhile the post-operative complication rates were similar between the two groups and so were the median lengths of hospital stay. The only parameter which proved to be significantly different between the two groups was represented by the 5-year overall survival, which seemed to be lower among vascular resection group. These data demonstrated the feasibility, safety and effectiveness of such extended resections, a significant difference in terms of survival being encountered only at the 5-year follow-up. One of the most recent reports which brought into discussion the recommendations for locally extended pancreatic tumors comes from the French study group conducted by Delpero and Sauvanet (20) and published in 2019. This report underlines once again that in cases presenting arterial invasion neoadjuvant chemotherapy followed by resection with curative intent can be taken in consideration after being discussed both with the patient and in multidisciplinary meetings, significant benefits in terms of survival being expected.

However, the decision of performing such extended resections should be taken in consideration according to patient's age and comorbidities (3). As for the type of surgical procedure, an 'artery first' approach is preferable in order to clarify the degree of arterial infiltration and the resectability

of the lesion before performing any irreversible surgical gesture (21,22). Due to the fact that the surgical techniques of resection and reconstruction are not well standardized in pancreatic head tumors with arterial involvement while the perioperative morbidity rate highly varies from 0 to 35% this surgical approach has not become yet the standard of care for such cases (3).

Regarding the most commonly encountered arterial resections which are needed during pancreaticoduodenectomy, they are represented by celiac axis and hepatic artery resection followed by reconstruction (23-25). In cases presenting hepatic artery involvement reconstruction is needed in all cases except when patients present aberrant hepatic arteries (6,7,26). As for the techniques of arterial reconstruction of the hepatic arteries, any kind of arterial or venous graft interposition seem to be suitable; however, ultrasound evaluation is mandatory in order to investigate the liver perfusion and to detect early any sign which might suggest the appearance of liver ischemia (3,27).

In cases in which the resected segment of the hepatic artery is shorter than 1.5-2 cm, direct anastomosis between the two remaining stumps might be taken in consideration; meanwhile, in cases presenting more extended arterial resections or in which an end to end anastomosis is not feasible an arterial or venous graft might be interposed with good results (26). A particular situation is represented by the presence of an aberrant hepatic artery from the superior mesenteric artery which might provide an adequate blood supply of the liver even if the common hepatic artery is no longer reconstructed (28).

One of the most recent studies which came to present the effectiveness of arterial resections in borderline resectable pancreatic lesions as well as details of arterial reconstruction techniques was reported by Zhang *et al* (29); the study included 21 such patients submitted to surgery from 2010 to 2015, in all cases microsurgical techniques of vascular surgery were needed in order to provide an effective arterial reconstruction. In cases in which the length of the resected artery was lower than 2 cm direct anastomosis was performed while in cases in which the resected segment was larger graft placement was used. In such cases the preferred graft was represented by autologous saphenous graft followed by allogenic iliac artery grafts; the anastomosis between an aberrant right hepatic artery and the left gastric artery was performed in one case while in another case the proper hepatic artery was anastomosed to the left gastric artery; as for the long-term outcomes, the authors reported an improved survival among patients submitted to surgery when compared to the chemotreated ones. However, the difference did not reach statistical significance.

In our present case the local anatomy and the extent of the arterial resection allowed us to perform an anastomosis in good conditions between the left hepatic artery and the left gastric artery while the right hepatic artery was reconstructed by the use of the splenic artery. The splenic artery represents one of the most commonly cited types of autologous grafts, being used either by transposition or interposition for both superior mesenteric and hepatic artery (30). Utility of splenic artery in order to provide an adequate arterial hepatic flow was initially investigated in living donor liver transplantation and proved to be a safe and efficient one (31). It seems that the use of this arterial segment is associated with low risks of intraoperative and postoperative complications and was further included in the therapeutic

armamentarium of hepatic arterial reconstruction after extended resections for borderline resectable pancreatic cancer (5).

Hepatic artery seems to be the most commonly involved arterial structure in borderline resectable pancreatic cancer. Although initially considered as a formal contraindication for surgery, hepatic artery invasion should be no longer considered as a sign of an unresectable lesion especially in cases presenting a good biological and clinical status. In such cases extended radical surgical procedures might be performed in order to achieve curative procedures; however, after these types of resections, complex procedures of reconstructive surgery should be performed in order to achieve an adequate hepatic flow and to minimize the risk of postoperative liver failure, the most commonly performed reconstructions consisting of direct anastomosis of the vascular partners or of placing arterial or venous grafts.

Acknowledgements

Not applicable.

Funding

No funding was received.

