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Original article

Celiac artery stenosis and cephalic duodenopancreatectomy: An undervalued risk?

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ARTICLE INFORMATION

Article history:
Received August 26, 2010
Accepted November 29, 2010

Keywords:
Arterial stenosis
Celiac artery/trunk
Duodenopancreatectomy
Pancreatic cancer
Multidetector computed tomography
Surgery
Humans

A B S T R A C T

Introduction: Significant celiac trunk or artery stenosis (CAS) is normally asymptomatic. However, when the arteries of the pancreatoduodenal 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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0009-739X/$ - see front matter

La estenosis del tronco celiaco y duodenopancreatectomía cefálica: ¿un riesgo infravalorado?

Palabras clave:
Estenosis arterial
Tronco celiaco
Duodenopancreatectomía
Cáncer de páncreas
Tomografía computarizada multidetector
Cirugía
Humanos

R E S U M E N

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 hemoperitoneo, 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.

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 fromn 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 skeletisation 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 al[1] conducted on patients undergoing CDP, to 49.7%, in a study by Szilagyi et al[2] on the general population. Whilst in studies on Western populations[1] the most common cause of celiac trunk stenosis was atherosclerosis, in studies such as the one conducted by the Korean investigator Park[3] 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.[6] 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,

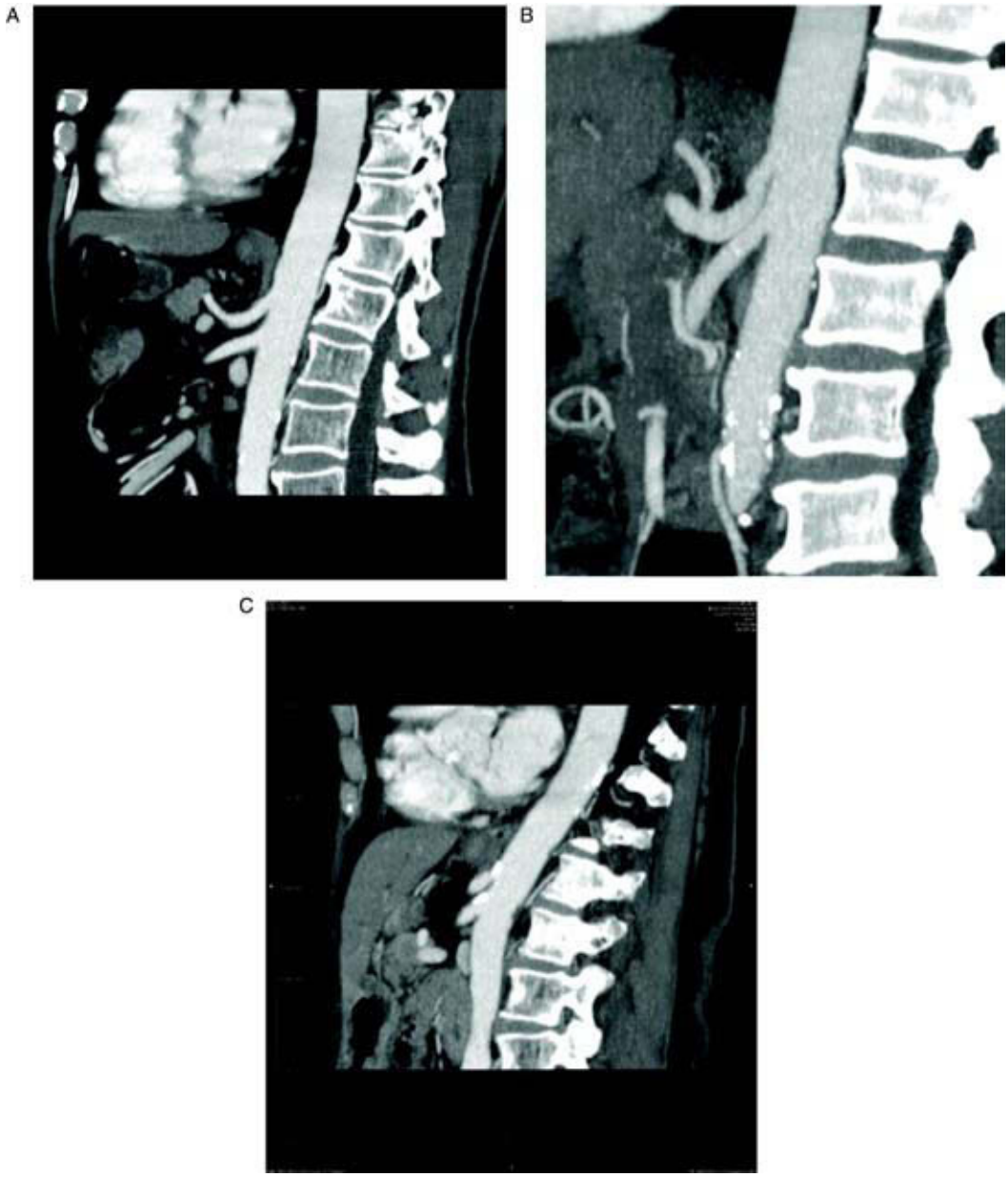

Figure – A: multidetector computed tomography; reconstruction using MIP (maximal intensity projection) technique; sagittal projection of the celiac trunk (CT) and the superior mesenteric artery (SMA). B: stenosis of the CT caused by the arcuate ligament. C: stenosis of the CT and the SMA as a result of atherosclerosis.

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 pancreatojejunostomy or pancreaticogastrostomy first. An end-to-side hepaticojejunostomy 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 al[7] 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 cholestasis (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 pancreatojejunostomy 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).

