Celiac artery stenosis and cephalic duodenopancreatectomy: An undervalued risk?

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ABSTRACT

Introduction: Significant celiac trunk or artery stenosis (CAS) is normally asymptomatic. However, when the arteries of the pancreaticoduodenal arcade are occluded, it could trigger a visceral ischaemia. The objective of this study is to determine whether preoperative CAS is a risk factor for developing complications in patients subjected to duodenopancreatectomy (DPC).

Material and methods: We have retrospectively analysed 58 consecutive patients subjected to DPC. We have associated significant CAS with post-surgical outcome. In all cases a 16-channel multidetector computed tomography (MDCT) in three hepatic phases was performed. We have reviewed the pre-surgical MDCT focusing on the morphology of the celiac artery (CA), particularly in the presence or absence of significant stenosis (>50%).

Results: We found CAS >50% in 13 patients (22%). The overall mortality was 5% (3 patients). Serious complications developed in 16 (28%) patients, 8 (62%) of whom belonged to the group with significant CAS (P=.004). Ten patients (17%) had a pancreatic fistula, 5 (38%) vs 5 (11%) (P=.036); Fourteen patients (24%) needed new surgery, 7 (54%) vs 7 (16%) (P=.009); Seven patients (12%) had a haemoperitoneum, 4 (31%) vs 3 (7%) (P=.038), in the group with and without CAS, respectively.

Conclusions: Significant radiological CAS is a risk factor of serious complications after DPC. The study of the calibre of the superior mesenteric artery (SMA) with MDCT should be routine before a DPC. The correction of a significant CAS should be evaluated preoperatively.

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RESUMEN

Introducción: La estenosis significativa del tronco celiaco habitualmente cursa de forma asintomática. No obstante, cuando se interrumpe la arcada de las arterias pancreatoduodenales, puede producirse isquemia visceral. El objetivo de este estudio es determinar si la estenosis preoperatoria del tronco celiaco es un factor de riesgo de complicaciones en pacientes sometidos a duodenopancreatectomía (DPC).

Material y métodos: Hemos analizado retrospectivamente a 58 pacientes consecutivos sometidos a DPC. Hemos relacionado la estenosis significativa del tronco celiaco con la evolución posquirúrgica. En todos los casos se ha realizado un estudio mediante tomografía computarizada multidetector (TCDM) de 16 canales en tres fases hepáticas. Hemos revisado la TCDM prequirúrgica centrándonos en la morfología del tronco celiaco, especialmente la presencia o ausencia de estenosis significativa (> 50%).

Resultados: Encontramos estenosis del tronco celiaco > 50% en 13 pacientes (22%). La mortalidad total fue de 3 pacientes (5%). La morbilidad total fue del 62%. En 16 pacientes (28%) hubo complicaciones graves, de los que 8 (62%) pertenecen al grupo de estenosis significativa del tronco celiaco (p = 0,004); 10 pacientes (17%) presentaron fístula pancreática, 5 (38%) vs. 5 (11%) (p = 0,036); 14 pacientes (24%) necesitaron reoperación, 7 (54%) vs. 7 (16%) (p = 0,009); 7 pacientes (12%) presentaron hemorragia, 4 (31%) vs. 3 (7%) (p = 0,038), en los grupos con y sin estenosis del tronco celiaco respectivamente.

Conclusiones: La estenosis radiológicamente significativa del tronco celiaco es un factor de riesgo de complicaciones graves tras DPC. El estudio del calibre de la AMS con TCDM debería ser sistemático antes de una DPC. Debería valorarse preoperatoriamente la corrección de la estenosis significativa del tronco celiaco.

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Introduction

Amongst the general population stenosis of the celiac trunk is usually asymptomatic. This is because of the different vascular systems which can supplement its irrigation. However, its presence in patients who are going to be subjected to a cephalic duodenopancreatectomy (CDP) may carry with it important ischaemic complications. These complications are derived from the interruption of communication between the celiac trunk and the superior mesenteric artery (SMA). The main communication routes between these two systems are the gastroduodenal artery (GDA) and the pancreaticoduodenal arteries, which, in the case of celiac trunk stenosis, supplement its vascularisation. During pancreatectomy, especially when the cause is malignant, the radical oncological procedure leads to skeletonisation of the celiac trunk, hepatic artery (HA) and SMA, requiring their collateral branches to be cut. In the case of celiac trunk stenosis, this dissection can produce ischaemia of the viscera and of the digestive anastomoses which are necessary for reconstruction.