Availability of data and materials

Not applicable.

Authors' contributions

VB and DR performed the surgical procedures. CD, CoS, NB and LI preoperatively investigated the patient. IBr, IBa, CoS, Cas, OB and LP reviewed literature data and prepared the draft of the manuscript. CaS and GG advised on the anaesthesia. EB and NB advised on the oncological outcome. OS advised on the cardiac approach. VB, IBr and NB reviewed the final version of the manuscript. All authors read and approved the final version of the manuscript.

Ethics approval and consent to participate

Written informed consent was obtained and signed from the patient in 23.03.2020.

Patient consent for publication

Written informed consent was obtained from the patient for the publication of all accompanying images.

Competing interests

The authors declare that they have no competing interests.

References

1. Siegel R, Ma J, Zou Z and Jemal A: Cancer statistics, 2014. *CA Cancer J Clin* 64: 9-29, 2014.
2. Schnelldorfer T, Ware AL, Sarr MG, Smyrk TC, Zhang L, Qin R, Gullerud RE, Donohue JH, Nagorney DM and Farnell MB: Long-term survival after pancreatoduodenectomy for pancreatic adenocarcinoma: Is cure possible? *Ann Surg* 247: 456-462, 2008.
3. Hackert T, Schneider L and Büchler MW: Current state of vascular resections in pancreatic cancer surgery. *Gastroenterol Res Pract* 2015: 120207, 2015.
4. Brasoveanu V, Anghel C, Barbu I, Pautov M, Ionescu MI, Motthor M, Balescu I, Dima S and Bacalbasa N: Pancreatoduodenectomy en bloc with portal and superior mesenteric artery resection - a case report and literature review. *Anticancer Res* 35: 1613-1618, 2015.
5. Brasoveanu V, Dumitraşcu T, Bacalbaşa N and Zamfir R: Splenic artery used for replaced common hepatic artery reconstruction during pancreatoduodenectomy - a case report. *Chirurgia (Bucur)* 104: 499-504, 2009.
6. Bacalbasa N, Brezean I, Anghel C, Barbu I, Pautov M, Balescu I and Brasoveanu V: Successful resection and vascular ligation of a large hepatic artery aneurysm - a case report and literature review. *In Vivo* 31: 979-982, 2017.
7. Bacalbasa N, Brezean I, Anghel C, Barbu I, Pautov M, Balescu I and Brasoveanu V: Management of a fulminant upper gastrointestinal bleeding exteriorized through hemobilia due to arteriohepatic fistula between the common bile duct and a right hepatic artery aneurysm - a case report. *In Vivo* 31: 983-989, 2017.
8. Bacalbasa N, Balescu I, Tanase A, Pautov M, Brezean I, Vilcu M and Brasoveanu V: Spleno-pancreatectomy en bloc with paracelular gastrectomy for splenic artery aneurysm - a case report and literature review. *In Vivo* 32: 915-919, 2018.
9. Bacalbasa N, Balescu I, Tanase A, Brezean I, Vilcu M and Brasoveanu V: Successful resection of a non-functional paraganglioma with celiac trunk invasion followed by common hepatic artery reimplantation - a case report and literature review. *In Vivo* 32: 911-914, 2018.
10. Seufferlein T, Porzner M, Becker T, Budach V, Ceyhan G, Esposito I, Fietkau R, Follmann M, Friess H, Galle P, *et al*: S3-guideline exocrine pancreatic cancer. *Z Gastroenterol* 51: 1395-1440, 2013.
11. Seufferlein T, Bachet JB, Van Cutsem E and Rougier P; ESMO Guidelines Working Group: Pancreatic adenocarcinoma: ESMO-ESDO clinical practice guidelines for diagnosis, treatment and follow-up. *Ann Oncol* 23 (Suppl 7): vii33-vii40, 2012.
12. Sasson AR, Hoffman JP, Ross EA, Kagan SA, Pingpank JF and Eisenberg BL: En bloc resection for locally advanced cancer of the pancreas: Is it worthwhile? *J Gastrointest Surg* 6: 147-157, 2002.
13. Shoup M, Conlon KC, Klimstra D and Brennan MF: Is extended resection for adenocarcinoma of the body or tail of the pancreas justified? *J Gastrointest Surg* 7: 946-952, 2003.
14. Hartel M, Niedergethmann M, Farag-Soliman M, Sturm JW, Richter A, Trede M and Post S: Benefit of venous resection for ductal adenocarcinoma of the pancreatic head. *Eur J Surg* 168: 707-712, 2002.
15. Riediger H, Makowiec F, Fischer E, Adam U and Hopt UT: Postoperative morbidity and long-term survival after pancreaticoduodenectomy with superior mesenterico-portal vein resection. *J Gastrointest Surg* 10: 1106-1115, 2006.
16. Ouaisi M, Hubert C, Verhelst R, Astarci P, Sempoux C, Jouret-Mourin A, Loundou A and Gigot JF; Multidisciplinary HPB Group of Center of Cancer: Vascular reconstruction during pancreatoduodenectomy for ductal adenocarcinoma of the pancreas improves resectability but does not achieve cure. *World J Surg* 34: 2648-2661, 2010.
17. Mollberg N, Rahbari NN, Koch M, Hartwig W, Hoeger Y, Büchler MW and Weitz J: Arterial resection during pancreatotomy for pancreatic cancer: A systematic review and meta-analysis. *Ann Surg* 254: 882-893, 2011.
18. Rose JB, Rocha F, Alseidi A and Helton S: Posterior 'superior mesenteric artery first' approach for resection of locally advanced pancreatic cancer. *Ann Surg Oncol* 21: 1927-1928, 2014.
19. Sgroi MD, Narayan RR, Lane JS, Demirjian A, Kabutay NK, Fujitani RM and Imagawa DK: Vascular reconstruction plays an important role in the treatment of pancreatic adenocarcinoma. *J Vasc Surg* 61: 475-480, 2015.
20. Delperio JR and Sauvanet A: Vascular resection for pancreatic cancer: 2019 French recommendations based on a literature review from 2008 to 6-2019. *Front Oncol* 10: 40, 2020.
21. Weitz J, Rahbari N, Koch M and Büchler MW: The 'artery first' approach for resection of pancreatic head cancer. *J Am Coll Surg* 210: e1-e4, 2010.
22. Gundara JS, Wang F, Alvarado-Bachmann R, Williams N, Choi J, Gananadha S, Gill AJ, Hugh TJ and Samra JS: The clinical impact of early complete pancreatic head devascularisation during pancreatoduodenectomy. *Am J Surg* 206: 518-525, 2013.