Table 1 – Epidemiological data

	Celiac trunk stenosis		P
	No	Yes	
Patients	45	13	
Males	25 (56)	11 (84)	.053
Age, years	63.8±9.8	66.5±8.8	.886
Diabetes mellitus	4 (9)	3 (23)	.168
Alcoholism	8 (18)	2 (15)	.551
Smoker	9 (20)	1 (8)	.261
BMI	25.8±4.2	24.5±3.5	.669
ASA			
2	17 (38)	2 (15)	.251
3	27 (60)	11 (84)	
4	1 (2)	0	
Tumour location			
Head of the pancreas	23 (51)	10 (77)	.093
Papilla	6 (13)	3 (23)	
Duodenum	4 (9)	0	
Bile duct	12 (27)	0	
Presentation			
Jaundice	35 (78)	9 (69)	.383
Pain	8 (18)	2 (5)	.604
Cholestasis	38 (84)	10 (77)	.396
Cholangitis	3 (7)	3 (23)	.119
Tumoral mass	29 (64)	9 (69)	.512
Preoperative bilirubin, mg/dl	7.67±6.8	6.25±5.61	.466
Preoperative Ca 19.9, ng/ml	436±980	191±246	.155

ASA indicates American Society of Anestesiology classification; BMI, body mass index.
The data are expressed as n (%) or mean ± standard deviation.

Table 2 – Surgical data

	Celiac trunk stenosis		P
	No	Yes	
Patients	45	13	
Soft consistency of the pancreas	22 (49)	2 (15)	.035
Anastomosis pancreaticogastrostomy	9 (20)	2 (15)	.53
Prepyloric preservation	32 (71)	7 (54)	.201
Antecolic gastroenterostomy	32 (71)	12 (92)	.11
Venous resection	6 (16)	6 (46)	.018
Arterial resection	2 (4)	1 (8)	.54
Wirsung diameter, mm	4.6±3.1	4.4±2.8	.84
Duration of the intervention, min	387±83	378±89	.75

The data are expressed as n (%) or mean ± standard deviation.

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,[5] 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 choleperitoneum 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

Table 3 – Pathological data

	Celiac trunk stenosis		P
	No	Yes	
Patients	45	13	
Tumour type			.095
Ductal adenocarcinoma	16 (36)	11 (84)	
Intestinal adenocarcinoma	4 (9)	0	
Ampulloma	7 (16)	1 (8)	
Cholangiocarcinoma	8 (18)	0	
Papillary adenocarcinoma	1 (2)	1 (8)	
NET	3 (7)	0	
IPMT	1 (2)	0	
Benign	5 (16)	0	
pT staging			.825
pT1	3 (8)	1 (8)	
pT2	6 (15)	2 (15)	
pT3	26 (58)	9 (69)	
pT4	5 (11)	1 (8)	
pN staging			.895
pN0	15 (33)	4 (30)	
pN1	27 (65)	8 (62)	
pN2	2 (5)	1 (8)	
Differentiation			.107
Good	18 (45)	1 (8)	
Moderate	18 (45)	8 (62)	
Poor	4 (10)	1 (8)	
Margin invasion	7 (16)	2 (15)	.679
Tumour diameter	2.4±1.4	3.2±1.5	.073

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

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.[9,10] The early referral of these patients to centres with plenty of experience has proven to reduce mortality to less than 5%[11-17] However, postoperative complications are still common, especially complications derived from pancreatic fistulae, haemorrhage or delayed gastric emptying.[18,19]

It is well documented that celiac trunk stenosis can cause visceral ischaemia if the substitute routes are interrupted during excision (e. g. duodenopancreatectomy).[20-22] In the literature there are also studies that estimate the incidence of celiac trunk stenosis in the general population[3,23] and the population undergoing CDP.[1,5] They even describe isolated cases and possible surgical solutions.[24] However, other authors believe that celiac trunk stenosis rarely leads to important clinical problems after a CDP.[3,5,20,25]

On the other hand, there are few series that attempt to establish the risk of postoperative complications following

Table 4 – Mortality and complications

	Celiac trunk stenosis		P
	No	Yes	
Patients	45	13	
Mortality	1 (2)	2 (15)	.123
Complications	26 (58)	10 (77)	.177
Serious complications	8 (18)	8 (62)	.004
Biliary fistula	3 (7)	2 (15)	.311
Pancreatic fistula	5 (11)	5 (38)	.036
Cholangitis	2 (4)	0	.599
Wound infection	4 (9)	0	.351
Intra-abdominal abscess	8 (18)	2 (15)	0.604
Delayed gastric emptying	7 (16)	1 (8)	.42
Haemoperitoneum	3 (7)	4 (31)	.038
Pneumonia	1 (2)	1 (8)	.401
Re-operation	7 (16)	7 (54)	.009
Postoperative stay, days	17 (11)	23 (16)	.098

The data expresses n (%) or mean ± standard deviation. Serious complication: complication >3a according to Dindo et al.[4]

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.[5] 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,[3] but it is not the most common cause of celiac trunk stenosis in elderly patients who are going to undergo a CDP.[26,27]

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 fistulae.

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.[24] In all our patients we performed a clamp test of the GDA 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, patients with preoperative radiological stenosis developed more complications, which could be attributed to the sequelae of visceral ischaemia.[21,22,26,27] Probably, the clamping of the GDA is not enough to detect cases of incomplete celiac trunk stenosis, although they might be haemodynamically significant. Nevertheless, not all the patients with radiologically significant stenosis presented complications which could be attributed to

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 a 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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