Numerous studies have established the prevalence of celiac trunk stenosis, which ranges from 2%, in a study by Berney et al1 conducted on patients undergoing CDP, to 49.7%, in a study by Szilagyi et al2 on the general population. Whilst in studies on Western populations3 the most common cause of celiac trunk stenosis was atherosclerosis, in studies such as the one conducted by the Korean investigator Park3 on an oriental population the most common cause was extrinsic compression.

Multidetector computed tomography (MDCT) is very sensitive for diagnosing vascular abnormalities and stenosis of the celiac trunk, as well as other vascular abnormalities.4 Owing to the possible complications derived from these vascular abnormalities, as well as their prevalence, preoperative detection may be a key factor in adequate pre-surgical planning.5

The aim of this study is to investigate whether significant celiac trunk stenosis is a risk factor for complications in patients undergoing CDP.

Patients and method

We conducted a retrospective study on all the patients who were consecutively subjected to a CDP from 2006 to 2009 to treat periampullary tumours, correlating the pre-surgical presence of significant celiac trunk stenosis with post-surgical clinical outcome.

Diagnosis

In all cases 16-channel MDCT (Phillips Mx8000) was performed in three phases after injecting 150ml of contrast agent. During the arterial phase, maximum enhancement of the celiac trunk and the SMA is achieved 30s after injecting the contrast agent. Anatomical variations, stenosis and contact between a tumour and the SMA can be evaluated, which is essential to the decision whether to remove them. During the portal phase, 70s after injection of the contrast agent, the pancreas can be visualised. During this phase, the difference in enhancement...
between the tumour and the healthy parenchyma is optimal, which enables the outline of the tumour, its contact with the superior mesenteric vein (SMV) and its possible invasion. The possible existence of hepatic and lymph node metastases is also assessed. Then an equilibrium phase is performed 3 min after injection, when the contrast medium has infiltrated all the parenchyma, in order to characterise any hypovascular hepatic lesions (cysts or haemangiomas).

In order to diagnose celiac trunk stenosis, a retrospective review on all the consecutive patients undergoing CDP was conducted by a radiologist, who was specialised in abdominal MDCT but had no prior knowledge of postoperative outcome. For the review, during the arterial phase sagittal reconstructions of the morphology of the celiac trunk were made using MIP (maximal intensity projection) techniques.

Significant celiac trunk stenosis was defined as stenosis affecting over 50% of the calibre of the vessel (Figure A).

**Surgical technique**

CDP was performed using a previously published technique. Briefly, a bilateral subcostal incision is made. After a manual and ultrasound oncological examination, the surgeon lowers the hepatic flexure of the colon and performs a Kocher manoeuvre. Once the head of the pancreas is mobilised, an inter-aorta-caval lymphadenectomy is performed, with dissection of the SMA at the level where it leaves the aorta. After that, the SMV and the SMA are dissected in the inframesocolic space. The first jejunal loop is cut and uncrossed. Next, in the supramesocolic space, the post-pyloric duodenum is severed.

![Figure A: multidetector computed tomography; reconstruction using MIP (maximal intensity projection) technique; sagittal projection of the celiac trunk (CT) and the superior mesenteric artery (SMA). B: stenosis of the CT caused by the arcuate ligament. C: stenosis of the CT and the SMA as a result of atherosclerosis.](image-url)
or, failing that option, the gastric antrum. This is followed by lymphadenectomy of the HA and the hepatic pedicule, with ligature of the GDA (before tying it, a clamp test is performed, observing the beat of the HA and the colouring of the liver). The surgeon continues with a common hepatic bile duct section and cholecystectomy, section of the pancreatic neck, separation of the uncinate process and ligature of the inferior pancreaticoduodenal arteries which are branches of the (previously released) SMA. The final step in the procedure is ligature of the gastrocolic venous trunk and the pancreatic veins, and the removal of the surgical piece. Reconstruction always involved using a single loop, performing the pancreateojunostomy or pancreaticogastrostomy first. An end-to-side hepticojejunostomy was then performed and, finally, an antecolic gastrojejunostomy in most of the patients. Multiperforated drains with a low aspiration pressure were used in the area of the pancreatic anastomosis. At the end of the intervention the nasogastric catheter was removed.