23. Glanemann M, Shi B, Liang F, Sun XG, Bahra M, Jacob D, Neumann U and Neuhaus P: Surgical strategies for treatment of malignant pancreatic tumors: Extended, standard or local surgery? *World J Surg Oncol* 6: 123, 2008.
24. Chua TC and Saxena A: Extended pancreaticoduodenectomy with vascular resection for pancreatic cancer: A systematic review. *J Gastrointest Surg* 14: 1442-1452, 2010.
25. Nakamura T, Hirano S, Noji T, Asano T, Okamura K, Tsuchikawa T, Murakami S, Kurashima Y, Ebihara Y, Nakanishi Y, *et al*: Distal pancreatectomy with en bloc celiac axis resection (modified appleby procedure) for locally advanced pancreatic body cancer: A single-center review of 80 consecutive patients. *Ann Surg Oncol* 23 (Suppl 5): S969-S975, 2016.
26. Vladov N, Takorov I and Lukanova T: The role of vascular resection in pancreatic cancer treatment, chapter 10, challenges in pancreatic pathology, intech open publishing house, pp195-217, 2017.
27. Hackert T, Stampfl U, Schulz H, Strobel O, Büchler MW and Werner J: Clinical significance of liver ischaemia after pancreatic resection. *Br J Surg* 98: 1760-1765, 2011.
28. Bacalbasa N, Balescu I, Vilcu M, Croitoru A, Dima S, Brasoveanu V, Brezean I and Popescu I: Pancreatoduodenectomy after neoadjuvant chemotherapy for locally advanced pancreatic cancer in the presence of an aberrant right hepatic artery. *In Vivo* 34: 401-406, 2020.
29. Zhang Q, Wu J, Tian Y, Duan J, Shao Y, Yan S and Wang W: Arterial resection and reconstruction in pancreatectomy: Surgical technique and outcomes. *BMC Surg* 19: 141, 2019.
30. Klaiber U, Mihaljevic A and Hackert T: Radical pancreatic cancer surgery with arterial resection. *Transl Gastroenterol Hepatol* 4: 8, 2019.
31. D'Albuquerque LA, Gonzalez AM, Letrinda RF, Copstein JL, Larrea FI, Mansero JM, Peron G Jr, Ribeiro MA Jr and Oliveira e Silva A: Use of the splenic artery for arterial reconstruction in living donor liver transplantation. *Transplant Proc* 39: 3202-3203, 2007.