**Postoperative follow-up**

All the patients were administered a postoperative treatment protocol consisting of epidural analgesia with bupivacaine and s.c. octreotide 0.1 mg/8 h, prokinetic drugs (endovenous erythromycin and metoclopramide), serum therapy, analgesia and proton pump inhibitors. Analytical tests, including haematology, biochemistry and C-protein profiles, were performed on days 1, 2, 3, 5 and 7 and when clinically indicated. Amylase was determined daily in the drainage liquid and in plasma. MDCT was performed at the end of the first week or when clinically indicated. Enteral or parenteral nutrition was not administered systematically but only when there were serious complications or delayed gastric emptying. On the third day after surgery, if the amylase concentration in the drainage liquid was <3 times its plasma value, abdominal drainage was removed.

**Postoperative complications**

The data regarding the surgical procedure, duration of the intervention, blood losses, transfusion, etc., were collected prospectively. The postoperative complications (mainly haemorrhage, pancreatic fistula and delayed gastric emptying) were classified in accordance with Dindo el al7 and the ISGPF.8

**Statistical analysis**

The data was analysed using the statistical programme SPSS version 15.0 for Windows. The descriptive statistics used was based on calculating the means ± standard deviations for the quantitative variables and on proportions for qualitative variables. The Kolmogorov-Smirnov test was applied to check the normality of the variables.

The tests employed for the statistical comparison of proportions were the chi-square test or, if the necessary conditions for its application were not met. For the comparison of two means, the Student’s t test was used, or the Mann-Whitney U test if the requirements of normality were not met. In all the tests P<.05 was regarded as statistically significant.

**Results**

From 2006 to 2009 58 consecutive patients, who are the basis of the study, were subjected to CDP radical surgery.

**Epidemiological data**

The average patient age was 64.5 (37-82) years. Most of the patients were male but this proportion was not significant (P=.053). The American Society of Anesthesiologist (ASA) classification was predominantly ASA III (38 patients; 65%), ASA II (19 patients; 33%) and ASA IV (1 patient; 2%), with no differences between the two study groups. The tumour clinically manifested itself as jaundice in 44 patients (76%), and most of the cases also presented cholesasis (48 patients, 83%), with a radiological image of a tumoral mass in 38 (66%) patients, pain in 10 patients (17%) and symptoms of cholangitis in 6 (10%). The average preoperative bilirubin concentration was 6.4 (6.5) mg/dl; preoperative biliary drainage was performed by means of endoscopic retrograde cholangiopancreatography (ERCP) in 26 cases (45%); average bilirubin concentration prior to drainage was 12.6 (8.8) mg/dl. In the demographic data there were no differences between the group with and the group without celiac trunk stenosis (Table 1).

**Radiological findings**

A retrospective review of the preoperative MDCT scans was conducted for the 58 CDPs. We found celiac trunk stenosis to be >50% in 13 patients (22%). Radiologically, tumoral contact with the SMV was <25% in 3 patients (5%), 25%-50% in 5 patients (9%) and >50% in 3 patients (5%). Thrombosis of the SMV was detected in 1 case. There was radiological evidence of tumoral invasion of the HA in 2 patients (4%).

**Surgical data**

Prepyloric preservation was performed in the majority of the operations (39 patients; 67%). Reconstruction entailed pancreateojunostomy in 47 cases (82%) and pancreaticogastrostomy in 11 cases (18%). The gastrojejunostomy was antecolic in 44 patients (76%) and retrocolic in 14 patients (24%), there being no differences between the two groups. In the group without celiac trunk stenosis, it was significantly more common for the pancreas to be of a soft consistency, while venous resection was performed more often in the group with celiac trunk stenosis (Table 2).

**Histopathology**

In our series the most common tumour type was adenocarcinoma of the pancreatic duct (47%), followed by cholangiocarcinoma (14%) and ampulloma (14%). With respect to tumour staging, most of the tumours were graded as pT3 (62%), N1 (61%), moderately differentiated (52%) and without invasion of the margin (85%). There was no significant differences for any of this data (Table 3).
Morbidity and mortality

The total perioperative mortality for this study was 3 patients (5%) and some kind of complication occurred in 62% of the interventions. Following the classification of Dindo et al., major complications were classified as those higher than grade 3a (interventions requiring general anaesthesia), and they accounted for 28%. There was a significantly greater difference in serious complications in the celiac trunk stenosis group. There was also a greater number of pancreatic fistulae, haemoperitoneum and re-operations in the celiac trunk stenosis group. Postoperative stay was shorter in the group without celiac trunk stenosis, although this finding was not statistically significant (Table 4).

Postoperative radiological findings

The postoperative MDCT scans performed on the 13 patients with significant celiac trunk stenosis were also retrospectively reviewed. In 7 patients there were no signs of visceral or hepatic ischaemia and only 2 suffered complications, which consisted of cholecystitis and intra-abdominal collection. Two patients showed signs of hepatic ischaemia on their MDCT scans, associated in both cases with complications: early-onset postoperative haemoperitoneum and late-onset haemoperitoneum secondary to a severe pancreatic fistula in the latter case. In the MDCT scan, one patient presented haemoperitoneum and a splenic infarction. Another patient showed signs of ischaemic colitis and...
another pneumoperitoneum secondary to colonic perforation. In one celiac trunk stenosis patient, who had a severe pancreatic fistula with late-onset haemoperitoneum, the postoperative MDCT could not be performed.

**Discussion**

CDP has established itself as the best treatment for periampullary tumours and other benign diseases which primarily affect the head of the pancreas. The early referral of these patients to centres with plenty of experience has proven to reduce mortality to less than 5%. However, postoperative complications are still common, especially in elderly patients who are going to undergo a CDP. The largest series is that of the Beaujon hospital, which systematically conducted a multidisciplinary evaluation of the existence of celiac trunk stenosis prior to pancreatic surgery in 545 patients. The incidence of celiac trunk stenosis in their series is 11%, but in most of these cases the patients had extrinsic stenosis as a result of compression of the celiac trunk by the arcuate ligament (Figure B). This problem seems to be common in oriental populations, but it is not the most common cause of celiac trunk stenosis in elderly patients who are going to undergo a CDP.

The most important finding in our study is the significant increase in serious surgical complications, pancreatic fistula, haemorrhage and re-operations in patients with significant celiac trunk stenosis in the reconstruction of the preoperative MDCT (Table 4). The postoperative X-ray studies also coincided with these preoperative findings. Thus, only 2 out of the patients without signs of visceral ischaemia in the postoperative MDCT developed serious complications, which were probably not secondary to visceral ischaemia. In contrast, all the patients with signs of visceral or hepatic ischaemia in the postoperative MDCT scans had serious complications, including late-onset haemoperitoneum secondary to severe pancreatic fistula.

In general, it is advisable to clamp the GDA before cutting it. If the pulse in the HA disappears, we recommend abandoning the CDP or, in some exceptional cases, performing a revascularisation of the HA. In all our patients we performed a clamp test of the celiac trunk before its ligature and in no case did we observe complete disappearance of bloodflow in the HA or a significant weakening of its beat. However, other authors believe that celiac trunk stenosis rarely leads to important clinical problems after a CDP.

### Table 3 – Pathological data

<table>
<thead>
<tr>
<th>Celiac trunk stenosis</th>
<th>P</th>
</tr>
</thead>
<tbody>
<tr>
<td>No</td>
<td>45</td>
</tr>
<tr>
<td>Tumour type</td>
<td></td>
</tr>
<tr>
<td>Ductal adenocarcinoma</td>
<td>16</td>
</tr>
<tr>
<td>Intestinal adenocarcinoma</td>
<td>4</td>
</tr>
<tr>
<td>Ampulloma</td>
<td>7</td>
</tr>
<tr>
<td>Cholangiocarcinoma</td>
<td>8</td>
</tr>
<tr>
<td>Papillary adenocarcinoma</td>
<td>1</td>
</tr>
<tr>
<td>NET</td>
<td>3</td>
</tr>
<tr>
<td>IPMT</td>
<td>1</td>
</tr>
<tr>
<td>Benign</td>
<td>5</td>
</tr>
<tr>
<td>pT staging</td>
<td></td>
</tr>
<tr>
<td>pT1</td>
<td>3</td>
</tr>
<tr>
<td>pT2</td>
<td>6</td>
</tr>
<tr>
<td>pT3</td>
<td>26</td>
</tr>
<tr>
<td>pT4</td>
<td>5</td>
</tr>
<tr>
<td>pN staging</td>
<td></td>
</tr>
<tr>
<td>pN0</td>
<td>15</td>
</tr>
<tr>
<td>pN1</td>
<td>27</td>
</tr>
<tr>
<td>pN2</td>
<td>2</td>
</tr>
<tr>
<td>Differentiation</td>
<td></td>
</tr>
<tr>
<td>Good</td>
<td>18</td>
</tr>
<tr>
<td>Moderate</td>
<td>18</td>
</tr>
<tr>
<td>Poor</td>
<td>4</td>
</tr>
<tr>
<td>Margin invasion</td>
<td>7</td>
</tr>
<tr>
<td>Tumour diameter</td>
<td>2.4±1.4</td>
</tr>
</tbody>
</table>

Net indicates neuroendocrine tumour. The data are expressed as n (%) or mean± standard deviation.

### Table 4 – Mortality and complications

<table>
<thead>
<tr>
<th>Celiac trunk stenosis</th>
<th>P</th>
</tr>
</thead>
<tbody>
<tr>
<td>No</td>
<td>45</td>
</tr>
<tr>
<td>Patients</td>
<td></td>
</tr>
<tr>
<td>Mortality</td>
<td>1</td>
</tr>
<tr>
<td>Complications</td>
<td>26</td>
</tr>
<tr>
<td>Serious complications</td>
<td>8</td>
</tr>
<tr>
<td>Biliary fistula</td>
<td>3</td>
</tr>
<tr>
<td>Pancreatic fistula</td>
<td>5</td>
</tr>
<tr>
<td>Cholangitis</td>
<td>2</td>
</tr>
<tr>
<td>Wound infection</td>
<td>4</td>
</tr>
<tr>
<td>Intra-abdominal abscess</td>
<td>8</td>
</tr>
<tr>
<td>Delayed gastric emptying</td>
<td>7</td>
</tr>
<tr>
<td>Haemoperitoneum</td>
<td>3</td>
</tr>
<tr>
<td>Pneumonia</td>
<td>1</td>
</tr>
<tr>
<td>Re-operation</td>
<td>7</td>
</tr>
<tr>
<td>Postoperative stay, days</td>
<td>17</td>
</tr>
</tbody>
</table>

The data expresses n (%) or mean ± standard deviation. Serious complication: complication >3a according to Dindo et al.

CDP and how they are related to celiac trunk stenosis. The largest series is that of the Beaujon hospital, which systematically conducted a multidisciplinary evaluation of the existence of celiac trunk stenosis prior to pancreatic surgery in 545 patients. The incidence of celiac trunk stenosis in their series is 11%, but in most of these cases the patients had extrinsic stenosis as a result of compression of the celiac trunk by the arcuate ligament (Figure B). This problem seems to be common in oriental populations, but it is not the most common cause of celiac trunk stenosis in elderly patients who are going to undergo a CDP.
visceral ischaemia. Therefore, other haemodynamic studies are needed to confirm the degree of ischaemia.\(^5\)

In all our patients the most likely cause of celiac trunk stenosis was atherosclerosis (Figure C). In none of the cases with significant stenosis there were any images compatible with compression by the arcuate ligament (Figure B). This must be due to the fact that the average age of our patients was >60 years and most of them were men (Table 1). Probably, the evaluation of the calibre of the celiac trunk and the SMA using MIP techniques should systematically be included in reports on preoperative MDCT studies in patients who are going to undergo a CDP. If celiac trunk stenosis is detected prior to surgery and it appears to be significant and secondary to atherosclerosis, the best treatment is the placement of a stent by an interventional radiologist.

Conclusions

Significant radiological celiac trunk stenosis is a risk factor for serious complications following CDP. Preoperative MDCT appears to be a more sensitive and more objective diagnostic method than the GDA clamp manoeuvre for detecting celiac trunk stenosis. Assessment of the calibre of the SMA using MDCT ought to be systematic prior to a CDP. The correction of haemodynamically significant celiac trunk stenosis should be considered before surgery, because the risk of complications is very high.

Conflict of interest

The authors declare that they have no conflict of interest.

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